Responding to climate change using an adaptation pathways and decision-making approach

(Formerly: Building capacity to assess vulnerability and adapt to climate change in the Coral Triangle of the Pacific)

A component of project ADB/GEF project R-CDTA 7753: Strengthening Coastal and Marine Resources Management in the Coral Triangle of the Pacific (Phase 2)

Mid-term report

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Contact details:

For further details about this report, please contact the principal author, Dr Sarah Park (s.park@cgiar.org).

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Contents

1 Executive Summary

This mid-term project report is aimed at summarizing progress to date relating to the 'Responding to climate change using an adaptation pathways and decision-making approach' project, and specifically on the four following aims:

a) Detailing the development, application and evaluation of a method for enhancing the capacity of communities to undertake adaptations to their livelihoods in response to drivers of change, including a long-term change in climate;
b) Providing community perspectives on the impacts of a changing climate on farming and fishing activities in two sub-regions in Timor-Leste, together with appropriate adaptation responses;
c) Providing the findings of empirical analyses of a number of adaptation options in the context of the two locations, from an economic, social and environmental perspective;
d) Providing recommendations for progressing the implementation and iterative management of adaptation efforts via an adaptation pathways and decision-making approach.

In this report, details on the progress made to date have been structured in terms of: (a) project management, and (b) the technical aspects of the project team's actions in developing and applying a method for facilitating communities to develop and plan the implementation of adaptation actions in response to climate change. The report has been written in discrete sections to enable readers to easily locate specific components of interest. For example, the current status of project management is contained in Section 1, whereas the technical aspects of the study are documented in Sections 2, 3 and 4. Those readers wishing to focus on the scientific aspects of the project may therefore consider skipping Section 1, and reading from Section 2 onwards, and vice-versa. Similarly, those interested in a specific analysis can find details of the method, its application to locations in Timor-Leste, results and conclusions to date, all contained in one section of the report.

In addition, each section relating to the application of the framework being developed in this project to Timor-Leste, is headed with a summary box. This summary provides an overview of the activity being reported, the aim, or key question being addressed; brief details of the method used in the analysis, and the key results. The information in these summary boxes provides findings to date, and in many sections analysis is still on-going. This report structure has also been adopted to facilitate the future production of a series of brochures (each detailing one section of the report), aimed at disseminating the findings to communities in an accessible manner. The Executive Summary has been extended beyond the usual couple of pages, to provide a comprehensive summary for those readers wishing to gain an overview of the project activities without necessarily reading the remainder of the report.

Details of the current status of project management include an overview of the Activity Plan (Tech 1, Appendix 1) and how the project is tracking against milestones and deliverables (Section 1.1); a report of finances and consultant inputs as of 10 December 2012 (Section 1.2), and a summary of partner engagements and dissemination of results undertaken from May to December 2012 (Section 1.3). At this time, the project is operating ahead of schedule

and is within budget. We anticipate a slight overspend in 2013 on budget category description 1182 (Miscellaneous Travel Expenses). However, this is likely to be offset by an anticipated similar value underspend on category description 1400 (studies, surveys and reports).

In terms of the technical aspects of this report, we firstly, briefly review the theoretical underpinning of the method, (referred to as a framework), being developed in this project (Section 3.1). The activities in the framework have been collated to reflect the perception of adaptation as a dynamic and on-going pathway of change that is navigated by decision-making and iterative management. To reflect this, we have identified key questions that we are seeking to address as we work with communities through the four action phases of the framework, and the methods we will use to answer these through participatory action research.

The decision-making approach adopted in this study is being taken in response to growing global recognition that assessments of vulnerability, impact and adaptation commonly fail to consider the selection of specific adaptations and planning for implementation, and hence offer little support to communities in taking adaptive actions. In Section 3.2 of this report we detail results from a review of peer-reviewed studies of climate change vulnerability assessment that have been conducted for the five focal countries (i.e. Timor-Leste, Papua New Guinea, Solomon Islands, Vanuatu and Fiji). We found a similar lack of consideration for implementation is also prevalent across the Pacific.

Application of the framework to Timor-Leste

Section 4 documents our application of the framework to the communities around Batugade and Atauro in Timor-Leste. At this time, we have undertaken scoping of the livelihood activities and broader livelihood systems of these coastal communities, and identified from secondary information the key issues relating to natural resources assets and their management, and the interactions between livelihood activities and past trends in climate. The most significant finding from this scoping analysis is that the dry season in Timor-Leste has been progressively occurring earlier in the year over the past six decades (see Section 4.2.1). Identifying such trends in observed climate data has been shown to be useful in motivating affected actors to adapt (PROVIA 2012). Indeed, this finding generated much interest and discussion when it was presented at the workshops held with community members in Batugade and Atauro. The trend for an increasingly earlier dry season resonated with the community members' experiences over the past years and they told of how they had noted a gradual creeping forward in time of significant farming and fishing activities, such as planting dates. The convergence of knowledge domains, i.e. from the scientific analysis of climate data and the highly context-specific experiences of the community members, was a valuable step in the project team building credibility with the communities, and a respectful working relationship. Discussion of this analysis also provided a useful framing for the participants to consider on-going future changes in the climate, and provided a useful link to discussing climate change projections obtained from global climate models.

Further details of the community workshops conducted in Batugade and Atauro are provided in Section 4.3. The same format for the workshops was used in both locations, with the overall structure aiming to introduce community members to not only the issue of climate

change and projections for the future, but importantly, to facilitate community members in considering what these changes may mean for their livelihoods. These first workshops were attended by a total of at least 64 community members over the two days, with nearly one third of the attendees being women. At the workshops 28 and 46 impacts were identified for farming and fishing activities in Atauro and Batugade, respectively, and some 41 and 49 related adaptation actions. The adaptation actions identified by the community were categorized into broad themes. For both locations, the underpinning themes relate broadly to improving the resilience of the natural resource base that underpins fishing and farming activities, through:

(i) reducing the level of exploitation of a resource (e.g. by either regulating access to fisheries or enabling access to alternative fisheries such as a presently under-utilised pelagic fishery or the introduction of aquaculture production);

(ii) enhancing the buffering capacity of a resource (e.g. practicing a suite of sustainable agriculture practices, including composting, mulching, integrated animal and crop production, and contour terracing, to enhance soil nutrient status, stability and water infiltration);

(iii) increasing access to a limited resource to enable more sustainable practices to be adopted (e.g. year round access to stored water to promote continuous ground cover to minimize soil erosion).

As such, the adaptation actions and strategies identified by the communities offer broad benefits to the sustainability of livelihoods and increased food security, regardless of uncertainty in climate change projections.

Whilst in the workshop we separated farmers and fishers into different focus groups to determine impacts and adaptations, it is clear that members of the Atauro and Batugade coastal communities practice a mix of activities relating to both of these occupations. Indeed, switching between fishing and farming is a common coping strategy employed in response to a highly variable climate. Switching between occupations also featured in a number of the adaptations suggested by the community members.

Although a small activity in the two-day workshop, drawings produced by youths of their desired community in the future provided a shared understanding of the goal of undertaking adaptation actions (see Sections 4.3.5 and 4.3.6). There is growing recognition of the usefulness of tools, such as visioning (and decision-tree analysis, as detailed in Section 4.4), in building consensus amongst community members, particularly where public adaptation decisions are to be made. Indeed, the inability to agree upon common goals can be a significant barrier to selecting adaptation options (Moser and Ekstrom, 2010).

Evaluation of selected adaptation options

The third activity phase of the framework being developed in this study relates to evaluating adaptation actions from an economic, social and environmental perspective. The aim of these evaluations is to provide the community members with information that will inform their decision-making about the selection of an adaptation action and developing plans for implementation. As the communities identified approximately 90 adaptation options, we have worked with them to identify which adaptation themes they are specifically interested in finding out more information on.

The members of the WorldFish project team were purposely assembled to include technical knowledge and skills spanning the economic, social and environmental disciplines, thus providing a pool of expertise from which to develop a suite of relevant and effective evaluation analyses. The selection of evaluation methods by the project team has been guided by the need for the evaluations to provide relevant information to inform decision-making by the community members in selecting and implementing adaptation actions.

As secondary aims, the evaluation methods have been selected with a focus on rapid data collection techniques, and the inclusion of community members and in-country partners in data collection and analysis to promote capacity building. A key outcome to date from the pilot study in Timor-Leste relates to efforts by the project team to enhance capacity in government and NGO personnel in respect to knowledge about climate change and building skills in applying this framework, and more specifically undertaking specific activities and analyses within them, independent of this study. To this end, national and sub-regional government staff and in-country NGO members have been engaged in planning and executing the workshops and subsequent data collection for the evaluation analyses.

Evaluation from an economic perspective

Decision-tree analysis was used to facilitate community members to identify a range of different designs for selected adaptations (Section 4.4). As mentioned above for the visioning exercise, decision-tree analysis can similarly be useful for building consensus amongst community members on what the adaptation should look like. Similar to other studies (Moser and Ekstrom, 2010), we also found it to be useful for identifying the sequence of events and the levels of governance needed to facilitate implementation. Each of the designs identified for an adaptation strategy was subjected to partial cost-benefit analysis. Section 4.4 also provides the costings produced during these assessments, which can be used to enable an economic comparison of the different computations (or designs) of an adaptation action.

Evaluation from a social perspective

Social evaluation has been conducted from the perspective of identifying the capacity of the governance and institutional environment to support farmers and fishers to adapt. Governance has been increasingly highlighted as a key factor in the planning, implementation and ultimate success of development interventions and has received attention at the global and nation state scale, resulting in a wide range of approaches being used to conceptualize governance (Pahl-Wostl 2009, ODI 2006).

The approach taken in this study recognizes the distinct differences in governance operating at the local community, sub-district/district and national scales. It also recognizes the importance of effective governance to support not only adaptation initiatives being implemented today, but also the capacity for the governance context to evolve and support a longer-term pathway of adaptation into the future. We therefore consider governance issues relevant to the efforts of farmers and fishers to adapt, from both temporal and spatial dimensions.

Three methods of evaluating governance have been used in this study, namely social network analysis, a survey of governance and institutional effectiveness, and a more formal governance capacity assessment. The different methods offer perspectives of governance

capacity from the local authority level, the community level, and sub-national to national level, respectively, and span current to longer term considerations.

Section 4.5 shows how social network analysis has provided a mapping of how flows of information, support (i.e. financial, physical and service-related) and pathways for problem solving currently operate between key actors in the fishing and farming communities. This baseline understanding of social networks was produced in collaboration with local authority decision-makers (i.e. key decision-makers at the community and sub-regional level, selected by in-country partners). This local authority perspective is valuable in assessing the capacity of the current networks to support specific adaptations and identify additional actors that may need to be included for adaptation actions to be successfully implemented and iteratively managed into the future.

The short, ten-question survey of governance and institution effectiveness conducted at community level is detailed in Section 4.6, and provides a snapshot of how farmers and fishers perceive the effectiveness of sub-national and national level ministries and NGOs in supporting their livelihood activities. Although this was a short and limited survey, its results show a current need for farmers and fishers in Atauro and Batugade to be better supported in terms of extension services and community level development activities. Similar to the network analysis, the survey highlighted the pivotal role that Suco Chiefs play in supporting the development of fishing and farming livelihoods.

The third social assessment conducted focused on assessing the current governance context (formal and informal) in which farmers and fishers operate, and considering what actions would best support the development of long-term capacity to reduce community vulnerability (particularly in respect to managing the natural resource base underpinning fishing and farming livelihood) (Section 4.7). This assessment draws on a range of primary and secondary information, including interviews with selected national, regional and community level stakeholders.

This assessment concludes that there is presently a relative governance vacuum at the level of National and District government, due largely to inadequate budgets, human resourcing, capacity, and communications and logistics. This means that extension functions do not provide much capacity or support to rural fishers and farmers. The planned transition towards decentralization and the creation of new municipal structures and the phasing out of the district/sub-district model, offers an opportunity to address this. The assessment also concludes that governance at the aldeia and suco level has considerable legitimacy, and supporting decision-making at this scale is key to community adaptation.

Evaluation from an environmental perspective

The adaptations identified by the community members for farming livelihoods focus on concerns for declining productivity and the need for: i) more sustainable farming practices, ii) improved management of pest insects and crop diseases, iii) an increase and maintenance of soil fertility and reduction in soil erosion, and iv) the need to capture, store and deliver water to crops and animals in the dry season. Section 4.8 details the use of Landscape Function Analysis (LFA) to provide a baseline of the current status of the natural resource base underpinning agricultural production and identify a range of simple management actions for increasing the sustainability of agricultural production systems. The actions aim to

mimic the ‘native vegetation-like’ aspects of tropical gardens to promote resistance and resilience to shocks and degradation. The analysis shows how these actions may positively impact various aspects of soil function and thereby promote increased and prolonged productivity.

Considering the effectiveness of adaptations at a landscape/seascape scale is necessary to avoid negative environmental outcomes (i.e. maladaptation) occurring where there is some form of landscape connectivity between communities. Whilst not yet complete, the pilot GIS-based ecosystem service assessment planned for Atauro seeks to determine the environmental impacts of adaptation actions at the landscape/seascape scale and how this may be expressed by changes to ecosystem service provision. Section 4.9 details the marine and coastal natural assets and the ecosystem services they provide for communities in Atauro, current status of these ecosystem services, and how these are likely to change as a result of implementing specific adaptation strategies. We detail some of the data already collected on ecosystem assets in Atauro and some of the preliminary mapping results. Further outputs will be reported in early 2013.

