FOOD AND AGRICULTURE ORGANIZATION – FAO

PROJECT FINAL REPORT

1. Project Identification

1.1. **Title**: Strengthening Monitoring, Assessment and Reporting on Sustainable Forest Management in Asia (MAR-SFM) – Pacific regional network on MAR and Long-Term Umbrella Plan on MAR for Pacific countries.

1.2. **Serial Number**: GCP/INT/988JPN

1.3. **Implementing Agency**: Secretariat of the Pacific Community (SPC), Suva, Fiji

1.5. **Starting Date**: July 2009

1.6. **Duration**: 12 Months

1.7. **Project Costs**: US$ 67,750.00

2. Period covered by this Report

This is the final report for the project summarizing the main project outcomes achieved including the status of the finances.

3. Description of the work implemented on the period

Under the MAR-SFM (GCP/INT/988/JPN) FAO had organized a Pacific MAR workshop in Nadi, Fiji, from 10-12 October 2007 with the assistance of the Secretariat of the Pacific Community (SPC). Among other things, participants to this workshop had recommended the following activities to be implemented by the MAR-SFM:

- Develop a long-term umbrella plan for Pacific countries (LUPP) for regular coordination of MAR, containing broad guidelines on cost-effective and harmonized methodologies for generation, preservation, reporting, use and dissemination of information that are flexible enough to address country specific needs;
- Create a fund raising mechanism for implementation of MAR at regular intervals, building on LUPP;
- Set up a regional network on MAR-SFM among the Pacific countries and collaboration organizations to establish well-harmonized and regionally accommodated MAR-SFM systems by sharing updated experience, expertise and knowledge of MAR and formalizing the LUPP among Pacific countries.

In response to the above, SPC, with funding from FAO, through the MAR-SFM (GCP/INT/988/JPN), implemented studies and consultations to determine how the proposed regional initiative on collaboration on MAR-SFM could be progressed, focusing on the development of the regional MAR network and elaboration of the LUPP.
The main activities carried included a questionnaire survey undertaken to gauge data availability and data importance to the countries which took part in the survey and also to identify areas of experience and expertise for which particular countries could offer assistance on to other countries.

In addition to the above, a Pacific Regional MAR-SFM workshop was also organized to discuss the findings and recommendations of the above study and to endorse next steps to progress the implementation of the Pacific MAR Network.

Some of the next steps recommended included:

- Identification or development of adapted and cost-effective methodologies for monitoring, assessment and reporting of the agreed MAR criteria. If necessary the methodologies have to be adapted to the country specific needs but should be comparable. The outcome of this process should only be restricted to descriptions of methodologies, but should provide an estimation of necessary resources for each proposed activity as well.
- A first set of (most important) methodologies shall be demonstrated and discussed during a regional workshop.
- After determining the criteria and methodologies each country has to identify their constraints concerning human, technical and financial resources. On this basis, specific support measures will be developed.

In response to the above, a proposal was submitted to FAO for additional funding through the MAR-SFM (GCP/INT/988/JPN), to implement relevant activities towards the above recommendations.

4. Progress of Implementation

In line with the above, a Letter of Agreement (LOA) was signed between FAO Bangkok and the SPC Land Resources Division (LRD) for the implementation of the required activities in early July of 2009.

Main outcomes achieved included:

- SOPAC-conducted training of appropriate staff in Kiribati to continue the working on the vegetation monitoring system which was earlier established using satellite imagery. A copy of the report of this training has already been provided.
- Selection, adaptation and field testing of MAR systems and methodologies. Selected methodologies were field tested in Tarawa, Kiribati and in Nakavu in Fiji. A copy of the draft report on this has been provided and which was also presented at the regional MAR workshop held earlier this year in Fiji. This work was conducted with significant inputs from the University of Applied Sciences in Eberswalde, Germany.
• Purchase of a new desktop computer with MapInfor software for Kiribati to assist in the data inputs into their vegetation monitoring system.

• Organisation of a Pacific regional MAR workshop held in Fiji where selected methodologies were discussed, tested, and endorsed by the participants. Draft manuals for forest rich countries and also atoll islands drawn up on the basis of the field testing earlier undertaken in Kiribati and in Fiji were used by the participants during the workshop. The manuals have been through reviews before they are finalized. Copies of the workshop report and the manuals are attached.

In addition to the above, SPC is currently funding a technician position with SOPAC to assist countries in map digitization, etc, towards the setting up of their vegetation monitoring systems. Also, Tonga is currently working in undertaking the inventory of forests in the island of ‘Eua and sampling methodology being used is that recommended by this project. SPC and SOPAC are providing technical assistance and support towards this initiative.

4.2. Progress in Implementation of the Activities

Progress of implementation of all the planned activities is summarised below:

<table>
<thead>
<tr>
<th>Activity</th>
<th>% Executed</th>
<th>Estimated Completion Date</th>
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<tbody>
<tr>
<td>1. Identification and development of adapted and cost effective methodologies for monitoring, assessment and reporting for selected MAR criteria</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1 Review of existing methodologies</td>
<td>100</td>
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<tr>
<td>1.2 Selection, adaptation and field testing of selected methodologies</td>
<td>100</td>
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<tr>
<td>2. Support development of a vegetation monitoring system for Kiribati as a model for other atoll island countries</td>
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<tr>
<td>2.1 Support setting up of vegetation map system using satellite imagery</td>
<td>50</td>
<td>March 2010</td>
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<tr>
<td>2.2 Conduct training on operation and maintenance of the system</td>
<td>50</td>
<td>Feb 2010</td>
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<tr>
<td>3. National focal points meeting to discuss and endorse the findings and recommendations of the methodological studies</td>
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<td></td>
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<tr>
<td>3.1 Preparations/organization</td>
<td>100</td>
<td>Jan 2010</td>
</tr>
<tr>
<td>3.2 Meeting</td>
<td>100</td>
<td>Jan 2010</td>
</tr>
<tr>
<td>3.3 Synthesis/reporting</td>
<td>100</td>
<td>March 2010</td>
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<tr>
<td>4. Progress report</td>
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<td></td>
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<td></td>
<td>100</td>
<td>Dec 2009</td>
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4.2. **Work Plan Review**

Since the submission of the project progress report and the satisfactory progress towards preparation of workshop, the work plan was again amended, bringing the completion date to April as shown below. But due to the delay in finalizing the audited financial statement, the final submission of this report has to be delayed to mid-August.

