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Training in soil assessment and scientific writing for aquaculture officers in Papua New Guinea

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Contents

1	Acknowledgments	4
2	Executive summary	5
3	Introduction	7
4	Objectives	8
5	Soil Assessment Training	9
5.1	Soil Theory Training.....	9
5.2	Field-based training	9
6	Scientific Writing Training	12
7	Conclusions and recommendations	15
7.1	Conclusions.....	15
7.2	Recommendations	15
8	References	17
8.1	References cited in report.....	17

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2 Executive summary

Why the work was done?

Soil assessment and an understanding of chemical and physical soil process are important for site selection, land capability assessment and pond management in land-based aquaculture. Soil-related problems such as erosion, pond leakage, water quality degradation and lack of phytoplankton blooms have limited pond-based production of fish in Papua New Guinea (PNG). Simple, low-cost methods of assessing, remediating and managing soils were developed by ACIAR Project FIS/97/22 (*Remediation and management of degraded, earthen shrimp ponds in Indonesia and Australia*) and FIS/2002/076 (*Land capability assessment and classification for sustainable, pond-based aquaculture systems*) in Indonesia. ACIAR and the National Fisheries Authority (NFA) in PNG recommended a Small Research and Development Activity (SRA) to transfer knowledge from these two Indonesian projects to PNG to build soil assessment skills in aquaculture officers. Additionally, the SRA would provide an opportunity to scope and develop a larger project that would involve soil assessment, site selection and land capability assessment based on approaches developed in Indonesia but relevant to PNG.

The final review of ACIAR Project FIS/2001/083 (*Inland aquaculture in PNG: improving fingerling supply and fish nutrition for smallholder farms*) identified a need to assist PNG research partners with the publication of research in scientific and industry journals as well as extension materials and research reports. The reviewers recommended a workshop to train the project team in scientific writing and other written modes of communicating research outputs to stakeholders. Skills in publishing are useful for the dissemination of past and future work across all the ACIAR and NFA projects in PNG.

What was achieved?

This project revised and adapted training materials from ACIAR projects in Indonesia to underpin the soils training workshops in PNG. Two class-based and two field-based workshops were conducted in the Eastern Highlands Province (EHP) and Lae. The participants advanced their understanding of soil forming processes, relationships between soils and landforms, the role of soil in pond productivity and the use of soil data in farm management. They also acquired and applied basic skills in soil sampling, the design of soil sampling programs, *in situ* and laboratory-based soil analyses, and data and interpretation. Field-based activities identified several problem soil types that limit pond productivity in established farming areas.

The scientific writing workshop participants increased their understanding of the research process and the steps and methods of communicating research findings through different publication modes. The goal of producing draft manuscripts for submission to scientific journals was not achieved due to limited data analysis undertaken by the participants prior to the workshop. The time required to achieve this goal was under-estimated. However, the participants developed a deeper understanding of the research and publication process, and improved their skills in critical thinking, literature review and scientific writing.

What impacts has the project had or is it likely to have in the future?

The skills gained from the soil assessment training will be applied in a new ACIAR Project commencing in 2010 (FIS/2008/023 - *Increasing production from inland aquaculture in Papua New Guinea for food and income security*). The project team will sample and analyse soils to develop site selection criteria and pond-management practices for inland aquaculture in PNG. The team will also use its skills in a land capability assessment exercise in the Western Province under this project. The NFA and NDAL team members will also apply the soil sampling and assessment skills in other aquaculture projects. NFA indicated it intends to develop a coastal aquaculture project that will utilise the participants' skills in a coastal soil assessment sub-program. The knowledge gained by

the participants has enabled them to identify causes of pond productivity problems and to select appropriate pond management practices.

The scientific writing training, although it did not generate manuscripts for publications under this SRA, has enabled the participants to rethink their approaches to research to ensure that future studies are well-designed from the outset. The participants will continue to work on their draft manuscripts, fill data gaps, re-analyse data and aim to submit their revised manuscripts. This process will be facilitated by the Australian project team from FIS/2008/023.