Planning implementation

Section 5 details the activities to be completed in Timor-Leste during the fourth and final activity phase of the framework, namely the engagement of the community in an evaluation of the material produced with them; evaluation of the adaptation actions using multiple (economic, social and environmental) criteria, and the identification of thresholds of action for determining when adaptation actions may need to be implemented. The aim of these final activities is to further progress communities towards the construction of a plan for implementing selected adaptation actions through informed decision-making. Beyond this final engagement activity, the communities of Timor-Leste will still need to undertake additional activities, such as obtaining support for funding selected adaptation actions, acquiring knowledge and skills training, and strengthening governance structures to support implementation and on-going adaptive management of adaptation activities. The care that we have taken as a project team in selecting evaluation methods aimed specifically at answering key questions regarding the adaptations, is intended to help inform where and how communities traverse these additional activities ahead of them.

Discussions with in-country partners in Timor-Leste have identified a number of options for disseminating the findings from this study to community, local authority, sub-national and national level officers concerned with adaptation to climate change. At the community level, we plan to produce a series of four-sided leaflets, each containing details of a single activity from the framework as it has been applied in Atauro and Batugade. These will be supplemented with a leaflet that provides an overview of the framework, to provide a comprehensive source of information for communities to access.

Proposals for the extension of this project

At this time in the project, we report on nine of the ten analyses proposed for Timor-Leste. Individually these analyses address specific questions that may inform decision-making by community members, local authorities, supporting NGOs and national departments relating to climate change, natural resource management and ministries of agriculture and fisheries. Although not specifically planned and budgeted for in the original project plan, there is

potentially extensive additional value to be gained from investing further resources in considering how we may integrate these individual analyses more closely to provide a more holistic and multi-faceted approach to adaptation in Timor-Leste, and specifically in the communities of Batugade and Atauro. This synthesis and integration activity would clearly benefit from the participation of those in-country partners who occupy prominent decision-making positions in government, NGOs and the community. In light of the request by Simon Tiller, ANZDEC at the ADB two-day workshop held in Manila in September 2012, for Project Leaders to consider submitting ideas for additional research to supplement the current suite of projects, we offer a proposal relating to this proposed activity. The proposal (Section 5.6) provides details of how the project team members and in-country partners could workshop the nine analyses conducted to date to identify their points of integration and applicability to on-going, in-country, climate change and natural resource management activities.

In addition to this integration activity, we have also identified three further opportunities for expanding knowledge of coastal livelihoods in Timor-Leste and enhancing resilience to climate change. The proposals relate to: (i) better understanding the ecosystem services that underpin livelihoods in Timor-Leste; (ii) exploring the relationships between historic temperature and rainfall patterns in Timor-Leste and the Southern Oscillation Index (SOI) in the context of agricultural production, and (iii) better understanding the range of socio-economic conditions that are likely to influence the capacity of coastal community members to transform from their present livelihood activities, to alternatives such as aquaculture. These are also detailed in Section 5.6.

3 Framework for developing a plan for implementing adaptation actions in response to climate change

3.1 Overview of framework

The framework being developed in this project is based on the perception of adaptation to climate change as a dynamic and on-going pathway that is navigated by decision-making and iterative management. The theoretical underpinning of this perspective is detailed in the Inception Report submitted to ADB in May 2012 (Park et al., 2012a). The development of the framework has progressed over the past six months in terms of firstly, identifying the key questions that we are seeking to answer (Figure 1). These questions have been considered in terms of the following four activity phases and seek to capture the kinds of decisions that stakeholders will need to make to respond to climate change:

a. the scoping of information required about the target communities and their livelihood activities and broader production system,
b. the identification of impacts of key drivers of change (and in particular climate) and appropriate adaptation actions,
c. the evaluation of selected adaptation actions, and
d. the synthesis of all the material produced to inform an implementation plan.

We have then identified the specific methods that we will use in the initial piloting of the framework to the Timor-Leste case study (Figure 2).

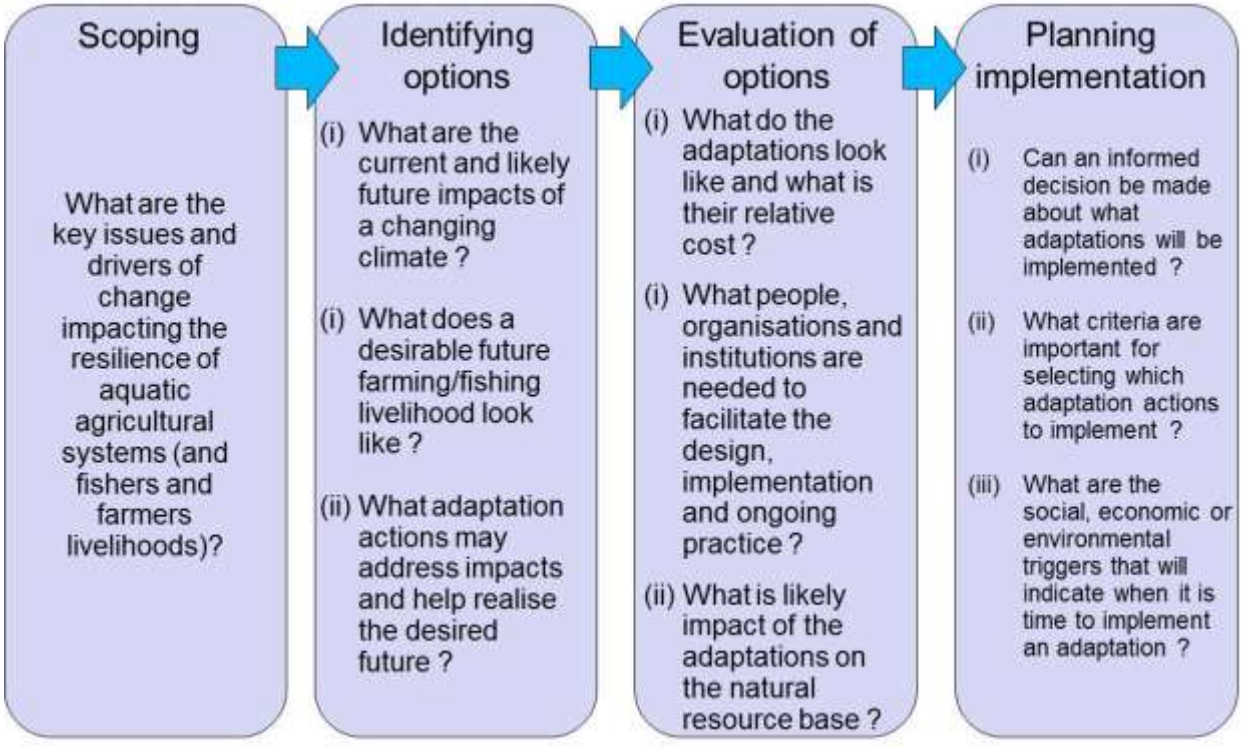

Figure 1 Framework containing questions.

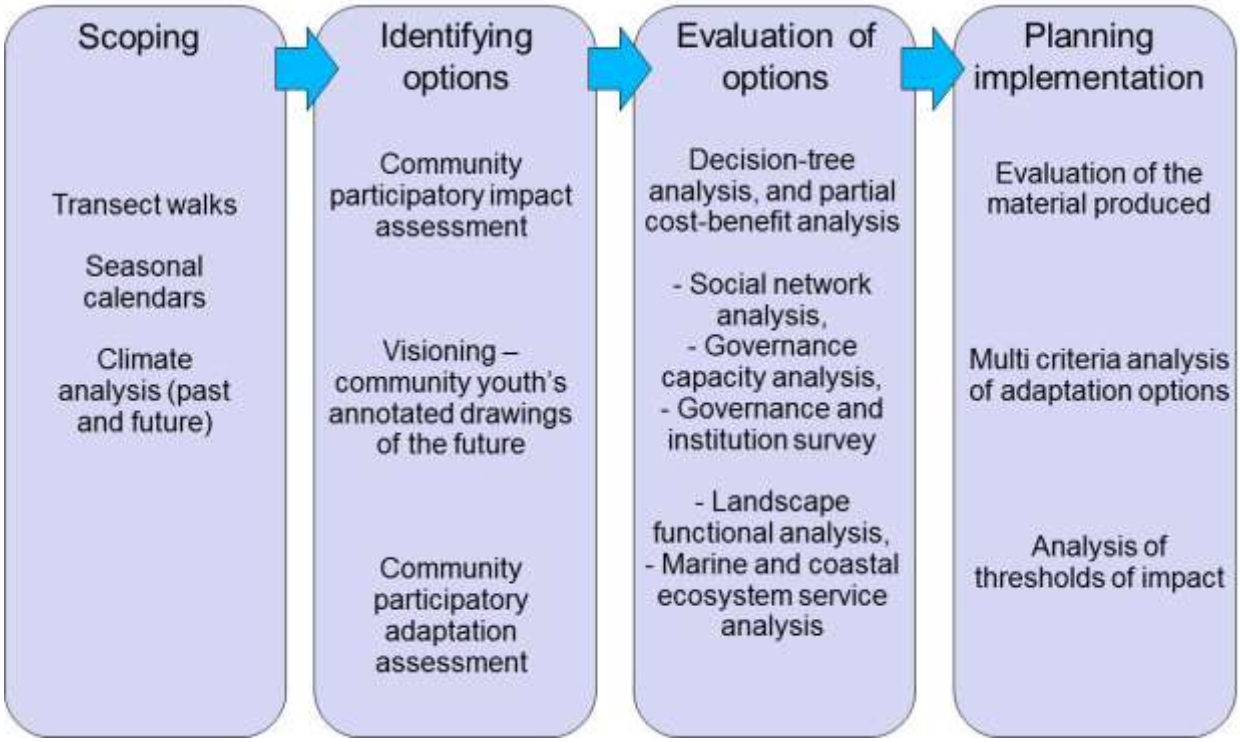

Figure 2 Framework with selected methods.

The activities included in the four activity phases, the aims of each activity and the proposed outputs can be seen in Table 1, Table 2, and Table 3.

Table 1 Activities being undertaken in the Scoping and Identifying Options activity phases of the adaptation framework.

Activity	Aim of activity	Proposed outputs
Secondary data collection from a range of activities identified through literature searches and interviews with in-country partners.	Identify and understand: (a) livelihood strategies and specific activities relating to fishing and farming in target communities; (b) important issues and threats to livelihoods, particularly in relation to the management of natural resources and climate change (including projections of climate change)	Inventory of: (a) fishing and farming livelihood strategies and specific activities undertaken; (b) natural resource issues and key drivers of change (including projections of climate change).
Stakeholder analysis.	Identify key stakeholders at community, regional and national scales to engage and/or participate in the action research activities.	List of decision-makers needing to be engaged in community workshops, data collection and dissemination of outputs.
Analysis of historic climate data for the region.	Determine if a trend can be observed in historic climate data that is likely to influence fishing and farming activities	Statistical trends in climate variables relevant to farming and fishing activities.
Community engagement workshop including: (a) impact assessment; (b) visioning of desired future community; (c) adaptation assessment.	Gain community (gendered where possible) perspectives on: (a) the likely impacts on farming and fishing activities of the projections for a change in temperature, rainfall and sea level, and a continuation of trends in historic rainfall and temperature; (b) pictures of desirable futures for communities, particularly in respect to natural resource assets and their use; (c) specific adaptation actions that may address the likely impacts of climate change and help realise the desirable future community.	Inventory of impacts of a changing climate on farming and fishing activities and associated adaptation actions; A selection of adaptation actions that the community would like evaluated from an economic, social and environmental perspective; Pictures of the desired future of communities.

Table 2 Activities being undertaken in the Evaluation of Options activity phase of the adaptation framework.

Activity	Aim of activity	Proposed outputs
Decision tree analysis and partial cost-benefit analysis	Understand: (a) the key decisions and design steps that need to be taken in order to progress an idea for adaption through to its implementation; (b) given a range of possible designs for an adaptation strategy (produced above), estimate the relative partial costs and benefits.	Decision trees for selected adaptation themes Estimates of the costs and benefits for a range of adaptation designs
Social network analysis	(a) Produce baseline social networks by identifying key actors that influence the capacity of a farmer's/fisher's capacity to produce food for consumption and cash sales. (b) Understand the links that exist between the farmers/fishers and other actors in the network in terms of the flow of information, physical support (e.g. equipment), financial support (cash and loans), and services (e.g. training, marketing). (c) Identify what additional actors may need to be included in the baseline network if a specific adaptation strategy is to be successfully implemented and iteratively managed.	Network maps for fishing and farming activities, detailing flows of information, support and problem solving services, together with details of actors (including their influence and power over fishing and farming decision-making and activities).
Governance and institutional effectiveness survey	Understand community perspectives on the extent and nature of interactions between farmers/fishers and (i) representatives of national level ministries of farming and fishing, and (ii) NGOs, that are aimed at supporting rural livelihoods.	Primary qualitative and quantitative data on community-level perspectives on the current effectiveness of national level ministries and NGO's to support fishing and farming activities.
Governance capacity assessment	Understand the current capacity of the formal and informal governance and institutional environment in which farmers and fishers operate to support their need to adapt.	Analysis of governance capacity at a community, sub-national and national scale
Landscape function analysis	(a) Understand the current status of the natural resources underpinning agricultural production; (b) identify a range of simple management options that communities can use to increase the sustainability of their farming systems; (c) hypothesize how function may change as a result of implementing adaptation actions.	Baseline assessment of the key natural resources underpinning farming livelihoods; Recommendations for sustainable agriculture activities to enhance production and improve the condition of the natural resource base.
Ecosystem service assessment using InVEST modelling software.	Understand: (a) what marine and coastal natural assets provide ecosystem services for the communities, (b) the current status of the ecosystem services provided and how these may change as a result of implementing specific adaptation actions	Spatial maps of ecosystem assets and an assessment of their status, the services they provide presently, and how these may change as a result of adaptations.

Table 3 Activities being undertaken in the Planning Implementation activity phase of the adaptation framework.