<table>
<thead>
<tr>
<th>Activities</th>
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<th>S</th>
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<tr>
<td><strong>1. Identification and/or development of adapted and cost effective methodologies for monitoring, assessment and reporting for selected MAR criteria</strong></td>
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<td>1.1 Review of existing methodologies</td>
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<tr>
<td>2.2 Conduct training on operation and maintenance of the system</td>
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<td><strong>3. National focal points’ meeting to discuss and endorse the findings and recommendations of the methodological studies</strong></td>
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<td>3.2 Meetings</td>
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<td>3.3 Synthesis/reporting</td>
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<td><strong>5. Final report and accounting</strong></td>
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**4.3.1. Financial Balance** *(funds available with SPC in USD)*

<table>
<thead>
<tr>
<th>Installments</th>
<th>Disbursed by FAO</th>
<th>SPC Contribution*</th>
<th>Expenditure</th>
<th>Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>First</td>
<td>20,315.00</td>
<td>2,000.00</td>
<td>67,490.00</td>
<td></td>
</tr>
<tr>
<td>Second</td>
<td>33,865.00</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Final</td>
<td></td>
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<tr>
<td>GRAND TOTAL</td>
<td>54,180.00</td>
<td>2,000.00</td>
<td>67,490.00</td>
<td>11,310.00</td>
</tr>
</tbody>
</table>

*new desktop computer & accessories for Kiribati
The audited financial report for the project under the LOA is attached. This showed that $USD54,180.00 have been received already out of which $USD65,490.00 have been utilized. The difference of $USD11,310.00 represents the amount which is still to be paid. SPC contribution of $USD2,000.00 for the purchase of a new desktop computer and accessories for the Kiribati Ministry of Agriculture is not included in the total expenses reported in the audited financial statement. The new computer was necessary to support Kiribati in the digitizing of vegetation maps, etc.

5. Conclusions

The work carried out under the existing LOA represent a very significant contribution towards the achievement of the objective of establishing a long-term umbrella plan (LUP) for regular coordination of MAR. Therefore the selection, field testing of methodologies, the application and discussion of these in the workshop were very much critical in moving the project to a satisfactory completion. The continuing efforts in Kiribati and the use of the recommended sampling methodology in Tonga are testament to the project’s success.

7. Acknowledgements

We wish to acknowledge the assistance and support of FAO MAR-SFM Project, SOPAC and the University of Applied Sciences in Eberswalde, Germany in the implementation of the various activities reported in this progress report.

8. Responsible for the Report

Name: Sairusi Bulai

Position held: Coordinator, Forests & Trees Group

Project Coordinator

Date: 20 August 2010
Proposal for Terrestrial Monitoring Methodologies

February 2010

Michael Mussong
for
SPC
Table of Contents

Summary

1. Background ........................................................................................................ 1

2. Objectives and TOR of mission ........................................................................ 1

3. Proposed Monitoring Plot Design and Methodologies ..................................... 2
   3.1 Diverse frame conditions and basic requirements
   3.2 Monitoring plot-design
      3.2.1 FAO NFI plot-design as orientation
      3.2.2 Proposed modified plot-design
      3.2.3 Adaptation to small island situation
   3.3 Data collection and measurements
      3.3.1 Definitions and measurement instructions
      3.3.2 Equipment
      3.3.3 Work procedure
      3.3.4 Permanent demarcation
      3.3.5 Field forms
   3.4 Sampling Intensity and Distribution of Plots

4. Field Tests (Mission Part I) ................................................................................ 11
   4.1 Meetings and Discussions
   4.2 Fiji
   4.3 Kiribati
   4.4 Results and Modifications
      4.4.1 Plot design and work procedure
      4.4.2 Preliminary time studies

5. Workshop and Field Exercises (Mission Part II) ............................................... 13

6. Recommendations ................................................................................................. 14

References

Annexes

Annex 1: Schedule of Consultancy Mission
Annex 2: MAR Criteria List
Annex 3: Workshop Programme
Annex 4: List of Participants
Annex 5: Field Forms
Annex 6: Comments during final workshop session:
Annex 7: Power Point presentation: Proposal for Terrestrial Monitoring Methodologies
Annex 8: Field Manual – Big Islands
Annex 9: Field Manual – Small Islands
Summary

With regards to sound forestry development and environmental preservation, the Pacific Island Countries (PIC) intend to develop a harmonized and cost-effective monitoring, assessment and reporting system (MAR) on forests and forestry.

After the initial workshop in October 2007, a questionnaire was distributed in May 2008 to determine the availability and the importance of the MAR-relevant criteria. The main result of the questionnaire was a list of criteria defining a “least common denominator” on forest-related information important for all PIC and as a basis for a harmonised MAR system. The criteria list was jointly discussed and slightly modified during a workshop in November 2008.

Terrestrial monitoring methodologies were identified throughout 2009. The basic monitoring plot design is based on the NFI-design proposed by FAO, but adapted to the PIC requirements. The 4 strips of each plot are smaller than in the FAO proposal and not based on a square design, but rather a cross design. Circular plots for (above ground) biomass and carbon estimation have been newly introduced in the design.

Field tests were carried out (November 2009) at several locations in Fiji (example for large forest-rich country) and Kiribati (example for atoll country). The plot design as well as the field work procedure was found to be easy to understand and easy to implement for a team of 3 to 4 persons. No high-tech equipment is required and it seems possible to establish one plot (4 strips) per team during one working day. Some weaknesses became visible especially regarding the dbh limits, tree height measurements, field forms, and subplot layout for estimating the amount of “ground carbon” (litter, grass, ferns etc.).

Up through the following workshop in January 2010, most of the technical problems were able to be solved. The updated methodologies were introduced to the workshop participants and thereafter jointly tested in several field exercises (pine plantations, indigenous rain forest, small island forests). The collected data were used for exercises on data analysing. The results of the field activities were discussed and incorporated into the system.

As next steps of the project it is recommended that at least one big island country and one atoll country should begin implementing MAR. Technical assistance should be offered by SPC. Other countries should be invited to take part in ongoing monitoring inventories to get training on the job. For storing and analysing the collected monitoring data, a database needs to be developed and implemented. Furthermore, it is vital that the regional expert database as well as the satellite-based vegetation mapping continually be further developed.
1. Background

Regarding sound forestry development and environmental preservation, the Pacific Island Countries (PIC) supported by SPC and FAO intend to develop a harmonized and effective monitoring, assessment and reporting system (MAR) on forests and forestry.

After the initial workshop in October 2007 and as a first step of the development process, a questionnaire was distributed in May 2008 to determine the availability and the importance of the MAR relevant criteria\(^1\) for the PIC. The main result of the questionnaire was a list of criteria defining a “least common denominator” on forest related information important for all PIC and acted as the basis for a harmonised MAR system\(^2\).

During the following workshop in November 2008, the criteria list was jointly discussed and slightly modified. The following was recommended as the next steps for implementing a Pacific MAR network\(^3\):

1. Final confirmation of the national coordinators (focal points);
2. Design of an internet platform as electronic communication network;
3. Design of a database on regional experts in MAR related fields as basis of a regional expert pool as task force;
4. Collecting of CV’s of regional experts;
5. Identifying or development of adapted and cost-effective methodologies for monitoring, assessment and reporting of the agreed criteria;
6. A first set of (most important) methodologies shall be demonstrated and discussed during a regional workshop;
7. Each country has to identify their restrictions concerning human, technical and financial resources. Based on this, specific support measures might be developed.