What future actions might be required?

ACIAR Project FIS/2008/023 will continue to build expertise in soil assessment and scientific writing. Skill gaps, identified under the SRA, will be addressed under the proposed training component. The new project will also investigate soil constraints identified during the SRA field training. Technologies from the Indonesian projects will continue to be adapted and tested for application in PNG.

3 Introduction

Fish farming is a growing industry in PNG and has the potential to provide an important source of protein and income (Government of PNG, 2004; Smith, 2009). Over 80% of the PNG population is unemployed and depends on farming for food (United Nations, 2006). In PNG, protein is often sourced from purchased commodities such as tinned meats and fish, and fresh poultry and imported meat. The cost of these commodities is often beyond the reach of most people in PNG. In PNG, fish are farmed in earthen ponds alongside vegetable gardens. Although fish farming practices are well developed in other countries, the methods are not always suitable in the highlands of PNG due to local environmental constraints and limited access to resources such as feed, fertilisers and technical support. Consequently, the industry is currently based on low-intensity methods that require lesser farm inputs, equipment and infrastructure than practices in Asia. The most commonly farmed species is the GIFT Tilapia which can be grown in small ponds. GIFT Tilapia production depends on abundant phytoplankton and good water quality. The industry in PNG, although evolving and growing, is not meeting targets. Many ponds are unproductive, poorly sited and costly to manage due to environmental factors and practices that don't consider constraints. Species such as trout and common carp are also farmed and depend on properly sited ponds with good soil and water quality to maintain profitable production levels and minimise pond management costs.

The productivity of pond-based aquaculture depends on a suite of environmental factors. Soil is a key factor because it affects chemical and biological processes in the water column and also influences water retention and pond-wall stability. Environmental controls have been rarely considered in the selection of suitable pond locations in PNG. Consequently, many ponds have been constructed in problematic soils and pond yields are low. Pond management costs are high and technical expertise in soil management is currently unavailable. ACIAR Projects FIS/97/22 and FIS/2002/076 in Indonesia developed methods to identify, assess and remediate problem soils for pond-based aquaculture. The projects also developed methods to assess environmental factors to improve site selection, pond design and pond management strategies. The outputs from the Indonesia-based project were identified, by the PNG National Fisheries Authority and ACIAR, as relevant to pond-based farming in PNG. A small research activity was suggested as a way of extending the project outputs from Indonesia to PNG with an emphasis on building skills in soil assessment and management in PNG aquaculture technicians and researchers. Additionally, the project would build the skills for future collaborative projects in PNG and existing and upcoming NFA-coordinated activities. The transfer of the Indonesia-based outputs to PNG was also identified as a priority in the ACIAR PNG Country Consultation in 2008. This SRA was developed in response to this need and priority area, and to support the development of ACIAR Project FIS/2008/023 and maintain the momentum of activity from a former project (FIS/2001/083).

The review team for ACIAR project FIS/2001/083 identified a need to build skills in research reporting through different publication media. Both NFA and ACIAR reinforced the need for a writing workshop to assist project participants with the publication of their research findings and to develop a better understanding of the research publication process for future work. A considerable data set was generated by FIS/2001/083 and linked postgraduate studies, but these data are yet to be fully published and disseminated to stakeholders. This SRA, therefore, included a scientific writing component to generate published outputs from FIS/2001/083 and linked projects, and to strengthen efforts to promulgate research findings from current and new projects.

4 Objectives

The following objectives underpinned the SRA in PNG:

Objective 1: To provide basic training in soil assessment, land evaluation and soil management for field officers and researchers.

Specific objectives:

- **Build theoretical knowledge in basic soil science.** This will involve class-based training in soil processes, physical and chemical properties of soils, soil sampling, in-situ soil assessment, data interpretation (from field data and sample data sets) and data presentation. Basic soil management practices and the principles of pond engineering and pond design. Training in general landscape description.
- **Develop field-based skills in soil assessment** by training staff in soil sampling, soil sample handling, sample preservation, field determination of field pH, soil texture, soil colour, soil structure and profile descriptions.