Activity	Aim of activity	Proposed outputs
Monitoring and evaluation	Facilitate communities in evaluating the material produced in terms of its potential to inform decision making about planning and implementing adaptation actions	Feedback from community members on how the material produced meets their needs to make decisions about adaptation planning and implementation.
Threshold analysis	Facilitate communities in identifying when adaptations will need to be implemented	Key thresholds of action for specific adaptation actions.

We can relate the above framework and activities back to the theoretical underpinning proposed in the Inception report, (i.e. the perception of adaptation to climate change as a dynamic and on-going pathway that is navigated by decision-making and iterative management), and more specifically to the Action Adaptation Cycle (Park et al., 2011). The activity phases in the framework being developed in this ADB/GEF funded project, seek to progress stakeholders through problem structuring and establishing the adaptation arena, and through the development of the adaptation agenda, vision and pathway, as depicted in the Action Adaptation Cycle. The scope of this project does not extend to implementing adaptation actions, but seeks to facilitate stakeholders in moving towards this stage.

3.2 Literature review for five target countries (Activity Plan: activity 2.1)

The Web of Science and Scopus databases were used to conduct a search of peer-reviewed published literature up to April 2012 using the search term: "climate change" + “vulnerability” + "country name" (where the five focal countries were used in place of “country name”). An interpretive review was carried out on the identified literature. The review was specifically designed to not only provide an overview of methods used to assess vulnerability to climate change and their findings, but also to infer the extent to which past studies have likely supported the implementation of adaptation actions and strategies in response to climate change. In order to collate a strategic sample of literature for the interpretive review a search was performed using the two major databases and the terms ‘climate change’, ‘vulnerability’, ‘Pacific’, and the five country names. Then, some additional documents were found, and a general search was conducted for grey literature.

Each document was evaluated in terms of the extent to which they considered or undertook activities relating to the assessment of vulnerability to climate change, identification of adaptation strategies, implementation of adaptation actions, and evaluation of the outcomes from adaptations. Each paper is also evaluated for characteristics considered important for promoting ‘effective’ adaptation.

The interpretive review specifically focused on the following issues:

a. The stage in the adaptation action cycle that is focused upon—this is relevant in terms of understanding the extent to which a study can progress decision-makers along a dynamic adaptation pathway based on the iterative management of adaptation actions;

b. The extent to which the vulnerability assessment was evaluated, either by the practitioners or the target stakeholders, in terms of effectiveness, accuracy or utility of the information produced—this is important in terms of understanding the level of confidence that can be attributed to the results;
c. To what extent governance is considered in the context of adaptation actions and their implementation—this relevant in terms of understanding the potential for effective implementation, uptake and sustained use of an adaptation action;

NB: This literature review was conducted in April 2012. Since this date a number of additional assessments of vulnerability to climate change have been published. Whilst not included in the review below, these publications will be included in further analysis (where appropriate) in this project.

3.2.1 Results

Forty-three publications were found in a literature review undertaken up to April 2012. A summary of the availability and scope of the literature for each of the five target countries is shown in Table 4. A complete list of literature is included in Appendix 4.

Table 4 Summary of the availability and scope of literature found in a review undertaken up to April 2012

Country	Availability and scope of literature
Timor-Leste	• Few publications available • NAPA has been produced • Some adaptation planning is documented, but no documentation of adaptation actions being undertaken, monitored or evaluated
Fiji	• Fiji is the focus of the majority of literature produced for the five target countries • Documented consideration of vulnerability assessments and adaptation planning activities, that has subsequently been used to refine adaptation actions • Most of the literature discussing adaptation is on focused on sectors, and in particular the tourist industry
PNG	• Limited literature is available • No published vulnerability assessments found • No NAPA has been produced
Solomon Islands	• Documentation of vulnerability assessment and adaptation planning resulting from NAPA • Comprehensive literature on community-level vulnerability and adaptation and human development • Some critical reflection on adaptation and implementation has been documented
Vanuatu	• Limited literature is available • NAPA has been produced • Most of the literature discussing adaptation is on focused on sectors, and in particular the tourist industry

The stage in the adaptation action cycle that is focused upon

Figure 3 shows the extent to which the assessments of vulnerability to climate change progressed stakeholders along a pathway of iterative management of climate change

adaptation. The arrows depict the most extensive study for a country, and it is notable in the literature that few studies extended beyond assessing vulnerability and producing suggested adaptation options.

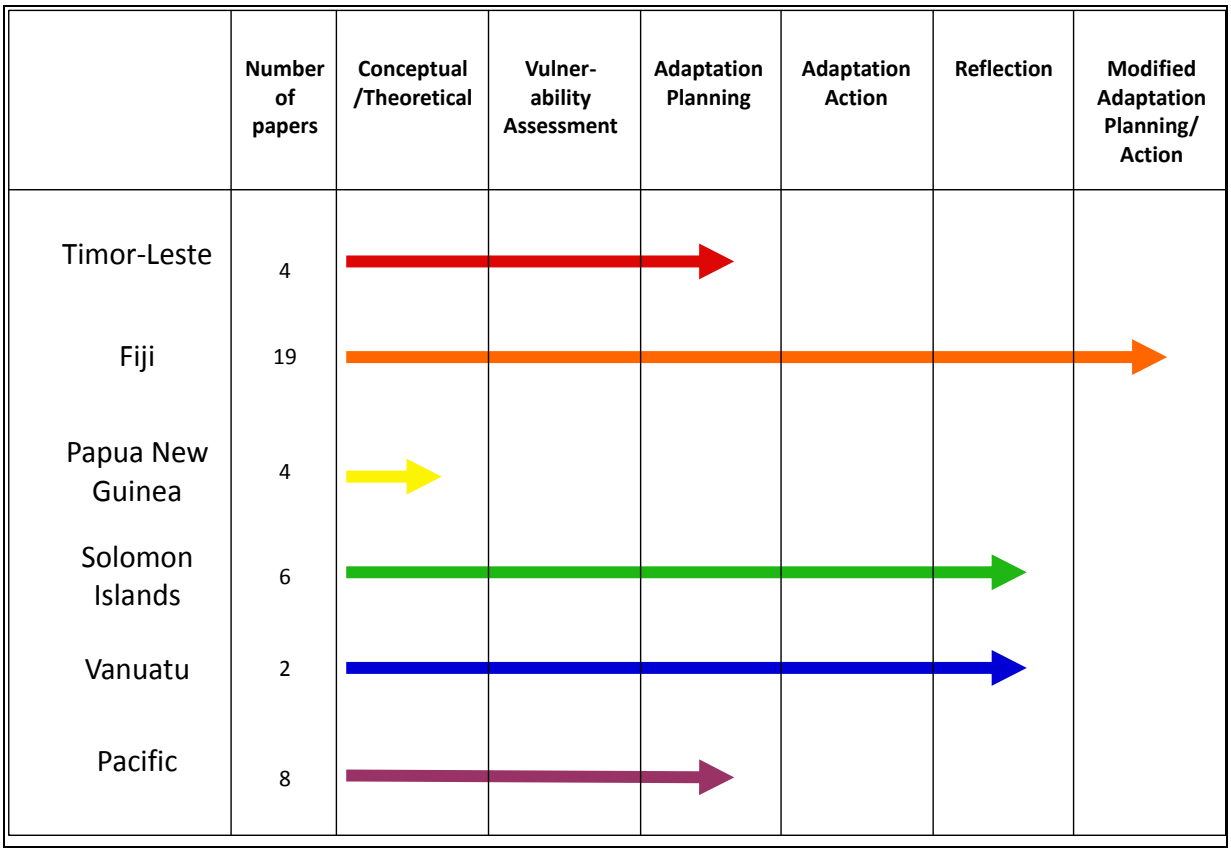

Figure 3 Maximum extent that an assessment of vulnerability has taken towards implementing and reviewing adaptation actions.

The extent to which the vulnerability assessment was evaluated in terms of effectiveness, accuracy or utility of the information produced

In the literature identified, critical reflection and review of adaptation actions that have been implemented by stakeholders only exists for two studies. These relate to climate change adaptation actions taken in respect to the tourist sector. It would appear that few studies of vulnerability adopt a perspective of adaptation that seeks to promote adaptation as a dynamic and on-going pathway that is traversed through iterative management.

The extent to which governance is considered in the context of adaptation actions and their implementation

From the analysis below, we can see that the majority of literature in climate change vulnerability and adaptation in the Western Pacific does not incorporate a robust conceptualization and analysis of governance. Notably, the majority of literature from PNG does not consider governance in terms of enabling adaptation. Some papers from the

Solomon Islands and Fiji cover this topic considerably more extensively (Gero et al. 2010; Fazey et al. 2010; Fazey et al. 2011; Schwarz et al. 2011; Agarawala et al. 2003), and can be used as a model to build upon in future work. As discussed in the Executive Summary at the beginning of this report, Governance has been increasingly highlighted as a key factor in the planning, implementation and ultimate success of development interventions.

Defines and analyzes formal and informal governance:

1. Gero et al. 2010 (Fiji)
2. Fazey et al. 2010 (SI)
3. Fazey et al. 2011 (SI)
4. Schwarz et al. 2011 (SI)
5. Agarawala et al. 2003 (Fiji)

No in-depth analysis or conceptualization, but emphasis on including various stakeholders in adaptation planning:

1. GEF 2007 (TL)
2. Barnett et al. 2007 (TL)
3. UNFCCC 2007 (Pacific)
4. NAPA 2008 (Sols)
5. NAPA (Vanuatu)
6. Barnett et al. 2003 (TL)
7. Chandra and Dalton 2010 (Fiji)
8. Moreno and Becken 2009 (Fiji)

No mention of governance or decision-making:

1. Agarawala and Van Aalst 2008 (Fiji)
2. Gravelle and Mimura 2008 (Fiji)
3. Woodward et al. 2000 (Fiji)
4. McLoed et al. 2010 (Pacific)
5. Mimura 1999 (Pacific)
6. Hay and Mimura 2006 (Pacific)
7. Buyataert et al. 2011 (PNG)
8. Haberle 2004 (PNG)
9. Rasmussen et al 2009 (SI)
10. Pandolfi 1999 (PNG)
11. Kelman 2010 (PNG)
12. Mercer 2010 (PNG)
13. Minnegal and Dwyer 2000 (PNG)
14. Munday 2004 (PNG)
15. IGCI 2000 (Fiji)
16. Becken 2004 (Fiji)
17. Becken n.d. (Fiji)
18. Kirono 2010 (TL)

Governance is mentioned, but not considered extensively:

1. Rasmussen et al. 2011 (SI)
2. Barnett 2001 (Pacific)
3. Kaly et al. 2002 (Pacific)
4. Mataki et al. 2006 (Fiji)

Informal governance mentioned, but not formal:

1. Lane and McNaught 2009 (Fiji)
2. Lata and Nunn 2012 (Fiji)
3. Nunn and Mimura 1997 (Fiji)
4. Klint 2012 (Vanuatu)

Formal governance mentioned, but not informal:

1. SPREP n.d. (Fiji)
2. Ellison 2010 (Fiji)
3. GFDRR 2011 (PNG)

4 Timor-Leste case study

4.1 Aim

Application of the framework in Timor-Leste was undertaken with the follow two aims:

Aim 1: In participation with community members from Atauro and Batugade, Timor-Leste, use the framework to (i) assess the likely impacts of climate change on coastal livelihoods; (ii) identify possible adaptation actions, and broader adaptation strategies; (iii) generate information on economic, social and environmental aspects of each adaptation strategy to enhance capacity in stakeholders for undertaking informed decision-making; (v) identify thresholds that will require adaptation actions and strategies to be implemented, and key activities to be included in a plan for implementation.

Aim 2: Apply the framework in two different locations to provide an initial evaluation of the utility of the framework in terms of: (i) the ease of application when used in participation in participation with members at the community level; (ii) the quality of output produced in respect to progressing communities along the adaptation pathway.

The remaining sections of this report detail the specific application of the framework to Timor-Leste. The sections cover an analysis of climate, community workshops, and evaluations from an economic perspective (using decision-tree analysis and partial cost-benefit analysis), social perspective (using social network analysis, a governance and institutional effectiveness survey, and a governance capacity analysis), and environmental perspective (using landscape function analysis and ecosystem service assessment using InVEST software). Analysis in all these sections is not fully complete at this time, but preliminary results offer an initial reporting and assessment of the application of the framework). Each of these sections is written as a self-contained chapter (i.e. containing method details, analysis, results and recommendations to date), in preparation for the production of four-page leaflets for dissemination to in-country partners and community members.

4.2 Climate analysis for Timor-Leste

Activity:	Assessment of climate using: • Analysis of observed (historic) temperature and rainfall data • Assessment of projections of future climate change
Aim/ Key question:	Are there any trends in past temperature and rainfall data, and are these trends consistent with projections of future climate change?
Brief details of method:	• Observed climate data for mean monthly temperature and rainfall interrogated using statistical analysis and statistical modelling to identify trends • Consideration of climate change projections
Key results:	Summary of trends in observed data • Inter- and intra-annual rainfall is highly variable in Timor-Leste, but the long-term trend has been somewhat stable over the past 60 years (1952-2011) • Average dry season rainfall has fallen substantially in recent decades, while average rainfall in the wet season may have slightly increased (although not statistically significant) • On average, the start of the dry season (May to October), has shifted ~45 days earlier over the past 60 years (assuming <20 mm to be the dry season) • Air temperatures are higher during the wet season, than in dry season months • The duration of the cooler season has contracted between 1900 and the present day (as indicated by both sea surface and air temperature). Conversely, the warm season has expanded • Marine temperatures (both sea surface and air temperature) have increased over the past century, across almost all months Summary of climate change projections (ABoM and CSIRO, 2011) • Reduced quantity of rainfall in the dry season • Increased quantity of rainfall in the wet season • Increase in the intensity of rainfall • Increase in surface air temperature (and sea-surface temperature) • Rise in sea level

4.2.1 Method used for analysing trends in observed climate data

Terrestrial weather stations

Historic monthly average precipitation and temperature data at specific terrestrial stations across Timor-Leste were sourced from the Australian Bureau of Meteorology and CSIRO (2011) and the (US) National Center for Atmospheric Research (NCAR, http://ncar.ucar.edu/). The stations included data collected at Dili Airport and Baucau (north east coastline). At the latter site data were relatively patchy in terms of temporal coverage, and since it located further from Atauro and Dili, data from the Dili airport site were selected to summarise terrestrial precipitation and temperature in Timor-Leste. The precipitation data series for Dili covered the period for 1952 to 2011, but has a gap between the years 2000 and 2003 (reason is unknown).