2. Objectives and TOR of mission

Throughout 2009, the listed tasks 1 to 4 were continuously developed by SPC. The current mission should contribute to no. 5, 6 and 7 of the list and was dividing into 2 parts, field testing and a workshop, which included field exercises for the participants. The specific tasks of the consultancy are to:

- carry out field tests in Fiji and Kiribati on selected methodologies appropriate for large forest rich countries and for small atoll countries (Nov. 2009);
- organise a 4-5 day regional workshop with the main objective of discussing the results of the field tests and to endorse most appropriate forest and tree monitoring methodologies for large and also small island situations to satisfy the identified priority FRA criteria (Jan. 2010);
- report to the SPC Coordinator – Forests and Trees and Forestry and Agriculture Diversification
  - short brief on field testing undertaken with recommendations for improvements, etc., after having carried out the Kiribati field testing;
  - preparation of a draft report on the whole assignment (i.e. workshop report including a full report on the field testing), submitted an electronic version for comments;
  - preparation of a final report on the whole assignment.

The schedules of both parts of the mission are attached as Annex 1.

\(^1\) the investigated criteria were orientated to the FAO driven Global Forest Resource Assessment (FRA) process but also other criteria could be included by the contributing countries


\(^3\) Mussong, M.: Results of the MAR-Workshop (November 18-19, Nadi, Fiji) and Further Steps towards a Harmonised MAR-System on SFM in the Pacific Island Countries. Standardisation of Monitoring, Assessment and Reporting (MAR) for Sustainable Forest Management in the Pacific. SPC, 2008.
The current report focuses on terrestrial monitoring only. This does not mean that remote sensing data sources are not necessary or welcome in the monitoring process. Wherever such data are available, they are valuable sources and need to be included in the monitoring process\(^4\). However, it is the consultant’s opinion that monitoring methodologies shall be introduced first, which can be easily applied in all participating countries without any sophisticated equipment or specialised education.

The report is structured into two main parts. The first part (Chapter 3) focuses on the justification of the proposed plot design and the critical issues of data collection. A detailed description of both the plot design and the data collection are found in the field manuals, which are attached as Annexes 8 and 9 to this report. It shall be explicitly noted that the field manuals are not yet completed but still in draft form\(^5\).

The second part summarises the course of the field tests (Chapter 4) and the workshop, including the conducted field exercises (Chapter 5). Recommendations on the further course of the project are given in Chapter 6.

### 3. Proposed Monitoring Plot Design and Methodologies

#### 3.1 Diverse frame conditions and basic requirements

The goal of the project is to develop a harmonized and cost-effective MAR system which meets the specific needs of the different participating PIC. Due to the large number of different monitoring parameters (11 criteria, 48 sub-criteria; cf. Annex 2) and the very diverse frame conditions in the different countries (cf. Tab.1), the situation is very complex and difficult to cover under one plot design satisfying at the same time all technical, statistical and financial needs.

**Table 1:** Relevant frame conditions

<table>
<thead>
<tr>
<th>Topography (atoll – high mountains)</th>
<th>Vegetation (rainforest – coconut)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human resources (no foresters – skilled professionals)</td>
<td>Financial resources (…)</td>
</tr>
<tr>
<td>Monitoring parameters (tree related – area related) – cf. Annex 2</td>
<td>Requirements of participating countries</td>
</tr>
</tbody>
</table>

In addition, a monitoring design should fulfil the following basic requirements:

- Easy and quick to implement/re-measure in the field (to allow also (relatively) unskilled personnel to carry out the work in good quality and in timely manner)
- Systematic sampling\(^6\) (to avoid any statistical bias)
- Permanent plots (to have direct comparison of the same sites over time)
- Cluster plots (to extend the number of replications and to minimise work load and costs more than one statistically independent plot shall be established at one site)
- Flexible for further development (in case more or other criteria be monitored in the future, it should be possible to link this to the existing design)

The frame conditions as well as the basic requirements lead to the conclusion that the plot design needs to be a compromise between technical, statistical, and financial restrictions. A

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\(^4\) e.g. vegetation mapping; currently carried out by SOPAC in several countries

\(^5\) the final draft of the field manuals will is expected to be completed in August 2010

\(^6\) Stratification should be taken into consideration if sensibly under the complex parameter structure.
completely new development would require intensive, long-lasting, and expensive scientific research. Therefore it is recommended to base the design on other already practised and recommended plot designs.

3.2 Monitoring plot-design

3.2.1 FAO NFI plot-design as orientation

A potentially suitable and already practised plot design for national forest inventories was introduced by FAO in 2004. The design is recommended for national forest inventories but is also used for monitoring purposes as a kind of periodically replicated inventories.

The design is characterised by four 20 x 250 m plots (strips) located as a square in the centre of a 1 km² tract (Fig. 1) and defined by the coordinates of the south-western corner. The (main)plots are 250 m apart from each other and contain each 3 subplots of 20 x 10 m (SP1) and 3 subplots of 3.99 m radius (SP2). Recording levels are defined for the main plots: all trees >= 20 cm dbh, for SP1: 10 to 19 cm dbh and for SP2: 1.3 m height – 9 cm dbh. The plots are established through cutting a plot central line and measuring 10 m left and right to the line.

![Figure 1: NFI plot design according to FAO (2004)](image)

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7 e.g.: investigate the potential variability of the different parameters to minimise inter-correlations between neighbouring sampling units and to optimise plot design (size of and distances between the sampling units) and number of replications.


Under the conditions of the PIC the plot design shows several weaknesses:

- The tract coordinates are approx. 350 m (air line) apart from the start of the first plot. This results in additional and time consuming walking distances.
- The width of the plots (20 m) is difficult to establish, especially in dense forests and in hilly terrain where slope corrections are necessary.
- The length of the plots (250 m) is also very time consuming and on many small islands just impossible to establish.
- The circular plots are located on the centre line. In consequence part of the trees/shrubs to be measures will be cut during line establishment. In addition a radius of 3.99 m is difficult to realise especially on steep slopes.
- There are no recording units foreseen inside the mainplots which makes it difficult to keep the overview during data collection.
- The proposed recording level for mainplot trees with 20 cm dbh and above seems to be quite low and will result, especially in closed natural forest, in a high number of required measurements.
- No trees smaller than 1.3 m height are recorded so that (important) information on regeneration and biomass/carbon stock is missing.
- No subplot or recording level for carbon “outside” trees/shrubs is foreseen in the design.
- No lying deadwood is assessed.
- A team of 5 to 6 persons are necessary to carry out plot establishment and data collection. The required working time for establishing one tract (4 strips) is estimated to 4 to 5 days\(^{10}\).
- Therefore, the costs for establishing a tract (4 strips) are very high. FAO-investigations estimate the costs per tract on average to be 3300 US\(^\$\)^{11}.