Objective 2: To facilitate project staff to publish scientific findings in journals and extension materials through a scientific writing workshop.

Specific objectives:

- **Delivery of a scientific writing workshop in Goroka, PNG.** Thirteen PNG staff will participate in a 5-day workshop to learn how to structure a paper, present data and write up a draft manuscript, extension-related publication or technical report.
- **Edit reports and manuscripts for publication.** A selection of no more than 8 participants will reconvene to review manuscripts with Dr Kailola at a follow up workshop. Options for publication will be reviewed with each participant based.

5 Soil Assessment Training

5.1 Soil Theory Training

Materials from FIS/2002/076 and FIS/1997/22 were revised and adapted for the environments, soil types and farming systems in PNG. A soil theory workshop was conducted by A/Prof Jes Sammut in Goroka in April 2009 and in Lae in November 2009. The Goroka workshop focussed on soils of the Highlands region, and the Lae workshop covered coastal and hinterland soils. The workshops included following topics:

- 1) Soil forming processes in the Highlands and coastal areas of PNG;
- 2) Relationships between landscape and soil type;
- 3) The chemical and physical properties of soils and their impacts on pond-based fish farming;
- 4) Soil classification schemes and their application to aquaculture planning;
- 5) Soil sampling methods and the design of soil sampling strategies;
- 6) *In situ* soil measurements and profile description;
- 7) Soil sample handling, storage and preparation for laboratory analyses;
- 8) Soil data interpretation and data display;
- 9) Soil remediation strategies with an emphasis on erosion, acidity, fertility and overall pond preparation techniques; and
- 10) Acid sulfate soils – identification, assessment, impacts, remediation and basic mapping principles

Participants were also trained to use and maintain field equipment provided by the project.

Skills were assessed to determine the level of competency of the participants. All participants achieved the targeted level of competency which enabled them to undertake basic field-based soil sampling and assessment. Further training, under ACIAR Project FIS/2008/023 will build on this basic level of competence so that the team will be able to evaluate a broader range of soil types and soil constraints. The next stage of training will also build their skills in the theory underpinning spatial assessment methods and soil and land capability mapping.

5.2 Field-based training

The project provided NFA and NDAL with soil sampling equipment, field pH/Eh meters, soil pH and Eh probes and Munsell Colour Charts. The equipment will be used under ACIAR Project FIS/2008/023 and NFA's baseline surveys and related field-based projects. NDAL will also use the equipment under their extension program.

Field-based training was conducted in April/May 2009 and November 2009 in Goroka, Aiyura and Lae. Sites in Goroka and Aiyura were used to sample highland soil types that developed from weathering of bedrock and alluvium. The sites in Lae were selected to investigate soils formed by fluvial and tidal processes during the Holocene and to train staff in acid sulfate soil identification.

The project team was trained to:

- 1) Use gouges, Jarret bucket augers and Russian D-Section corers.
- 2) Measure/assess and record soil pH, pH after peroxide oxidation, soil colour, soil structure, soil texture and profile development;
- 3) Prepare samples for storage and preparation for laboratory analysis;
- 4) Code soil samples for identification and data management;
- 5) Identify acid sulfate soils based on field indicators and field-based measurements; and
- 6) Calculate lime and fertiliser requirements based on field and laboratory data

Soil sampling of highland soil types was conducted at privately-owned farms and the Bihute Prison in Goroka, and in the broodstock and growout ponds at HAQDEC, Aiyura. Coastal and hinterland soil types were sampled in Lae, Morobe Province.