In the case of air temperatures at Dili airport, data were supplied from CSIRO for the period 2003 to February 2011, a duration that is insufficient for quantifying long-term changes. To

'fill the gap' a database maintained by NCAR was interrogated for Dili Airport for data for the period 1952 to 1998. Analysis was then carried out on air temperature data for Dili Airport from NCAR for 1952 to 1998 and for 2003 to 2011 from CSIRO. We have based the analysis reported in this section on this integrated dataset, in recognition of the absence of more extensive and continuous datasets. However, by also examining and finding similar trends in marine data (detailed below), we are reasonably confident that the trends and patterns reported are genuine and not an artefact of, for example, changing measuring and sampling techniques.

Marine climate data

Data for air and sea temperatures within the Exclusive Economic Zone (EEZ) of Timor-Leste were obtained from the International Comprehensive Ocoean Atmosphere Data set (ICOAD) (http://icoads.noaa.gov/). ICOADS contains surface marine data for the entire globe and spans the past three centuries. ICOADs consists of observations from many different observing systems covering the evolution of measurement technology over hundreds of years and is probably the most complete and heterogeneous collection of surface marine data in existence. The location of ICOADS data for the Exclusive Economic Zone of Timor-Leste is displayed in Figure 4. It should be noted that ICOADs does also contain many other variables of interest such as cloud cover, wave height and period and wind speed and direction. These variables await detailed analysis.

Data in the ICOAD dataset were available for the period 1763 to present. In this analysis we use data for the period 1900 to present only were examined since those collected prior to 1900 were rather sparse. Averages of the air and sea-surface temperature measurements within the EEZ of Timor-Leste were calculated and plotted as both time-series and 3D surfaces. The trends were also summarized with the supsmu (*described below*) smooth function.

Statistical analyses

In summary precipitation and temperature data for Dili airport, plus ICOADs data for Timor-Leste's EEZ were used for statistical analyses. Coverage in space and time was variable. All data were initially explored using exploratory visual techniques, i.e. plotting as functions of both long-term and seasonal time. A smoothing function available within the R-package called 'supsmu' was used to summarise some of the trends. The 'supsmu' smoothing function is a running lines smoother which chooses between three spans for each line. Running line smoothers are symmetric, with k/2 data points each side of the predicted point, and values of k as 0.5 * n, 0.2 * n and 0.05 * n, where n is the number of data points. If a span is specified, a single smoother with span '*span x* 'is used. The best of the three smoothers is chosen by cross-validation for each prediction. The best spans are then smoothed by a running lines smoother and the final prediction chosen by linear interpolation (Friedman 1984).

Formal stochastic modeling has only yet taken place on the precipitation data (1952 to 2011) for Dili Airport. The precipitation data were modeled using Generalised Additive models from the Gamma 'family'.

Modelling analysis

The rainfall data were also modelled statistically using a Generalised Additive Model (GAM) (Hastie and Tibshirani 1990) which models non-linearity using (non-parametric) smooth functions. Average rainfall per month was modelled as a function of year and month where year entered the model as a continuous (integer) predictor and month was fitted as a 'factor'. The rainfall data were highly skewed so the Gamma distribution was assumed in the models. The following 'nested' series of four models were fitted to the data:

1. *Average rainfall = 1 + ε*
2. *Average rainfall = lo(year,span=.25) + ε*
3. *Average rainfall = lo(year,span=.25) + month + ε*
4. *Average rainfall = lo(year,span=.25) * month + ε*

Model 1. Is the 'null' model and Model 2 fits average rainfall to year. Models 3 and 4 both include year and month, but in Model 3 the dependence on year must be parallel for each month, while in model 4 it is allowed to *covary* or *interact* with year. In model 3, therefore, the shape of the seasonality *must* be the same each year, although the overall level (of rainfall) can change. In model 4 the shape of the seasonal cycle in rainfall can be different each year: albeit this change must occur 'smoothly'.

Table 5 Analysis of Deviance table to compare nested models 1-4.

Model	Resid. Df	Resid.Dev	Df	Deviance	P(>Chi)
rainfall ~	654	1247.56			
rainfall ~ rainfall ~ lo(trend, span = 0.1)	644	1246.95	1	0.61	0.477
rainfall ~ lo(trend, spam = 0.1) + fseas	633	774.93	11	427.03	<0.05
rainfall ~ lo (trend, span = 0.1) * fseas	622	745.33	11	29.6	<0.05

(Note: *lo*=locally-weighted regression smoother (Cleveland and Devlin 1988), *span* determines the degree of smoothing, and *month* enters the model as a factor. The Gamma distribution is assumed).

A model in which the month factor interacted with the year (i.e. the seasonal pattern could change with respect to year) was thus selected as being the best (see **Error! Reference ource not found.** above). That is to say, for an extra 11 degrees of freedom (model 4 cf model 3) we reduce our deviance by 29.6 which is significant. This means that there is statistical evidence that seasonality in precipitation changes with long-term time. Predictions from the model were then plotted both as a time-series and as a 3D 'surface plot' (to shows changes in the shape and timing of the seasonal cycle in precipitation). These same modelled data were then re-examined to extract seasonal cycles from the model output for the years 1960, 1975, 2002, and 2011.

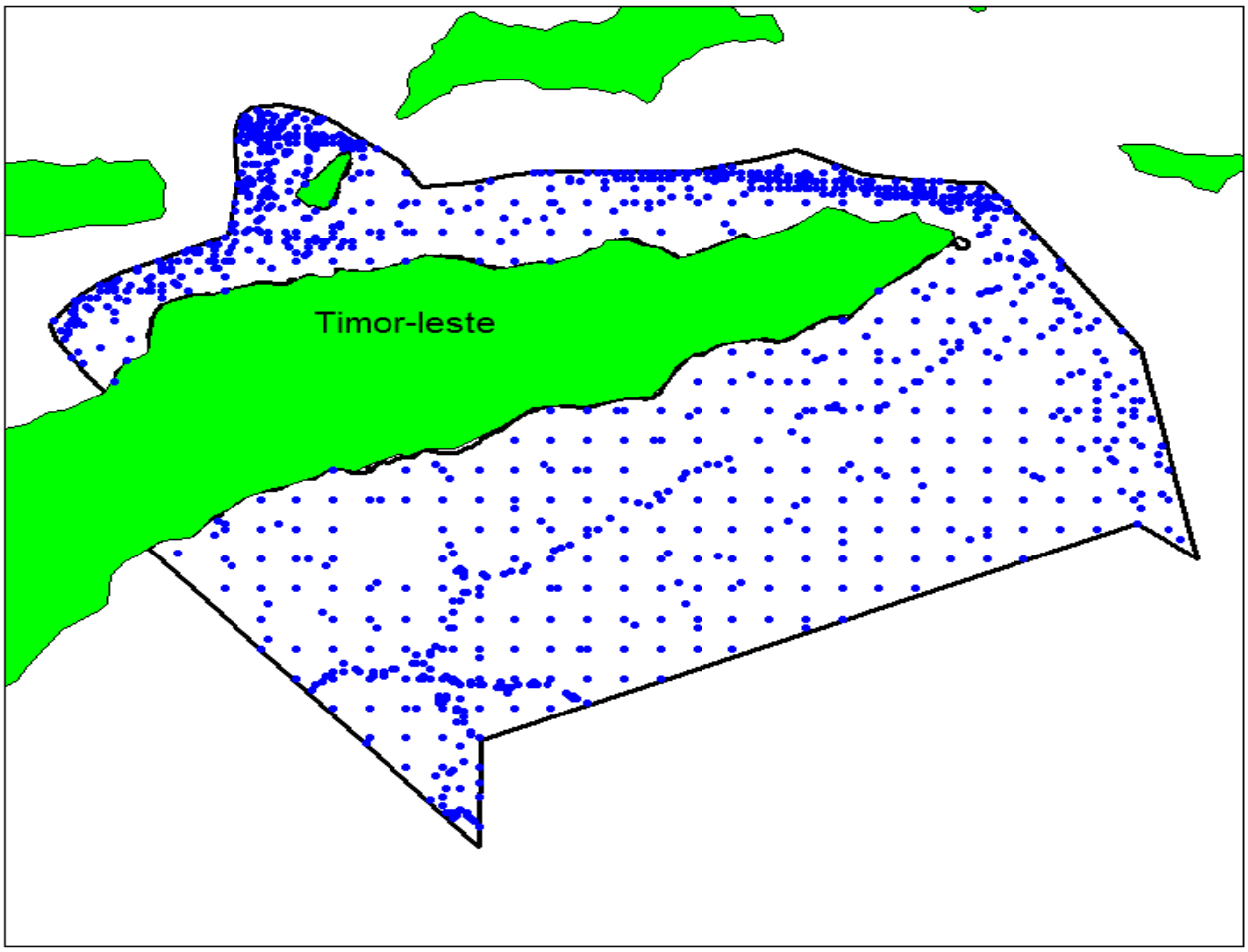

Figure 4 Map showing distribution of ICOADS data in the Exclusive Economic Zone (EEZ) of Timor-Leste.

4.2.2 Results

Rainfall

Average rainfall at Dili Airport was 74 mm over all months between 1952 and 2011 (Figure 5). The driest months on average were July, August and September; the wettest typically January, February, March and April. In November, December, January, February, March, and April (wet season) the average rainfall was 120 mm, while from May to October (dry Season) the average was 29 mm (see Figure 6 for a summary of the typical annual cycle in rainfall). These graphs also show that inter- and intra-annual rainfall is highly variable in Timor-Leste. Inter-annual variability in rainfall in Timor-Leste has been attributed to the strong influence of El Niño Southern Oscillation (ABoM & CSIRO, 2011). However, the overall average long-term trend in monthly rainfall (at least at Dili Airport), has been somewhat stable over this 60 year period.

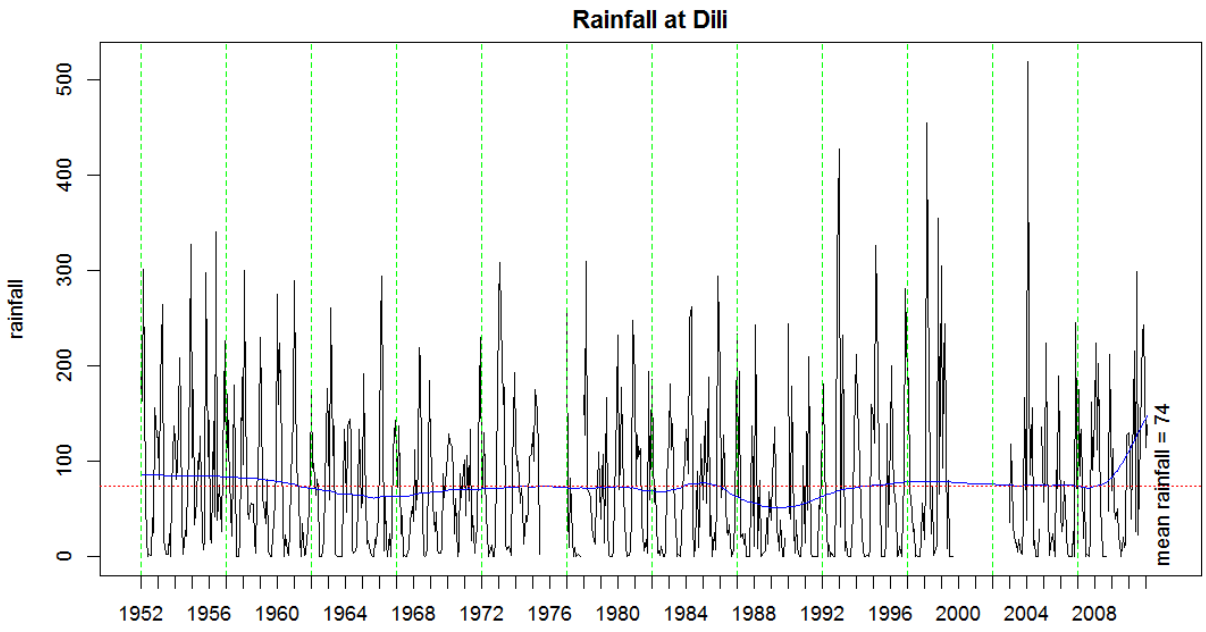

Figure 5 Average rainfall at Dili airport 1952–2011. The black lines are the raw data, the red line is the long-term mean and the blue line is the *supsmu* smoothing function which summarises long-term trend.