3.2.2 Proposed modified plot-design

The first step to adapt the FAO NFI design to the possibilities of PIC countries is to simplify the layout, reduce the plot dimensions and increase the recording levels (dbh limits). Thus, the field work can be carried out in shorter time and with less qualified staff, which results in lower costs. Of course, statistical shortcomings may occur due to less measurements and relatively longer “boundary lines”, but are accepted in order to provide a probable solution.

The proposed modifications are as follows:

- Starting the measurements as close as possible at the determined coordinates.
- Reducing the width of the strips to 10 m (5 m left and 5 m right of the centre line).
- Reducing the length of the strip to 100 m and keeping a minimum distance between two strips of 100 m.
- Reducing the number of subplots (level 1) from to 3 to 2.
- Reducing the circular plot (subplot level 2) to a radius of 2.00 m (measurable with a stick - even in steep terrain) and moving the plot away from the centre line\(^{12}\).
- Establishing systematic recording units along the centre line (putting pegs every 20 m) which may lead to (slightly) more “staking out” time but saves time due to better overview during plot establishment and data collection.

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\(^{10,13}\) Atrell analysed corresponding NFIs carried out in Zambia, Cameroon, Nicaragua, Honduras and Bangladesh: teams of in average approx. 5 team members established in average 3 tracts per month. Cost vary from 1800 to 5300 in average 3300 US\(^\$\)/tract: Atrell, D., 2009: NFMA Process – time frame and costs. [http://www.icfre.org/UserFiles/File/Presentations_CIFRN_27-29April09/3%20Session/3%20Session%20100%201330/8-Atrell-NFI_CostTimeAnalysis.pdf](http://www.icfre.org/UserFiles/File/Presentations_CIFRN_27-29April09/3%20Session/3%20Session%20100%201330/8-Atrell-NFI_CostTimeAnalysis.pdf)

\(^{12}\) In the newly published FAO NFMA-brochure the circular plot is also moved away from the center line: FAO 2009: National Forest Monitoring an Assessment. NFMA brochure; [http://www.fao.org/forestry/17277-0-0.pdf](http://www.fao.org/forestry/17277-0-0.pdf)
• Lifting up the recording level for mainplot trees from 20 to 25 cm dbh.
• Introducing a small circular plot (radius= 0.3 m) for collecting "ground carbon" (litter, grass, ferns etc.) and counting regeneration (up to 1.3 m height). Due to the required laboratory analyses the FRA-relevant criteria "carbon below ground" is currently not included in the monitoring.
• Introducing a sampling procedure for lying deadwood.
• Reducing number of required staff to 3 (to 4) persons (line cutter, surveyor, team leader/recorder, (assistant)).

**Figure 2:** Simplified FAO NFI plot design

In addition, it has been proposed to change the design from a square layout to a cross-layout (Fig. 3). The advantages are as follows:

- The coordinates are in the centre of the monitoring cluster. The plots start at 80 m from the coordinates in North, South, East and West direction. Thus, it is certain that the minimum distance between two strips is still 100 m.
- Because only one right angle needs to be measured, it is easier to establish a cross layout. All other plot pegs will be put in a straight line. Thus, also the plot identification during re-measurements in the future will be easier.
- When taking a closer look, the theoretically longer walking distances for a cross-layout (4 x walking up and down each 180 m = 1440 m) instead of (4 x walking forward each 200 m =) 800 m in a squared layout actually shows that the difference is much smaller because backward movements are also necessary (establishing the line at least to the next peg, then moving back for data collection; cf. Fig 4).\(^\text{13}\)

\(^{13}\) This could be avoided only when working with two separate teams: one for line cutting and one for surveying. In this case unproductive waiting time may occur due to different working speed of the team.
Due to the big number of parameters to be monitored, it seems easier (and perhaps quicker) to collect the data for some criteria moving forward while establishing the central line and collecting the data for the other criteria while moving backwards. For criteria like forest functions, forest characteristics, disturbances, etc., it is more helpful to first get an impression (when moving forward) before the final recording (when moving backward). Recording biodiversity could be carried out during the forward and backward movement. Corrections (wrong measurements, forgotten trees etc.) are easily possible. Thus, the recording quality will be better than recording all criteria moving in one direction.

If it should be necessary in the future to include more strips or other observation units in the monitoring concept, a cross-design would be more flexible than a square-design.
• During field work, luggage/food/water/equipment/bags for biomass samples could be stored in a suitable place in the centre of the cross and need not to be carried during the data collection (like in the forward orientated square-design). The storage place could be used as a rest place for brakes after finishing a strip and allow a performance preserving work structure. Also, if two teams are required (e.g. if the plot is very remote and need a long way to access) a cross layout is better to divide than a square layout.

3.2.3 Adaptation to small island situation

In many cases for atoll situations, the cross-design is not suitable due to the fact that on many islands, the distance from coast line to coast line is less than the required 360 m. In addition, there is most often a zonal distribution of vegetation and land use parallel to the coast lines. A cross-design following the 4 directions would hardly be representative for a zonal situation. Therefore an optimal layout for narrow islands should crosscut the zones to create a representative situation.

For such atoll situations, the “cross” is changed to a sequence of four parallel strips (10x100m), securing at least a distance of 100 m between the strips (Fig. 5). The coordinates of a pre-established systematic grid act as the starting point. The moving direction is the shortest distance to the more remote coast line. If the strip (or the 100 m distance in between) ends in the water, the distance over water will be measured and will continue in the parallel line/strip running in the opposite direction. Due to the same shape and size of the strips and the distance between the strips, (at least 100 m), the “snake-design” is statistically comparable to the cross-design. All methods of measurements in the plot are identical to those of the cross-design.

Figure 5: Plot design and procedure for narrow atoll situation

It is recommended to use the cross-design wherever possible and to switch to the snake-design in cases where the islands are too narrow (Fig. 6). To minimize confusion regarding which design to choose, a detailed planning (grid – design – direction) is necessary before beginning the field work. Current maps, areal photos or satellite images are required.
3.3 Data collection and measurements

3.3.1 Definitions and measurement instructions

The definitions of the criteria to monitor are taken from or strongly orientated to the definitions of the FRA documents\(^1\) and can be found in the field manuals (Annex 8, 9). Likewise, the measurement instructions can be found there as well.

While most of the criteria are assessed visually\(^2\), some of the criteria are surveyed by using concrete measurements\(^3\). Regarding dbh-measurement conventional diameter tapes are recommended. For trees up to 25 cm, dbh callipers would speed up the measurements. For height measurements, a very quick method is recommended using a reference height (2 m stick) instead of measuring the distance to the tree. It must be emphasized that this method should be used only if the team members are able to work very precisely. If this is not possible, conventional height measurements with distance determination is required.

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\(^{2}\) e.g.: disturbances, functions, forest characteristics etc.