The highlands sampling identified highly erodible soils, iron and aluminium rich soils and cracking clays. Farmers reported that productivity in iron and aluminium rich soils (identified by the team) was low. These ponds were also characterised by leakage and inadequate phytoplankton blooms. Soil pHs were generally less than 5. The source of acidity was attributed to iron and aluminium transformations in the disturbed soils, soil leaching processes and parent material characteristics. The low pH and iron and aluminium chemical species are the probable cause of the low phytoplankton blooms due to control of these metals on phosphate availability in the water column (Mustafa and Sammut, 2007). ACIAR Project FIS/2008/023 will investigate this hypothesis as a research activity. Soil cracking in the pond soils at Aiyura can be attributed to the aluminium-induced flocculation of clays (Sammut, 2000). Iron and aluminium processes in the soils also cause soil acidification. The basic soil data collected at these sites were used to discuss possible soil remediation strategies such as liming and fertilising and the integration of soil data into site selection criteria. These field-based activities reinforced the need to consider soil factors in local, pond-based aquaculture. Soil conversation strategies, such as increasing vegetative cover, redesigning ponds and pond layout, were also discussed.



Figure 1: Soil sampling at A1 trout Farm, Goroka. The team members gained skills in selecting and using different soil sampling equipment for various soil types.



Figure 2: Workshop participants assessing soils at the Bihute Prison aquaculture ponds in Goroka, May 2009. The participants learned to extract soil cores and perform field tests on the physical and chemical properties of soil.

6 Scientific Writing Training

Two scientific writing workshops were originally planned. The main objectives of the first workshop were to train participants in the principles of scientific writing, review draft manuscripts and data, and to provide direction so that manuscripts could be redrafted for a future workshop. Less than half the participants provided a draft manuscript and a review of the work suggested that further development of the manuscripts and additional data analyses were required before a second workshop could be undertaken. This could not be achieved within the timeframe of the SRA. A decision was made to carry over the development of the manuscripts to ACIAR Project FIS/2008/023 to give the participants sufficient time to improve their drafts and complete additional data collection and analysis.

Participants are or were involved in the following fisheries projects in PNG:

- FIS/2001/083 Inland aquaculture in PNG: improving fingerling supply and fish nutrition for smallholder farms
- FIS/2004/065 Culture of promising indigenous fish species and bioremediation for barramundi aquaculture in northern Australia and PNG.
- FIS/2006/138 Developing aquaculture based livelihoods in the Pacific Islands region and tropical Australia

The core training was provided by Dr Patricia Kailola with assistance from Cathy Hair, Jacob Wani and A/Prof Jesmond Sammut. The training topics covered:

- **Principles of science writing** - the purpose of publishing, the importance of rigour, identifying a target audience, reproducibility of the research, producing original work and adding to knowledge base
- **Structure of reports and scientific papers** – order and placement of information, level of information, differences between report and paper structure, and logical flow of information
- **Writing an abstract, introduction, methods, results and discussion** – what is included, level of detail, following author guidelines and concise presentation of information
- **Citations and referencing** – referencing styles, avoiding plagiarism, referencing unpublished and secondary sources, acknowledging sources and intellectual contributions
- **Presentation of figures and tables** – selecting appropriate graph styles, level of detail and scale of figures, tabulation and captions
- **Grammar** – expression, basic grammar, writing clearly
- **Vocabulary** – increasing word power, proper usage, avoiding common errors with usage
- **Critical thinking** – critically evaluating past studies, placing work in context,
- **Literature review** – integration of other work into manuscripts, finding past studies, interpreting the work of others, targeting literature searches, locating relevant literature

Several training methods were used:

1. The first two days were dedicated to systematically working through the components of a paper and developing the participants' appreciation of the purpose of scientific writing. Different publishing formats were compared to help

participants understand the level of information, and the type of structure and approach used for journal articles, theses, reports and extension materials;

2. Examples of research papers and reports were used to discuss writing style, structure, data presentation and referencing, and to reinforce key points raised in the overview topics. Participants reviewed examples of published work to improve their critical thinking skills and their understanding of scientific writing;
3. Participants were asked to prepare presentations based on their own work. Group discussion was used to evaluate and critique the participants' material, and to recommend actions to improve the content, style and structure of the manuscripts; and
4. Focus groups and one-on-one discussion were used for more targeted assistance.