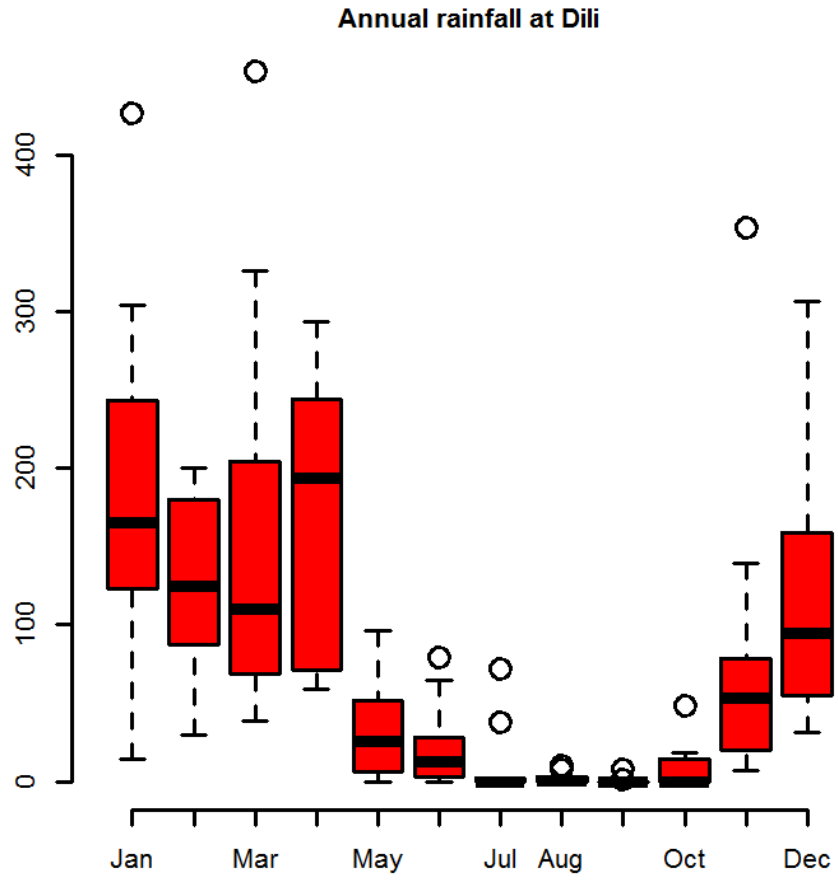

Figure 6 Average rainfall at Dili Airport for the period 1952 to 2011. The horizontal black lines show the median, the third quartiles are defined by the top and bottom of each box. The whiskers are the maximum and minimum, and the open circles are 'outliers' that may require 'special attention'. See http://msenux.redwoods.edu/math/R/boxplot.php.

The long-term trends in monthly rainfall over the period 1952 to 2011 are shown in Figure 7. These also indicate the highly variable rainfall received during the wet season and almost total absence of rain in the dry season. When the rainfall data were aggregated into (what are somewhat arbitrary) 'dry season' and 'wet season' categories, it was clear that the overall average dry season rainfall has fallen quite substantially in recent decades (Figure 8), while the wet season average rainfall appears to have risen slightly (Figure 9). (See table above for statistics).

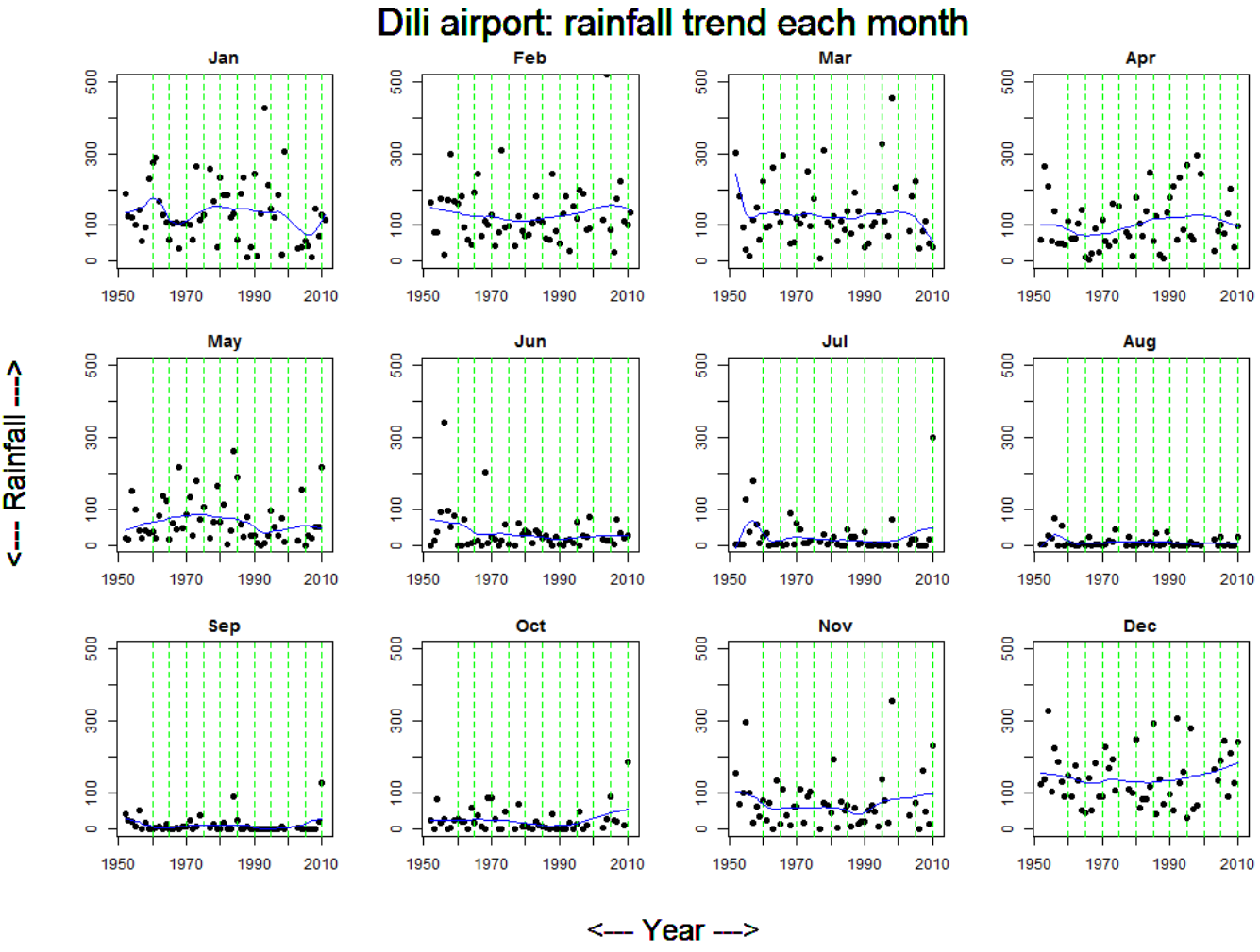

Figure 7 Long-term trend in monthly rainfall over the period 1952 to 2011 at Dili Airport.

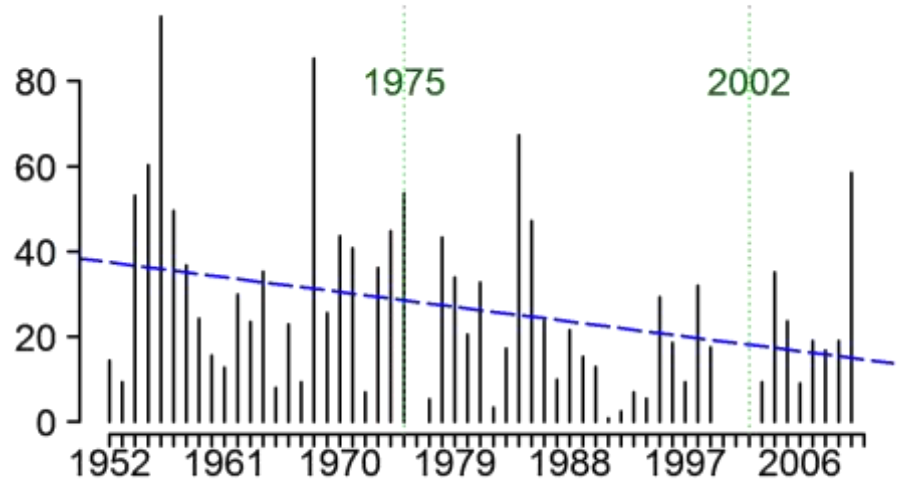

Figure 8 Dry Season Rainfall at Dili Airport 1952–2011. 1975 = Independence from Portugal and 2002 = end of war with Indonesia.

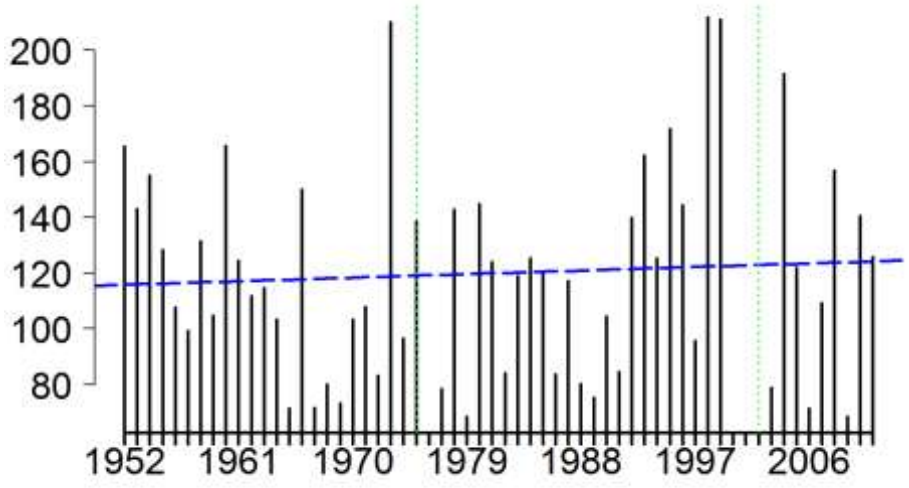

Figure 9 Wet season rainfall at Dili Airport 1952–2011.

Predictions from the regression (GAM) described above, are plotted in Figure 10 and Figure 11. The time-series modelled data in Figure 9, suggest that rainfall has been relatively constant in Timor-Leste since 1952. However, when the same data is plotted as a 3D 'surface plot' (Figure 10), it is possible to discern changes in the shape and timing of the seasonal cycle in precipitation. The red area in this plot represents the dry season, and the contour lines (also referred to as isoline) show gradients or change in observed monthly rainfall. From the contour lines it is possible to see that in more recent decades, the airport site has started to receive less than 20 mm of rainfall around mid-June each year. This contrasts with rainfall levels from the middle of the 1960s, when monthly rainfall of less than 20 mm did not tend to occur until early August.

These same modelled data are re-examined again in Figure 11 in which seasonal cycles from the model output have been extracted for the years 1960, 1975, 2002, and 2011. These plots simply clarify the interpretation of Figure 10 described above. In the 1960s and mid 1970s the driest period focused on the months of August, September, and October. More recently (2002 and 2011) June and July have been equally as dry. This suggests that, on average, the start of the dry season (as defined by a monthly rainfall level of 20 mm), has shifted from the start of August to mid-June (i.e. approximately 45 days) over the past 60 years.

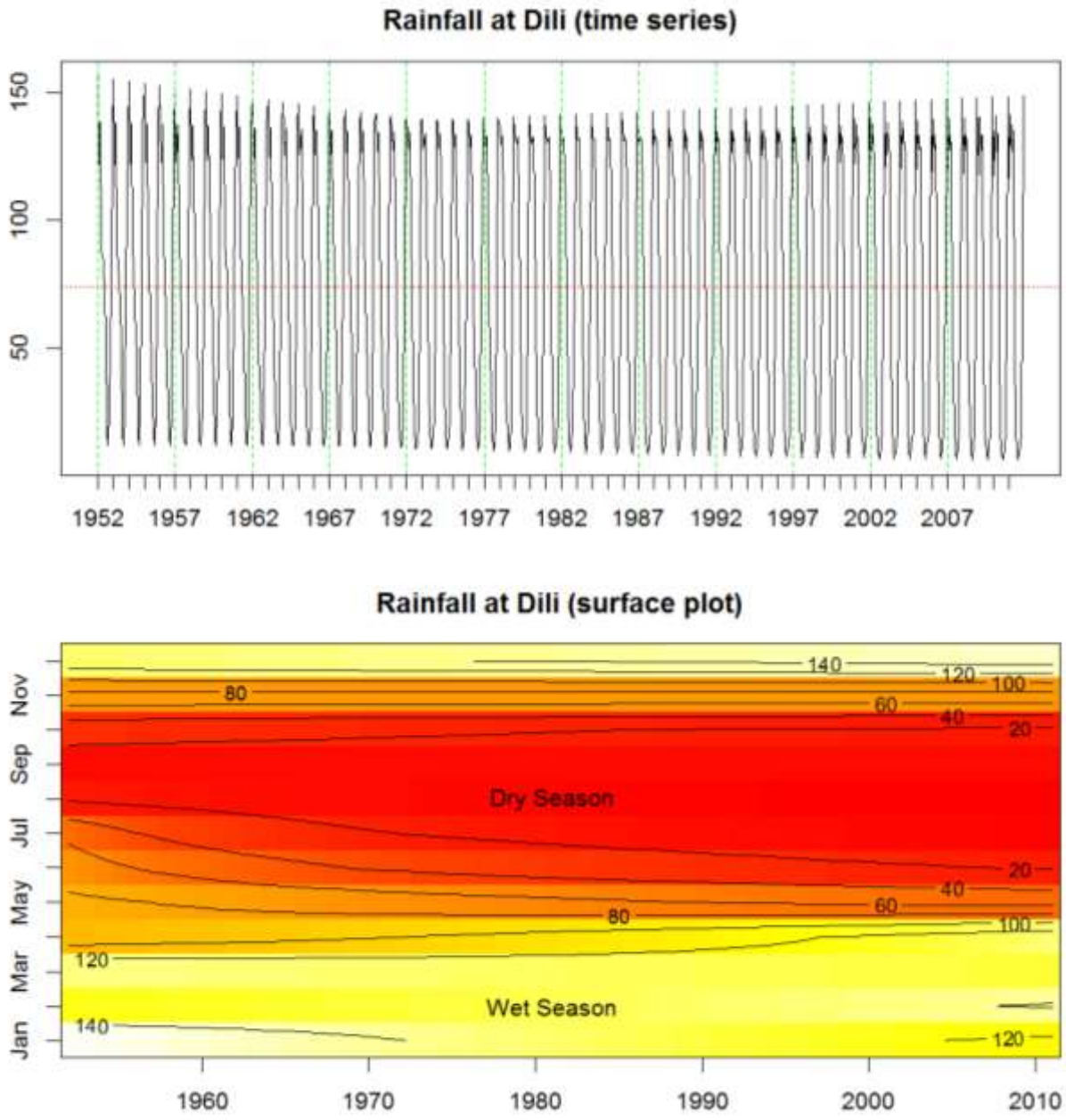

Figure 10 Modeled data for rainfall at Dili Airport (1952–2011) plotted as a time series (top) and 3D surface (bottom).