\(^{3}\) e.g.: standing volume, biomass stock, carbon stock etc.
3.3.2 Equipment

With the exception of a GPS for identifying the coordinates, only simple, robust and (comparably) inexpensive equipment is used:

- Bush knives for line cutting and peg preparation
- Measuring tapes for distance measuring (plot length, width) and right angle establishment
- Diameter tape for dbh measurement (if possible a 25 cm calliper for dbh and lying dead wood measurements in the sub- and circular plots)
- Compass for line establishment
- Clinometer for height and slope measurements
- Slope correction table for distance measurements
- Self-prepared sticks (2 m, 0.30 m) for circular plot establishment and as reference height (2m) for height measurement
- (spray) paint or flagging tape for better visibility of pegs and sticks. For permanent plots, marking all the trees, or at least of all the boundary trees, is recommended
- Plastic bags for collecting “ground-carbon”
- Pencils, clipboard for recordings

3.3.3 Work procedure

The monitoring team consists of a line cutter\(^4\), a surveyor and a recorder (team leader). Due to the fact that a large number of criteria have to be assessed or measured, it seems reasonable that some of the criteria are recorded during the forward movement (away from the coordinate point) and the other criteria during the return movement (back to the starting point) (Fig. 7). This would allow for a better structured and less interrupted work procedure and would improve the quantity and quality of work.

\(^4\) preferably member of the landowning community and familiar with the local situation
3.3.4 Permanent demarcation

To receive high quality information on the relevant criteria, it is recommended to establish permanent monitoring plots which are exactly re-measured during each monitoring cycle. The permanent demarcation could be carried out in different intensities, ensuring that at least the coordinate point is marked with a (non-removable) post. Furthermore, it would be ideal to have one more peg/post along the centre line at the beginning and the end of each strip. For all other corners of the strips, it is preferable to also have some demarcation. However, this will depend on the available resources. Marking of all measured trees with a non-toxic paint is also ideal and would speed up the re-measurements in the monitoring cycles thereafter.

3.3.4 Field forms

Consequently, the field forms need to be adapted to the work procedure. Only two field forms – one for the forward movement, one for the backward movement – are necessary to record the required data. Thus, the risk of creating confusion with several sheets is more or less eliminated, in spite of the fact that a lot of different data will be recorded during the procedure. The field forms are attached as Annex 5.

3.4 Sampling Intensity and Distribution of Plots

The number of plots (replications) to establish depends on the statistical requirements, the number and qualification of the staff and finally on the available budget. Regarding the statistical requirements information is needed concerning the tolerated sampling error and the variances of the parameters (criteria) to monitor.

While the sampling errors can be determined according to the individual needs, the variances for most of the parameters are not known in advance. Due to the assumption that different parameters will have different variances for each parameter, a separate optimal sampling intensity may arise. Therefore, no “true” sampling intensity can be determined with reasonable effort.

In most cases, the budget or a fixed number of plots (based on the budget) will determine the sampling intensity. As an empiric rule, at least 7 observations per reporting unit should be investigated, but as a roughly estimated target, 100 plots (400 strips) per country should be envisaged. For big countries like PNG, 200 to 300 plots are recommended.

Fig. 8 shows an example of how the systematic sample plot distribution can be calculated.

---

5 also non-visible demarcations with metal rods hidden in the ground are possible (to relocate a metal detector would be required)
6 subplots (level 1, 2, 3), lying deadwood
7 mainplot trees (dbh, height, forest functions, disturbances, extend, ownership characteristics
8 \( n = \frac{t^2 \cdot cv^2}{E^2} \) (n: number of plots; t: t-value (approx. 2); cv: coefficient of variation; E: tolerated sampling error)
9 sampling errors of 10 to 20 % are suggested
10 reporting unit: e.g.: village area, island, province, state
11 e.g: in Cameroon which has almost the same area like PNG 236 NFI plots were established.
4. Field Tests (Mission Part I)

4.1 Meetings and Discussions

Field tests of the developed plot design were foreseen for Fiji as representative for a large forest rich country and Kiribati as typical atoll country.

Prior to the field tests, initial meetings took place with the SPC Forests and Trees Coordinator, project staff and a German student acting as an SPC project intern and supporting the project through literature search and methodology identification.

During the main meeting, the proposed plot design was introduced (PowerPoint presentation) and discussed with SPC staff and participants from Forestry Department (Headquarters, Management Services, Research Division) and SOPAC. The announced USP representative didn’t participate.

Discussions and comments showed support for the “cross-design”. One participant proposed a stratification according to existing maps before plot establishment. This proposal faces two problems:

1. For very small and scattered situations (like on atolls) there is often just not enough space to establish a 10 x 100 m strip in a certain strata. If the size or the shape of the plots are changed, the original goal of harmonisation would be at risk.
2. Due to the large number of partly very diverse criteria to monitor stratification (e.g. on vegetation types) does no necessary make sense for all criteria. Thus, several stratifications might be necessary, which would probably lead to a larger number of replications than during a non-stratified survey.

After field tests in Fiji and Kiribati, the SPC Forests and Trees Coordinator was informed about the course and the first testing results.
4.2 Fiji

In Fiji two field testing days were carried out with support of Forestry Department and Nakavu village tree spotters in sustainably harvested rain forests (Nakavu) and one day in pine plantations (Lautoka), investigating two locations (approx. 15 year old pine stand and former pine stand approx. 2 years after clearcut).

During the testing phase, at least for one strip, all measures of establishing and data collection were carried out according to the developed design. The relevant data of all criteria (Annex 2) were recorded on prepared field forms.

In total 5 strips were established in Nakavu and 2 strips in Lautoka. After getting used to the work procedure, the work was going well. However, the fact that too many people were present became an obstruction during the test.

4.3 Kiribati

The field test in Kiribati was logistically and, during the field work, physically supported by a student from Kiribati, currently with SOPAC. After having arrived, there was an initial briefing with the Kiribati MAR coordinator and staff of the Agriculture Department. On the following day, the Permanent Secretary, Director of Agriculture and other relevant staff of the Ministry, were also informed about the MAR project and the foreseen activities.

During the one-day field test, two strips were established according to the developed design. In addition, a mangrove stand was inspected and the problems of accessibility were discussed. Before departing, a final discussion about the experiences and the work plan for the remaining project staff took place. Several strips were established in the following days.

4.4 Results and Modifications

4.4.1 Plot design and work procedure

The plot design as well as the field work procedure was found to be easy to understand and easy to implement for a team of 3 to 4 persons. The following improvements were introduced:

- Due to the conditions of more “open” forest areas, the dbh-limit in mainplots was reduced from 30 cm to 25 cm and in the subplots (level 1) from 29 cm to 24 cm.
- To receive more representative information on the “established regeneration”, two 10 x 10 m subplots (level 1; instead of one 10 x 20 m) were introduced on both ends of each strip.
- Field forms were improved to promote a clear work structure and to ensure that all relevant data were recorded.

All changes are already included in the previous chapters and the draft of the field manual.