Despite the lack of fully-developed manuscripts, the workshop was still very worthwhile and had positive outcomes. The participants developed a greater appreciation of the importance of experimental design, and have a clearer understanding of scientific standards. All participants agreed that the next project should include more capacity building activities in the early stages with an emphasis on experimental design and statistical analyses. The participants also identified a need for training in data collection methods and research project management.

Course feedback

Feedback was collected through a structure questionnaire and a discussion session. The participants felt the workshop was very worthwhile but all commented that it should have been conducted in the early phases of the previous project and preceded by a workshop or training activity that addressed experimental design and data analysis. The participants indicated that the workshop had enabled them to critically evaluate their approach to research and identify skill and knowledge gaps that need to be addressed for future research.



Figure 3: Workshops participants at Goroka, Eastern Highlands Province, April 2009.



Figure 3: Dr Patricia Kailola tutoring Joe Alois and Douglas Kawa at the Scientific Writing Workshop, Goroka, April 2009 (Photo courtesy of Dr Kailola).

7 Conclusions and recommendations

7.1 Conclusions

The PNG participants demonstrated an understanding of basic soil theory which will be developed further under FIS/2008/023. The training activities in EHP and Morobe Province identified a number of problematic soil types that were previously unknown to the local aquaculture industry. These soils will be evaluated further under FIS/2008/023 to include their limitations in site selection criteria and to develop remediation strategies for existing ponds. The training activities confirmed the need to address soils as a limiting factor for pond-based aquaculture in PNG, and the participants demonstrated that they are able to learn and apply soil sampling and assessment methods. Further training under FIS/2008/023 is likely to advance their skills and lead to greater scientific, environmental and community impacts.

Although the scientific writing workshop participants were unable to submit manuscripts for publication, the process of developing their materials will be adopted by FIS/2008/023. The workshop did, however, raise their understanding of the scientific publishing process and the need for well-designed research, and also motivated them to reevaluate their materials and data needs to meet the goal of publishing.

7.2 Recommendations

Participants from the project will form the core team for ACIAR Project FIS/2008/023. The new project will continue to develop and apply their skills in soil sampling and assessment. The training will also focus on research methods to underpin studies on broodstock management, fingerling production, fish nutrition and the development of husbandry packages.

Partnership with the University of Technology (UniTech) in Lae will strengthen the soil assessment capacity of the PNG research team participating in FIS/2008/023. UniTech staff will co-teach soil assessment with UNSW staff. Similarly, collaboration with Gadjah Mada University, Indonesia, will benefit training in site assessment and spatial data analyses.

The scientific writing workshop identified a need to mentor and train researchers and technicians to design experiments, improve data collection and analysis, and to publish their work. ACIAR Project FIS/2008/023 and its linked projects will address this need through further research training and coordination of the publication process.

The new project will expand the training program to:

- 1) Cover more soil types representative of conditions in the highlands and coastal areas of PNG
- 2) Develop a stronger understanding of the relationship between soil type and landscape evolution
- 3) Develop site selection criteria and land classification schemes for pond-based aquaculture

- 4) Build skills in GIS and other approaches to spatial modelling
- 5) Develop skills in measuring soil and water quality and interpreting chemical and physical data
- 6) Improve skills in research design, data collection (production and environmental data) and analysis including statistical methods
- 7) Ensure that the findings of past and present projects are communicated through research, technical and farmer-level publications
- 8) Improve the skills of participants in research management
- 9) Utilise soil and water quality data in pond management strategies
- 10) Underpin mapping strategies in Western Province and to scope opportunities to extend soil and site capability mapping in other areas.

ACIAR Project FIS/2008/023 will be launched in August 2010 and end in December 2013.

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