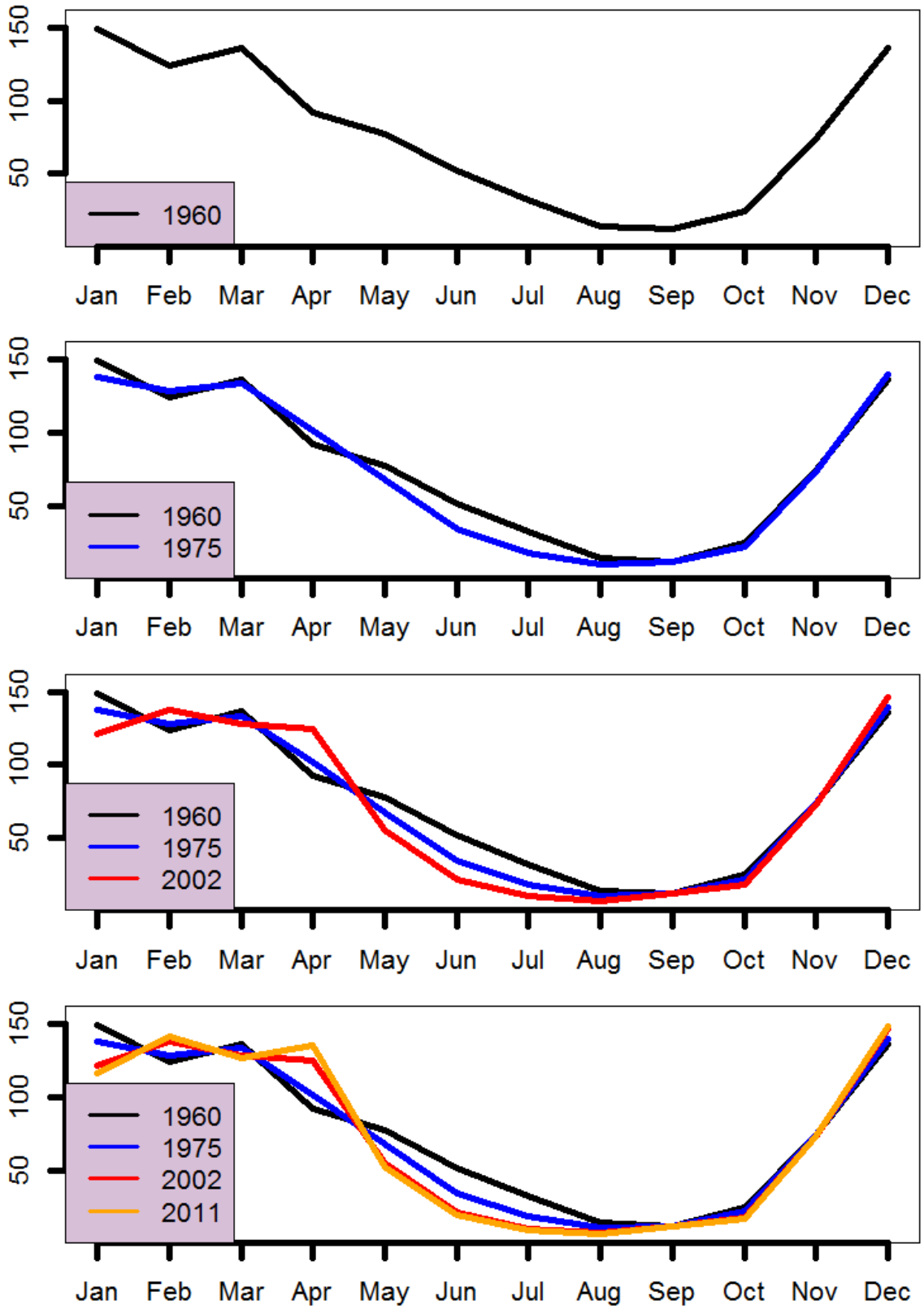

Figure 11 Modelled monthly rainfall data at Dili Airport. Note that seasonal cycles have been extracted for the years 1960, 1975, 2002, and 2011 using model 4 above.

Temperature

Temperature has risen dramatically at Dili Airport between 1952 and 2011 (Figure 12). In 1952 the median temperature was 26.9 ^{o}C while in 2011 it was 28.55 ^{o}C, an increase of nearly 2 ^{o}C during this 60 year period. The average seasonal cycle in temperature (Figure 13) shows a tendency for it to be warmer during the wet season and cooler during the dry season months. Median January temperatures were 27.4 ^{o}C, while August, the coolest month, had a median temperature of 24.65 ^{o}C.

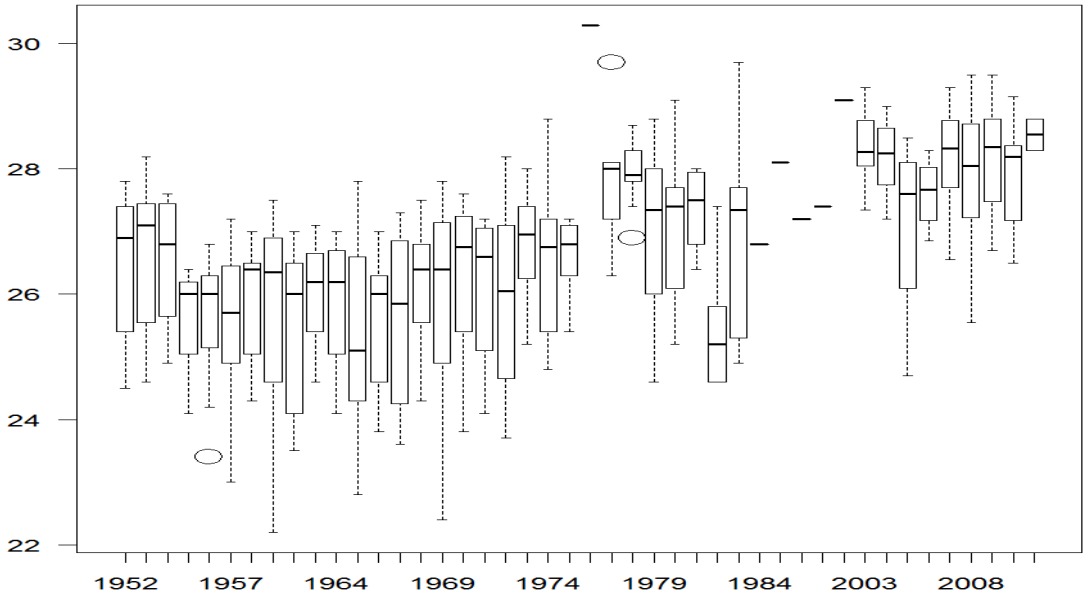

Figure 12 Long-term change in temperature at Dili Airport 1952-2011.

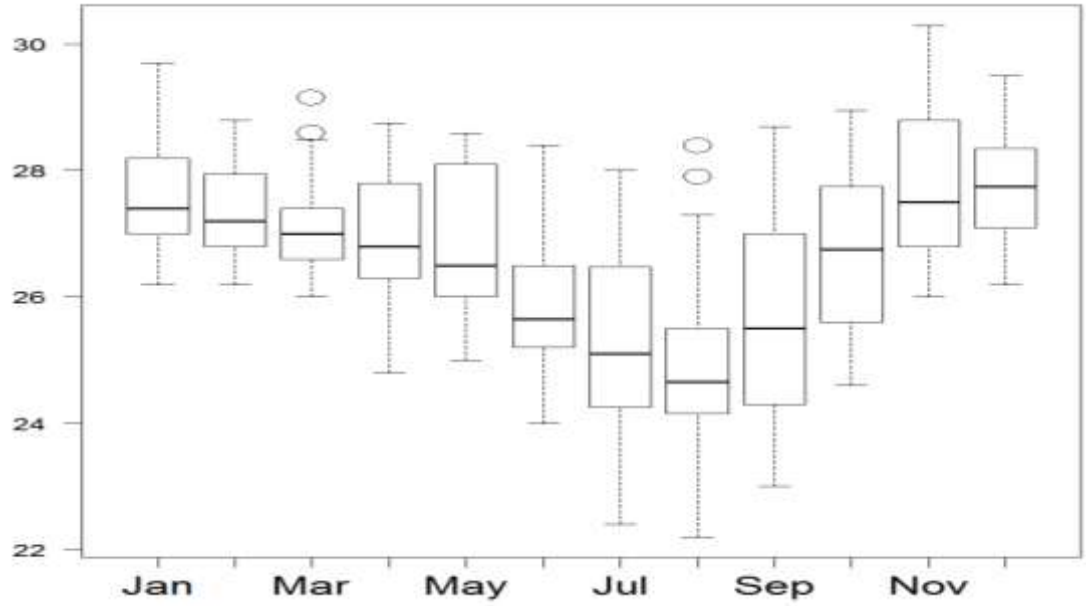

Figure 13 Average seasonal change in temperature at Dili Airport based on available data between 1952 and 2011.The horizontal black lines show the median, the third quartiles are defined by the top and bottom of each box. The whiskers are the maximum and minimum, and the open circles are 'outliers' that may require 'special attention'. See http://msenux.redwoods.edu/math/R/boxplot.php.

Air and sea temperatures from the Exclusive Economic Zone of Timor-Leste

Averages of air and sea-surface temperature for Timor-Leste (obtained from the ICOADs dataset) were calculated and plotted as 3D surfaces in Figure 14. It is evident from these plots that the duration of the cooler season (blue) has contracted between 1900 and the present data for both sea surface temperature (Figure 14, top) and air temperature (Figure 14, bottom). This has clearly coincided with an expansion in the warmer season (green and yellow) for both air and sea surface temperatures. When the same sea surface data were plotted by month (Figure 15), and the trends are summarized using the 'supsmu' smooth function (solid red line), it clearly shows a trend for increasing marine temperatures (sea surface and air temperature) over the past century, across almost all months.

In summary, the temperature data from Dili Airport (terrestrial station) and ICOADs (marine locations) are supportive of each other. Terrestrial air temperatures show an increasing long-term trend, generally over all months, which is supported by similar increasing long-term trends recorded over the marine area. Sea surface temperatures also show increasing annual trends both when examined overall and by individual months. The terrestrial and marine data show that, on average, both air and sea surface temperatures are cooler during the dry season compared to the wet season.

It is clear from Figure 6 and Figure 13 that seasonal patterns in temperature (both terrestrial and marine) are positively correlated with each other. One might assume from this that one drives the other; if it rains heavily it should then be warmer, and similarly, if it is dry, then it should be cooler. Our data show, however, that over the long-term, precipitation during the dry season has declined while temperatures have increased (Figure 8 and Figure 12). The findings imply that precipitation and temperature are positively correlated over the seasonal cycle, but negatively correlated over the longer term. This may suggest wider meteorological changes caused by climate change. In future work, rather than exploring each time-series dataset separately, we will find methods to examine them simultaneously, thereby exposing the connection between precipitation and temperature in more detail.

With an increase in the duration of the dry season being observed in rainfall data over the past 60 years, the relatively cooler period in the year may therefore be expected to similarly increase. However, it needs to be remembered that whilst there has been a shift to a longer duration cooler period within the year, the absolute temperatures during this cooler period have increased in absolute terms. Thus, inter-annual warmer period temperatures experienced a couple of decades ago, may well become more redolent of cooler period temperatures as the trend for increasing absolute temperatures continue into the future.