One issue still remains problematic, being the proposed methodologies for height measurement (c.f. 3.1) and “ground carbon” collection. Regarding the “ground carbon” plots, there is still a need for further improvement. The current method has weaknesses in precision (proportionally much carbon is located along the plot boundary) and there is a need to identify/develop a simple field procedure to estimate the carbon contents in biomass without any laboratory analysis (most countries will have no possibility to forward collected biomass systematically to laboratories for carbon analysis).
4.4.2 Preliminary time studies

For orientation purposes, brief time studies were carried out to estimate the required working time. In total 5 strips were established in different locations in natural forests. The average time for 180 m line cutting and 100 m plot establishment (including 1 subplot 10x20 m and 4 circular plots (radius= 2.0 m and radius 0.3 m)) was 63.6 minutes per strip. One cluster of 4 strips would result in 254.4 minutes or approx. 4 hours and 15 minutes. A 6 to 8 hour day, including coming and going and breaks, is occupied by one cluster.

It took slightly more time for the two strips in the pine plantation. The required time for both the pine stand as well as the clearcut, was 74 minutes per strip and approx. 5 hours per cluster.\(^{12}\)

According to the time measurements carried-out in Kiribati, it could be expected that the required time for plot establishment is more or less the comparable to the results in Fiji. Even if the terrain is easier and faster for walking, it takes partly more time for line cutting due to thick undergrowth. Also peg establishment is often more problematic due to rocky ground and rare possibilities to cut suitable pegs in the field.

All in all it can be expected that a cluster of 4 strips will need in average approx. 4 to 5 hours which will allow in most cases to finish one cluster within one day.

5. Workshop and Field Exercises

Participants from in total 11 PIC took part in the workshop. Workshop programme and list of participants is attached as Annexes 3 and 4.

The workshop took place from January 25 to 29 in several locations in Fiji. The introduction to the project, the proposed methodology\(^ {13}\) and some first exercises on plot establishment, height and diameter measurement as well as volume, biomass and carbon calculation was carried out in Nadi.

After the introduction field exercises were conducted in Pine stands (Nabou), small island forests (Moskito Island/Lami) and indigenous rainforests (Nakavu). Three teams were formed out of the participants to carry out plot establishment and data collection under the guidance of SPC-staff familiar with the methodology. All participants were able to familiarize themselves quickly with methodologies and the work procedure.

Analyses of data collected during the field exercises followed in the classroom (Lami/Suva). Volume, biomass, and carbon figures were calculated for different stands/forest types using Excel spreadsheets.

In the final meeting some critical points on the presented methods were discussed. A list of comments is attached as Annex 6. However, the opinion of the participants was generally positive. The Solomon Islands intend to start already this year with appropriate monitoring. The Fiji Islands want to take over at least the survey methods, but are also thinking about taking over the plot-designs.

\(^{12}\) due to not sufficient number of replications, missing routine of the staff and not optimal number of team members (partly to much staff joining the field test) the results are not statistically approved but never the less presumable close to reality

\(^{13}\) The PowerPoint presentation on the proposed monitoring methodologies is attached as Annex 10.
6. Recommendations

In conclusion, the following recommendations based on the field tests, field exercises and discussions with the workshop participants are as follows:

1. Continue to develop the regional expert/specialist data base including the collection and storing of CVs. The formerly envisaged internet platform on MAR does not need to be continued at the moment but postponed to a later stage of the project development; currently an e-mail list of the involved persons will meet the demand.

2. Finalize the methodology development and prepare the field manuals for publishing\(^\text{14}\).

3. For storing and analysing data, a MAR-database needs to be developed. Training measures will be required on database management, analysing, and reporting. This training could be carried out during a workshop but an e-learning module should be preferred\(^\text{15}\).

4. For at least one big and one small island country, support shall be offered during MAR implementation (training courses on methodologies, data base management, reporting). Scientific attendance will be necessary during the first implementations in order to optimise the monitoring system\(^\text{16}\).

5. Continue satellite based vegetation mapping and linking with terrestrial monitoring activities (SOPAC/SPC).

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\(^{14}\) Especially biomass and carbon estimation methodologies need some further improvement (e.g: form factors for coconut or other palm trees, stump diameter–dbh correlation (for estimating the removals), “ground” carbon weighting in the field).

\(^{15}\) The University of Applied Sciences Eberswalde offers support in identifying a student (Master programme Forest Information Technology) who could develop the data base as well as a e-learning module.

\(^{16}\) Also here support is offered by the University of Applied Sciences Eberswalde.
References


Mussong, M., 2008: Survey on the Status of Forest Data in Selected Pacific Island Countries. Standardisation of Monitoring, Assessment and Reporting (MAR) for Sustainable Forest Management in the Pacific. SPC.

Mussong, M., 2008: Results of the MAR-Workshop (November 18-19, Nadi, Fiji) and Further Steps towards a Harmonised MAR-System on SFM in the Pacific Island Countries. Standardisation of Monitoring, Assessment and Reporting (MAR) for Sustainable Forest Management in the Pacific. SPC.
## Annex 1

### Schedule of Consultancy Mission

#### Part I: Field Tests

<table>
<thead>
<tr>
<th>Date</th>
<th>Activity</th>
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<td>Departure Germany</td>
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<tr>
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<td>Arrival Fiji</td>
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<tr>
<td>Nov. 15</td>
<td>Meeting with German students</td>
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<td>Nov. 16</td>
<td>Briefing with SPC/Sairusi Bulai and staff</td>
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<tr>
<td>Nov. 17</td>
<td>Presentation of proposed plot design (participants from SPC, FD, SOPAC)</td>
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<td>Nov. 18</td>
<td>Field test Nakavu</td>
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<tr>
<td>Nov. 19</td>
<td>Data analysis, Modifications in procedure and field forms</td>
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<td>Nov. 20</td>
<td>Field test Nakavu</td>
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<td>Data analysis, Preparation field test</td>
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<td>Briefing DFO West, Field test Lautoka/Ba</td>
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#### Part II: Workshop

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<tr>
<td>Jan. 24</td>
<td>Preparation workshop</td>
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<td>Jan. 25</td>
<td>Workshop Nadi: Indoor session</td>
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<td>Jan. 26</td>
<td>Workshop Nadi: Indoor session; practical exercises on field measurements.</td>
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<td>- Nabou pine forest</td>
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<td>- Mosquito island/Lami (atoll situation)</td>
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<td>Jan. 28</td>
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<td>- Nakavu (rain forest)</td>
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<td>Jan. 29</td>
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### Annex 2