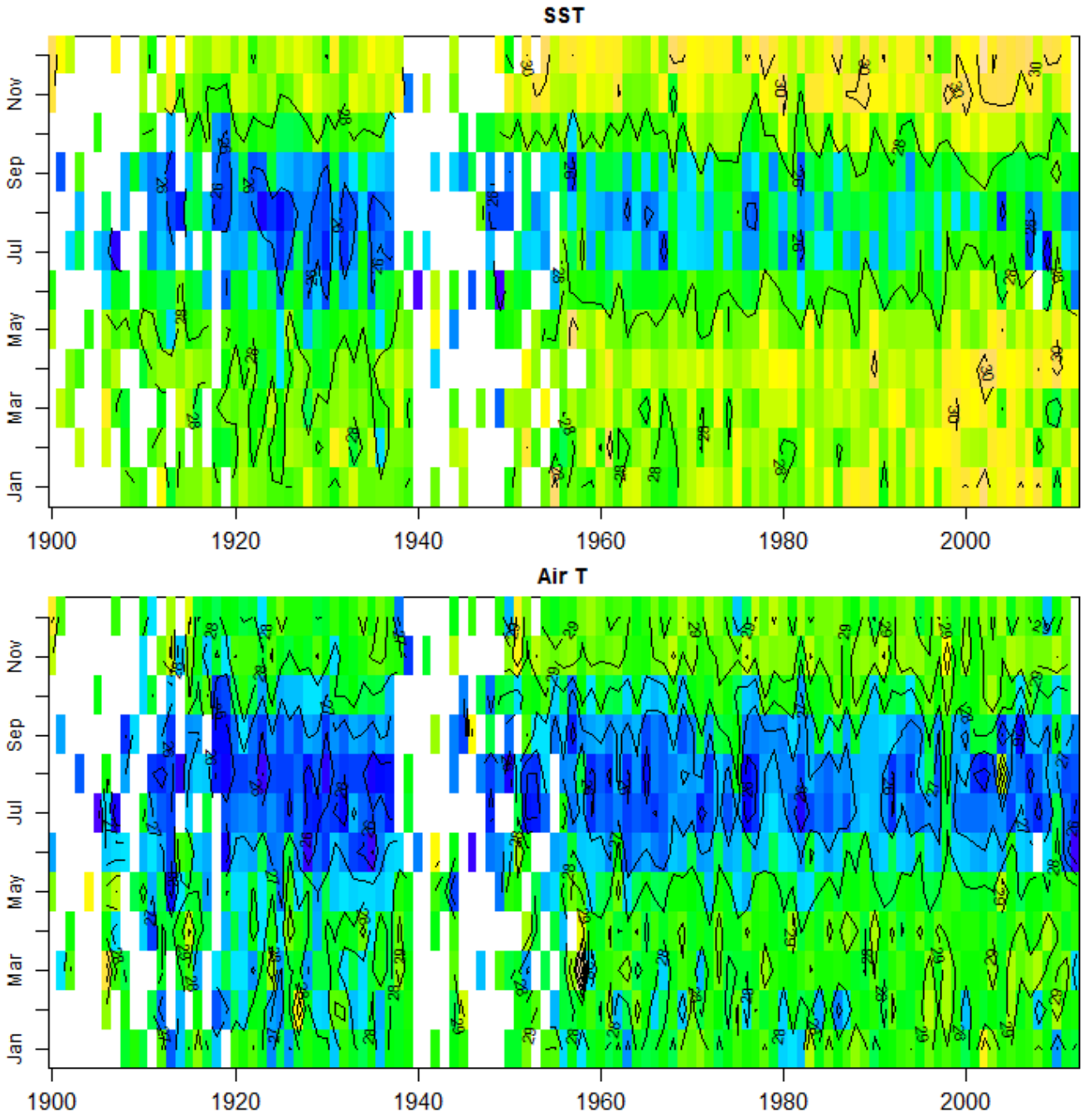

Figure 14 Average sea surface (top) and air temperature (bottom) in Timor-Leste's EEZ between 1900 and 2012. Blue indicates cooler periods and green and yellow indicates warmer periods.

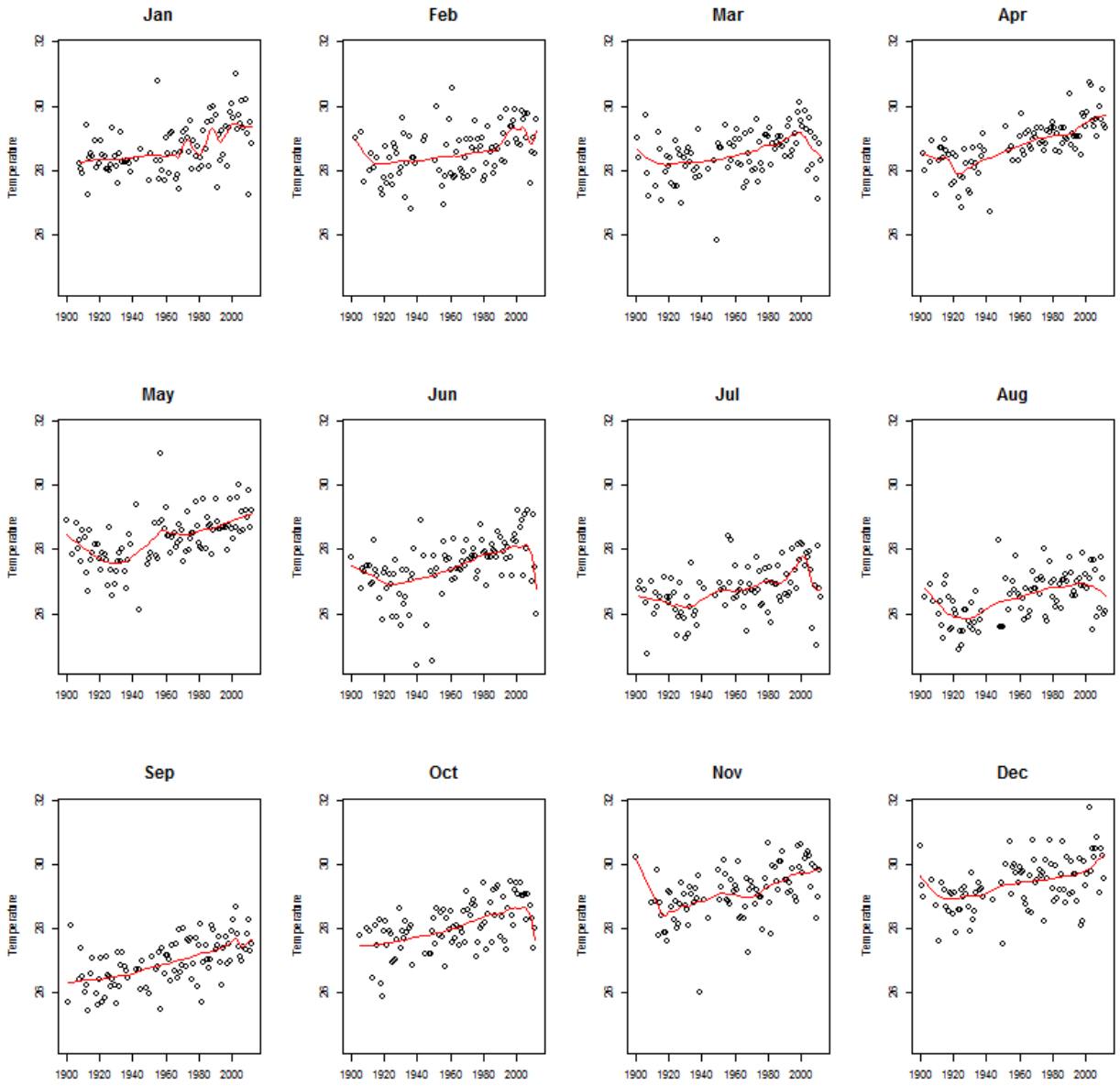

Figure 15 Change in average sea surface temperature by month between 1900 and 2012. Red line shows the *supsmu* (op cit) smoother function.

4.2.3 Climate change projections

Projections of climate change for Timor-Leste were obtained from the Australian Bureau of Meteorology and CSIRO (2011). Key projections relative to farming and fishing activities in Timor-Leste have been summarised in Table 6. This table also includes summary findings from the trend analysis conducted above on observed climate data for Dili Airport. To avoid unintentionally suggesting that past trends are attributable to long-term climate change, we collectively refer to these projections and observed trends as 'changing climate issues'.

Table 6 List of historic trends in climate and climate change projections for Timor-Leste (collectively referred to as 'changing climate issues').

Changing climate issue	Source
Early start to the dry season	Climate trend analysis (Section 3.2.1)
Reduced quantity of rainfall in the dry season	ABoM & CSIRO (2011)
Shorter wet season (because of longer dry season)	Climate trend analysis (Section 3.2.1)
Longer dry season	Climate trend analysis (Section 3.2.1)
Increased quantity of rainfall in the wet season	ABoM & CSIRO (2011)
Increase in the intensity of rainfall	ABoM & CSIRO (2011)
Increase in surface air temperature and sea-surface temperature	ABoM & CSIRO (2011)
Rise in sea level	ABoM & CSIRO (2011)

When the trends identified in the climate analysis conducted in Section 3.2.2 are compared to corresponding climate variables in the projections of climate change (ABoM & CSIRO, 2011), there is a high degree of conformity (Table 7).

Table 7 Correspondence of trends in climate identified in analysis in Section 3.2.2 and climate change projections.

Trend analysis (Section 3.2.2)	Projections of climate change (ABoM & CSIRO, 2011)
Long-term trend in annual rainfall has been relatively stable over the past 60 years	Little change in total annual rainfall over the course of the 21st century.
Average dry season rainfall has fallen quite substantially in recent decades	Reduced quantity of rainfall in the dry season
Average rainfall in the wet season has perhaps risen slightly	Increased quantity of rainfall in the wet season
On average, the start of the dry season (as defined by a monthly rainfall level of less than 20 mm), has shifted approximately 45 days earlier over the past 60 years.	No projections given for the onset of the dry season, however it is noted that El Niño events generally bring drier conditions to Dili and often lead to a late onset and early finish to the wet season. "There is no consistency in projections of future ENSO activity."
There is a tendency for terrestrial air temperatures to be warmer during the wet season, than in the dry season months.	No projections provided for monthly temperatures.
The duration of the cooler season has contracted between 1900 and the present day for both sea surface and air temperature. This has coincided with an expansion of the warmer season in marine temperatures.	Increase in inter-annual surface air temperatures (and sea-surface temperature)
Marine temperatures (sea surface and air temperature) have increased over the past century, across almost all months.	Increase in annual surface air temperature (and sea-surface temperature)

4.3 Community workshops

Activity:	Stakeholder participatory workshop
Aim/Key question:	What are the likely impacts of a change in future climate on key livelihood activities for fishers and farmers in the two focal locations in Timor-Leste, and what adaptation actions may help to reduce negative impacts and capitalize on opportunities?
Brief details of method:	• Identify climate-sensitive livelihood activities and changes in their management in response to changing temperature and rainfall • Consider the above in terms of past trends and projections of future changes in climate (i.e. identify impacts of climate change on livelihoods) • Identify appropriate adaptation strategies and actions • Identify visions of a desirable future for communities to guide their adaptation actions
Key results:	A total of 28 and 46 impacts were identified for farming and fishing activities in Atauro and Batugade, respectively, and some 41 and 49 related adaptation actions. The adaptation actions identified by the community were categorized into broad themes by the project team. For both locations, the underpinning themes relate broadly to improving the resilience of the natural resource base that underpins fishing and farming activities. Local authority level community members identified the following as the adaptation themes they wanted to be evaluated from a social, environmental and economic perspective: <u>Atauro fisheries</u> • Special regulation to enhance the condition of nearshore (coral) fisheries • Enhanced exploitation of deep water fisheries (e.g. through the use of echo sounders and fish aggregating devices (FADS), and also including training and knowledge via courses and overseas trips) <u>Atauro agriculture</u> • Improved collection of water (during the wet season), its storage, and delivery to crops and animals • Enhanced knowledge and training for improved agricultural production techniques <u>Batugade fisheries</u> • Increase ability to fish different species using new technologies and skills • Improve income and food production from non-fishing activities, such as aquaculture <u>Batugade agriculture</u> • Increase production of trees, crops and animals using sustainable agriculture techniques (including training) • Improve income and food production from improved management of water harvesting, storage and distribution

4.3.1 Method - community workshop

Community workshops were held in Atauro and Batugade in August 2012. A previous study had identified decision makers in the Atauro and Batugade communities that were important in decision-making for successful implementation of interventions relating to nature resource management (Abernethy et al., 2012). This group of actors were invited to the community workshops.

The same format for the workshops was used in both locations, with the overall structure aiming to introduce community members to: (a) the project team and in-country partners, the issue of climate change, and projection of future climate; (b) facilitate community members reflecting on their livelihoods in light of past and future climate to consider likely impacts; and (c) facilitate community members in considering adaptation actions that may address their identified impacts. These activities were scheduled to be undertaken over a two-day period (see Appendix 5 for details of the workshop agenda). The workshops were conducted in the local language, Tetum, and in-country partners provided translation between the community members and the English-speaking Project Team.

Slight modifications were made to the agenda in both Atauro and Batugade to reflect location-specific differences, such as the number and gender mix of attending participants, the arrival time of participants on the two days, and the number and experience of in-country facilitators and translators that were assisting. The following provides more specific details of the methods used to facilitate key participatory activities in the workshop.

Livelihood focus groups' identification of the likely impacts of a changing climate on their livelihoods

The participants were asked to form focus groups according to the main focus of their livelihoods, i.e. fisher, farmer, or local authority. (The broad term 'local authority' was used to capture those members of the community whose main occupation was in the formal or informal administration of the communities and regional government representatives.) Where there were sufficient numbers of men and women, livelihood focus groups were subsequently split by gender. The groups were asked to discuss how a continuation of past trends in rainfall and temperature, and projected changes in climate (see Section 3.2), may impact current livelihood activities. Existing material detailing livelihood activities (e.g. seasonal calendars, (Abernethy et al., 2012)) was used to prompt this discussion. The impacts identified by each group were recorded in terms of the eight changing climate issues shown in Table 6. The results were recorded on butcher's paper by the livelihood focus groups.

The members of the livelihood focus groups were encouraged to be specific about the likely impacts that may occur to an activity, e.g. name the fish or crop species, and explain how this impact affected their livelihood (i.e. not just that "it will be difficult to plant crops"). The Project Team recorded additional notes from these discussions. The focus groups were also encouraged to consider environmental, social, and economic impacts.

Once the exercise was complete, each livelihood focus group presented their findings to the whole workshop, and plenary discussions were facilitated with the aim of allowing all community members' views to be expressed.

Visioning the future of communities

The aim of this activity was to produce a shared vision of a desirable future for the communities, with particular reference to the use and management of the natural resource base, thus providing a common goal to guide them when considering possible options for adapting to a changing climate.

The youths in the community were invited to undertake this activity with the idea that they would be the major beneficiaries of effective adaptation planning and implementation in the future.

The community youths were asked to draw a picture of their community and the special things in it that made it a nice place to live, i.e. those features that they would like to keep special as they grow into an adult. The youths were asked to annotate their pictures to community details of the special features and describe why they were considered special and important to look after.