**Workshop 2008**

**MAR-criteria list**

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<td>Conservation of biodiversity</td>
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<td>8:30 – 9.30</td>
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<td>Welcome and Opening Remarks</td>
<td>Mr. Sairusi Bulai</td>
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<td>9.55 – 10.00</td>
<td>House Keeping &amp; Introductions</td>
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<td>10.00 - 10.30</td>
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<td>10.30 – 11.00</td>
<td>SESSION 1: Progress on MAR - SFM Project at country level (Fiji, Vanuatu, PNG,</td>
<td>Country Presentation</td>
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<td>11.00 –11.30</td>
<td>SESSION 2: Vegetation Monitoring in Kiribati, Tonga &amp; Tuvalu</td>
<td>Dr. Wolf Forstreuter</td>
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<td>11.30 – 11.45</td>
<td>Proposed Vegetation Survey in FSM</td>
<td>Ms. Alissa Takesy</td>
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<td>11.45 – 1.00</td>
<td>Presentation of results of the methodology testing in Fiji and in Kiribati</td>
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<td>3.00 – 3.30</td>
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<td><strong>Day 2: Tuesday 26th</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.00 – 8.30</td>
<td>SESSION 4: RECAP OF DAY 1</td>
<td>Prof. Mussong</td>
</tr>
<tr>
<td>8.30 – 9.00</td>
<td>Presentation on the Expert Database</td>
<td>Dr. Wolf Forstreuter</td>
</tr>
<tr>
<td>9.00 – 10.00</td>
<td>Introduction to Data Analysis</td>
<td>Prof. Mussong/ Mr. Tom Thiele</td>
</tr>
<tr>
<td>10.00 – 10.30</td>
<td>COFFEE BREAK</td>
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</tr>
<tr>
<td>10.30 – 1.00</td>
<td>SESSION 5: Data Analysis Exercise</td>
<td>Prof. Mussong/ Mr. Tom Thiele</td>
</tr>
<tr>
<td>1.00 – 2.00</td>
<td>LUNCH</td>
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<tr>
<td>2.00 – 3.00</td>
<td>Data Analysis Exercise</td>
<td>Prof. Mussong/ Mr. Tom Thiele</td>
</tr>
<tr>
<td>TIME</td>
<td>ACTIVITY</td>
<td>LEAD PERSON</td>
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<tr>
<td>3.00 – 3.30</td>
<td>COFFEE BREAK</td>
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<tr>
<td>3.30 – 5.00</td>
<td>SESSION 6: Practical Exercise on Plot Establishment &amp; Field measurements (Skylodge compound)</td>
<td>Mr. Tom Thiele</td>
</tr>
<tr>
<td><strong>Day 3: Wednesday 27rd</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.30</td>
<td>SESSION 7: Depart Skylodge for the Suva Field Trip</td>
<td>Jalesi Mateboto</td>
</tr>
<tr>
<td>9.00</td>
<td>Field Measurement in Nabou Pine Forest – Forest Plantation situation</td>
<td></td>
</tr>
<tr>
<td>12.30</td>
<td>Depart for Novotel Hotel, Lami</td>
<td></td>
</tr>
<tr>
<td>3.45</td>
<td>Check in at the Novotel Hotel</td>
<td></td>
</tr>
<tr>
<td>4.30</td>
<td>Depart for Mosquito Island</td>
<td></td>
</tr>
<tr>
<td>4.35 – 5.30</td>
<td>Field measurement for Atoll island situation &amp; Back to the Hotel</td>
<td></td>
</tr>
<tr>
<td><strong>Day 4: Thursday 28th</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.30</td>
<td>SESSION 8: Depart hotel for Nakavu Field work (Normal Forest Situation)</td>
<td>Jalesi Mateboto</td>
</tr>
<tr>
<td>4.00</td>
<td>Back in the Hotel (Assignment: Group Data analysis until 8.30am tomorrow)</td>
<td></td>
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<tr>
<td><strong>Day 5: Friday 29th</strong></td>
<td></td>
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</tr>
<tr>
<td>9.00 – 9.30</td>
<td>SESSION 9: Presentation and discussion of field exercises, presentation of country constraints</td>
<td>Prof. Mussong</td>
</tr>
<tr>
<td>9.30 – 10.00</td>
<td>Group Data analysis</td>
<td>Prof. Mussong</td>
</tr>
<tr>
<td>10:00-10.30</td>
<td>COFFEE BREAK</td>
<td></td>
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<tr>
<td>11.00 – 11.30</td>
<td>Progress on MAR-SFM Project</td>
<td>Dr. Masahiro Otsuka</td>
</tr>
<tr>
<td>11:30 – 12.45</td>
<td>SESSION 10: Development of specific support strategies</td>
<td>Prof. Mussong</td>
</tr>
<tr>
<td>12.45 – 1.00</td>
<td>Closing</td>
<td>Mr. Sairusi Bulai</td>
</tr>
<tr>
<td>1.00 – 2.00</td>
<td>LUNCH</td>
<td></td>
</tr>
<tr>
<td>2:00</td>
<td>Standby Session: Tour of the Fiji Forestry Department facilities, WUD, TITC, FTC, Research, MSD</td>
<td>Depending on Session 10</td>
</tr>
<tr>
<td>5.00</td>
<td>Back at the hotel</td>
<td></td>
</tr>
</tbody>
</table>
Annex 4

MAR-SFM REGIONAL WORKSHOP
25-29 January 2009, Nomad’s Skylodge Hotel, Nadi, Fiji Islands

List of Participants

COOKS ISLANDS

Mr. Nooroa Tokari
Senior Project Officer
Department of Agriculture
P O Box 96, Rarotonga
Cooks Islands
Tel: (682) 28711
Fax: (682) 21881
E-mail: noot@agriculture.gov.ck

FEDERATED STATES OF MICRONESIA

Ms. Alissa Takesy
FSM Protected Areas Network Coordinator
Department of Resources & Development
P O Box PS-12
Palikir, Pohnpei FM 96941
Federated States of Micronesia
Tel: (691) 320 2620/2646/5133
Fax: (691) 320 5854
E-mail: fsm_pan@mail.fm/artakesy@fsmrd.fm

Mr. Erick E Waguk
State Forester
Kosrae Island Resource Management and Authority
P O Box 403
Kosrae, FM 96944
Federated States of Micronesia
Tel: (691) 3702076
Fax: (691) 3703000
E-mail: ewaguk@yahoo.com / kosraeforestry@mail.fm

Mr. Francis Ruegorong
Yap Division of Agriculture and Forestry
Department of Resource and Development
P O Box 463, Colonia
Yap FM 96943
Federated States of Micronesia
Tel: (691) 3502183
Fax: (691) 3504693
E-mail: ucfyap@mail.fm

FIJI ISLANDS

Mr. Samuela Lagataki
Deputy Conservator of Forests
Forestry Department
Ministry of Primary Industries
P.O. Box 2218, Government Buildings
Suva, Fiji Islands
Tel: (679) 330 1611
Fax: (679) 331 8692
E-mail: Samuela_lagataki@yahoo.com
Mr. Viliame Tupua  
Forestry Department  
Ministry of Primary Industries  
P.O. Box 2218, Government Buildings  
Suva, Fiji Islands  
Tel: (679) 330 1611  
Fax: (679) 331 8692

KIRIBATI
Ms. Tearimawa Natake  
Senior Agricultural Officer (Agroforestry Section)  
Ministry of Environment, Lands and Agriculture Development  
P.O. Box 234 Bikenibeu  
Kiribati  
Tel: (686) 28211/ 28108  
Fax: (686) 28334  
E-mail: tearimawa21@yahoo.com.au

NIUE
Mr. Brandon Tauasi  
Head of Forestry  
Department of Agriculture, Forestry & Fisheries  
Box 74, Alofi, Niue  
Tel: (683) 4032  
Fax: (683) 4079  
E-mail: flex@niue.nu

PAPUA NEW GUINEA
Mr. Fletcher Onise  
Senior Forester/Trainer  
Foundation for People and Community Dev Inc  
P.O. Box 297, Madang 511  
Papua New Guinea  
Tel: (675) 8523536  
Fax: (675) 8522718  
E-mail: fonise@fpced.org.pg / fkonise@yahoo.com.au

Mr. Bruno Kuroh  
PNG Forest Research Institute.  
PNG Forest Authority  
P.O. Box 1119, Boroko, NCD  
Papua New Guinea  
Tel: (675) 3258470  
Fax: (675) 3252670  
E-mail: bkuroh@pngfri.pngfa.pg

Mr. Mark Taian Pilon  
Projects Officer – Area West  
PNG Forest Authority  
P.O. Box 5055, Boroko, NCD  
Papua New Guinea  
Tel: (675) 3277874  
Fax: (675) 3277827  
E-mail: mpilon@pngfa.gov.pg
SAMOA
Ms. Annie Mauga Kalala
Planning and Policy Officer
Forestry Division; Min. of Natural Resources & Environment
Private mail Bag, Apia
Samoa
Tel: (685) 23800
Fax: (685) 51543
E-mail: annie.mauga@mnre.gov.ws

SOLOMON ISLANDS
Mr Jimmy Irokete Wanefaia
Principal Planning Officer
Forestry Department; Ministry of Forestry
P. O. Box G24, Honiara
Solomon Islands
Tel: (677) 24216
Fax: (677) 24160
E-mail: jwirokete@yahoo.com

TONGA
Mr. Heimuli Likiafu
Forestry Officer
Forestry Division
Ministry of Agriculture, Food, Forests and Fisheries
P. O. Box 14, Nuku’alofa
Tonga
Tel: (676) 23 038
Fax: (676) 23 093
E-mail: hlikiafu@yahoo.com

TUVALU
Mr. Uatea Vave
Senior Agricultural Officer (Agroforestry)
Agroforestry Unit, Department of Agriculture
Ministry of Natural Resources and Environment
Private Mail Bag
Vaïaku, Funafuti Atoll
Tuvalu
Tel: (688) 208136
E-mail: uateavave@gmail.com

VANUATU
Mr. Rexon Viranamangga
Senior Forest Officer – Planning
MAR-SFM Vanuatu National Coordinator
Department of Forests, Ministry of Agriculture, Quarantine, Forestry and Fisheries
PMB 9064, Port Vila
Vanuatu
Tel: (678) 23171/23856
Fax: (678) 23856
E-mail: virarexon@yahoo.com

Mr. Harold Moli Wora
Senior Mapping & Remote Sensing Officer
Department of Land Surveys
PMB 9024, Port Vila
Vanuatu
Tel: (678) 22892/23171
Fax: (678) 23568
E-mail: hwora@vanuatu.gov.vu
RESOURCE PERSON
Dr. Michael Mussong
Professor
Eberswalde University
Germany
Tel: (49) 3334 65484
E-mail: mmussong@fh-eberswalde.com

FOOD AND AGRICULTURE ORGANIZATION
Mr. Otsuka Masahiro
Forest Officer – Special Projects
Regional Office for Asia and the Pacific
FAO
Maliwan Mansion, 39 Phra Atit Road
Bangkok 10200, Thailand
Tel: (662) 697 4000
Fax: (662) 697 4445
E-mail: Otsuka.Masahiro@fao.org

SOPAC
Dr. Wolf Forstreuter
GIS Sensing Specialist
SOPAC
Private Mail Bag
Suva, Fiji Islands
Tel: (679) 3381377 Ext237/9272462
Fax: (679) 3370040
E-mail: wforstreuter@yahoo.co.uk

SECRETARIAT OF THE PACIFIC COMMUNITY
Mr. Sairusi Bulai
Coordinator – Forests and Trees and Forestry and Agriculture Diversification Groups, Land Resources Division
Secretariat of the Pacific Community
Private Mail Bag, Suva
Fiji Islands
Tel: (679) 337 0733
Fax: (679) 337 0021
E-mail: sairusib@spc.int

Mr. Jalesi Mateboto
Community Forestry Technician
E-mail: jalesim@spc.int

Mr. Tom Thiele
Forestry Intern at SPC from Germany (Eberswalde University)
E-mail: tthiele@fh-eberswalde.de

Ms. Bale Wilikibau
Programme Assistant
E-mail: balew@spc.int
# Annex 5

## Forward Sheet

<table>
<thead>
<tr>
<th>Date</th>
<th>Plot Coordinates</th>
<th>UNIT No.</th>
<th>Subplot No.</th>
<th>Weight (kg)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
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<td></td>
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</tbody>
</table>

**Lying Deadwood**

| Diameter (cm) | Species (local name) | BMIH (cm) | Remarks | UNIT No. | Subplot No. | No. of trees
<table>
<thead>
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<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>10-20 (SU1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;20 cm (SU2)</td>
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</tr>
</tbody>
</table>

**Biodiversity Observations**

- Indicator species
- Endangered species

---

## Backward Sheet

<table>
<thead>
<tr>
<th>Unit No.</th>
<th>Species (local name)</th>
<th>DBH (cm)</th>
<th>Taper</th>
<th>Stick</th>
<th>Log</th>
<th>Top</th>
<th>Height (m)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
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</tr>
</tbody>
</table>

**Biodiversity Observations**

- Indicator species
- Endangered species

---

### Diagram

- **SU1 - CU1**: Forest
- **SU2 - U2**: Forest External
- **SU3 - U3**: Other wooded land
- **SU4 - U4**: Fallow land
- **SU5 - U5**: Agriculture land

**Plot Details**

- **Subject**: 20 x 20 cm, **Subplot**: 1 x 1 cm
- **Aspect**: 0 degrees
- **Angle**: 0 degrees
Annex 6

Comments during final workshop session:

Tree height measurement:
problem with accuracy (2 m stick); use of signal colours/reflectors for better stick visibility; very accurate measurements required; quick cross checks in the field desirable (e.g. checking table); alternatively other height measurement procedures (e.g. with distance measurements) also possible

Plot design:
more walking because forward and backward movement; if surface is problematic (e.g. swamp) it is also possible to carry out all measurements in one moving direction (like in the atoll-design)

Inaccuracies in the manual:
definitions should be more precise (e.g. forest functions, concrete slope figure for soil protection; how to measure leaning trees etc.)

Including more information:
soil survey; involving local biologist; below ground biomass; crown cover/crown dimensions

Equipment:
In some countries the relevant equipment is not available