Livelihood focus groups' identification of adaption actions

Each of the livelihood focus groups was asked to discuss what actions they could take to respond to: (a) the negative impacts, and (b) opportunities presented as a result of a change in climate. These adaptation actions were recorded next to the impacts written on the butcher's paper the previous day.

Once the exercise was complete, each livelihood focus group presented their ideas for adaptation actions to all the workshop participants. This was followed by members of the Project Team presenting further ideas for adaptation actions that they had knowledge of from previous studies. A plenary discussion allowed the participants to consider the full range of possible adaptations that had been presented.

Identifying adaptation actions for evaluation from an environmental, social and economic perspective

An activity had been developed that aimed to facilitate the workshop participants in prioritising the fishing and farming adaptations to identify the four they would most like the Project Team to evaluate from a social, environmental and economic perspective. This activity involved the participants sticking coloured card onto the adaptation options written on the butcher's paper. However, for the workshops conducted in both Atauro and Batugade there was insufficient time to conduct this activity. As an alternative, the Project Team synthesized the adaptation actions identified by the communities in terms of broad strategies or themes for adaptation. The themes were developed by member of the Project Team by drawing on their disciplinary expertise to drill down to the root cause, and subsequently theme underpinning each adaptation.

These adaptation themes were then presented to a convenience sample of community members in a separate meeting (i.e. a small group of local authority-level decision makers related either to agriculture, or an equivalent group related to fisheries). After the relevant

themes were discussed by the groups, a unanimous decision was reached within each group as to the most appropriate adaptation themes that should be evaluated from a social, environmental and economic perspective by the Project Team. For both fisheries and agriculture, the local authority level decision makers did not base their decisions wholly on the count scores resulting from the thematic reviews (see results below), but rather used the themes as the basis for their discussion and to inform their decision.

4.3.2 Attendees (and consent) at community workshop for Atauro and Batugade

Table 8 details the number of men and women attending the community workshops in Atauro and Batugade. At the outset of each workshop (and all subsequent data collection activities), the participants were provided with details (in Tetum) of the nature of the data to be collected from them, and how the information would be used and stored (see Appendix 6 for these details). Participants were also informed about their right to refuse or end participation in the study, issues of confidentially that the Project Team would adhere to, and any risks or benefits that would likely flow from their participation. Those community members agreeing to consent to these terms were asked to provide their signature.

Table 8 Number of men and women attending the community workshops in Atauro and Batugade.

Location	Day 1		Day 2	
	Men	Women	Men	Women
Atauro	21	6	28	7
Batugade	15	8	26	7

4.3.3 Outputs produced from community workshop in Atauro (assessment of impacts of a changing climate and possible adaptation options)

Farming related impacts and adaptations

A total of 15 impacts were identified for agricultural activities in response to a future change in climate (0, Tables 29–33). These were thought to likely result from an increasingly early start date to the dry season, a decrease in rainfall in the dry season (or the months immediately before and after the dry season), an increase in rainfall in the wet season and an increase in the intensity of rainfall. Two further impacts were identified for non-specific changes in climate. A total of 24 adaptations were identified for the above impacts on agriculture (0, Tables 29–33). In many cases the adaptation actions suggested were already being practiced in some form or another. However, in some instances the adaptation options put forward by the community were more aspirational in nature. When these were categorized in terms of adaptation themes (Table 29), nearly two-thirds (64%) of the suggested adaptations (namely, themes A, A(i), A(ii), and D) were specifically related to practices that could be described as sustainable agriculture (Box 1).

Table 9 The themes identified from the adaptations associated with agriculture in Atauro, and the number of actions falling into each theme.

Code	Theme	Count
A	Adaptations aimed at combining (a) improved collection of water (during the wet season), storage of water, and deliver of water to crops and animals; (ii) improved use of sustainable agriculture practices (including the use of new crop species and varieties with increased tolerance to drier conditions), and (iii) improved use of agricultural practices with increased suitability to drier conditions.	4 (17%)
A(i)	Adaptations specifically aimed at improved collection of water (during the wet season), storage of water, and delivery and use of water for crop and animal production	9 (36%)
A(ii)	Adaptations specifically aimed at improved management of soil resources for agricultural production, with an emphasis on enhancing soil nutrients and capacity to retain soil moisture, improving pest management, improving soil drainage, and improving the management (e.g. corralling for containment and manure collection) of animals	2 (8%)
B	Adaptations aimed at improved ability to purchase and store food	3 (13%)
C	Adaptations aimed at improving the effectiveness of services provided to support farmers in making changes to their agricultural practices	1 (4%)
D	Adaptations aimed at improving land management practices (including reforestation and agricultural practices, with increased emphasis on erosion control)	3 (13%)
E	Adaptations based on fishing-related activities	2 (8%)

Box 1 Sustainable Agriculture

Sustainable agriculture is based on the use of farming practices that are underpinned by the principles of ecology (i.e. the study of relationships between organisms and their environment). Sustainable agriculture has been defined as "an integrated system of plant and animal production practices having a site-specific application that will last over the long term. It is consider to do this through: (a) satisfying human food and fibre needs; (b) enhancing environmental condition and function and the natural resource base upon which the agricultural economy depends; (c) making the most efficient use of non-renewable resources and on-farm resources and integrates, where appropriate, natural biological cycles and controls; (d) sustaining the economic viability of farming activities, and enhancing the quality of life for farmers and society as a whole (US Congress, 1990)

Many of the practices used in permaculture (an agricultural production approach widely known about in both Atauro and Batugade) have a similar ecological underpinning to sustainable agriculture. The types of activities undertaken include permanent agriculture as an alternative to shifting cultivation (e.g. slash and burn), the integration of trees and agro-forestry into the production system, activities to increase soil fertility (e.g. legume crops, mulch, compost, fertilisers and the use of manure) and reduce erosion (e.g. contour lines), integrated pest management, crop diversity and rotations, and seed saving. Many of these activities are described in Live & Learn Environmental Education (2011).

Fishing related impacts and adaptations

A total of 13 impacts were identified for fishing activities in response to a future change in climate (Appendix 8, Table 32 34–39). These were thought to likely result from an increasingly earlier start date for the dry season, an increase in surface air temperature (and sea-surface temperature), increase in rainfall in the wet season, trend for a longer dry season, projected increase in sea level, and trend for a shorter wet season. A total of 17 adaptations were identified for the above impacts on fishing (Appendix 8, Table 32 34–39). Similar to the agricultural adaptations suggested by the community members, in many cases the adaptations for fisheries were already being practiced in some form or another, although there were a number of adaptation options put forward that were more aspirational in nature (e.g. fish aggregating devices). Table 10 shows the Project Teams' categorization of these adaptations in terms of themes.

Table 10 The themes identified from the adaptations associated with fishing in Atauro, and the number of actions falling into each theme.

Code	Description	Count
A	Adaptations aimed at increasing fishing activity (non-specific to nearshore or deep water)	1 (6%)
A(i)	Adaptations focused on increased exploitation of deep water fisheries, through: (a) enhanced technical capability (e.g. fish aggregation devices); (b) knowledge and skills training; and (iii) alternative techniques.	5 (28%)
A(ii)	Adaptations specifically aimed at continuing the exploitation of nearshore (coral) fisheries	2 (11%)
B	Adaptations specifically aimed at improved the health and condition of nearshore (coral) fisheries through regulation	1 (6%)
C	Adaptations aimed at fishing-related land based (e.g. mending gear, drying fish, collecting and drying seaweed) activities	3 (17%)
D	Adaptations based on relocation of communities or fishing infrastructure	1 (6%)
E	Adaptations specifically aimed at re-vegetation for coastal protection	1 (6%)
F	Adaptations aimed at non-fishing-related activities (e.g. agriculture, trading)	3 (17%)
G	Adaptations aimed at educating community members in relation to climate change	1 (6%)

Table 11 shows the adaptation themes identified by the small groups of local authority-level decision makers related either to agriculture or fisheries, as being the most appropriate for evaluation by the Project Team from a social, environmental and economic perspective.

Table 11 Adaptation themes for Atauro identified for evaluation from a social, environmental and economic perspective.

Sector	Adaptation theme
Fisheries	Special regulation to enhance the condition of nearshore (coral) fisheries
	Enhanced exploitation of deep water fisheries (e.g. echo sounders and FADS, and also including training and knowledge via courses and overseas trips)
Agriculture	Improved collection of water (during the wet season), its storage, and delivery to crops and animals
	Enhanced knowledge and training for improved agricultural production techniques

4.3.4 Outputs produced from community workshop in Batugade (assessment of impacts of a changing climate and possible adaptation options)

Farming related impacts and adaptations

A total of 35 impacts were identified for agricultural activities in response to a future change in climate (Appendix 9, Table 38–46). These were thought to likely result from an increasingly earlier start date for the dry season, a longer dry season, a hotter dry season, a decrease in rainfall in the dry season (or the months immediately before and after the dry season), an increase in the amount of rainfall in the wet season, an increase in the intensity of rainfall and a shorter wet season.

A total of 32 adaptations were identified for the above impacts on agriculture (Appendix 9, Table 38–46). In many cases the adaptation actions suggested were already being practiced in some form or another and the focus was on extending or enhancing the present practices (e.g. the capture, storage and distribution of water from the river). However, in some instances the adaptation options put forward by the community were more aspirational in nature (e.g. increased knowledge for improved decision making, and selling surplus produce at Dili and local markets). When the ideas for adaptations were categorized into themes (Table 12), nearly one third (31%) of them related to managing water for human consumption or animal and crop production. The second most common (21%) theme related to actions aimed at improving the effectiveness of services provided to support farmers in making changes to their agricultural practices (including access to new varieties, providing information and training).

Table 12 The themes identified from the adaptations associated with agriculture in Batugade, and the number of actions falling into each theme. (Themes and codes used for Batugade have been aligned to those for Atauro to enable comparisons to be made).

Code	Theme	Count
A	Adaptations aimed at combining (a) improved collection of water (during the wet season), storage of water, and deliver of water to crops and animals; (ii) improved use of sustainable agriculture practices (including the use of new crop species and varieties with increased tolerance to drier conditions), and (iii) improved use of agricultural practices with increased suitability to drier conditions.	0 (0%)
A(i)	Adaptations specifically aimed at improved collection of water (during the wet season), storage of water, and deliver of water to crops and animals	9 (31%)
A(ii)	Adaptations specifically aimed at improved use of agricultural practices with increased emphasis on enhancing soil nutrients and capacity to retain soil moisture, improving pest management, improving soil drainage, improving perennial crops, and improving the corralling of animals	4 (14%)
B	Adaptations aimed at improved food storage or increasing access to food (i.e. purchasing)	4 (14%)
C	Adaptations aimed at improving the effectiveness of services provided to support farmers in making changes to their agricultural practices (including access to new varieties, providing information and training)	6 (21%)
D	Adaptations aimed at improving land management practices (including reforestation and agricultural practices with increased emphasis on erosion control)	3 (10%)
E	Fish-related activities (e.g. fishing or aquaculture)	3 (10%)

Fishing related impacts and adaptations

A total of 11 impacts were identified for fishing activities in response to a future change in climate (Appendix 10, Tables 47–54). These were thought to likely result from an increasingly earlier start to the dry season, a hotter dry season, less rainfall in the dry season, increase in the intensity of rainfall, projected increase in sea level, trend for a shorter wet season, and the projection for more rain in the wet season. A total of 17 adaptations were identified for the above impacts on fishing (Appendix 10, Table 45–Table 52). Similar to the agricultural adaptations suggested by the community members, in many cases the adaptations for fisheries were already being practiced in some form or another (e.g. fishing in Indonesian waters). Interestingly, nearly half (44%) of the adaptation options suggested related to non-fishing activities, including agriculture and aquaculture. Table 13 shows the Project Teams' categorization of these adaptations in terms of themes.

Table 13 The themes identified from the adaptations associated with fishing in Batugade, and the number of actions falling into each theme.

Code	Description	Count
A	Adaptations aimed at increasing fishing activity (non-specific to nearshore or deep water), which may include support services, education and training and credit	4 (25%)
A(i)	Adaptations focused on increased exploitation of deep water fisheries, through: (a) enhanced technical capability (e.g. fish aggregation devices); (b) knowledge and skills training; and (iii) alternative techniques	2 (13%)
A(ii)	Adaptations specifically aimed at continuing the exploitation of nearshore (coral) fisheries	0 (0%)
B	Adaptations specifically aimed at improved the health and condition of nearshore (coral) fisheries through regulation	1 (6%)
C	Adaptations aimed at fishing-related land based (e.g. mending gear, drying fish, collecting and drying seaweed) activities	0 (0%)
D	Adaptations based on relocation of communities or fishing infrastructure	1 (6%)
E	Adaptations specifically aimed at revegetation for coastal protection	1 (6%)
F	Adaptations aimed at non-fishing-related activities (e.g. agriculture, trading)	7 (44%)
G	Adaptations aimed at educating community members in relation to climate change	0 (0%)

Table 14 shows the adaptation themes identified by the small groups of local authority-level decision makers related either to agriculture or fisheries, as being the most appropriate for evaluation by the Project Team from a social, environmental and economic perspective.

Table 14 Adaptation themes for Batugade identified for evaluation from a social, environmental and economic perspective.

Sector	Adaptation theme
Fisheries	Increase ability to fish different species using new technologies and skills
	Improve income and food production from non-fishing activities, such as aquaculture
Agriculture	Increase production of trees, crops and animals using sustainable agriculture techniques (including training)
	Improve income and food production from improved management of water harvesting, storage and distribution

4.3.5 Stakeholders visions of the future of communities in Atauro

Three youths from Atauro drew pictures of how they desired their communities to look at some time in the future (Figure 16a). The notation on the pictures is yet to be translated from Tetum to English, but it is clear to see the abundance of trees, crops and fish in the pictures.

4.3.6 Stakeholders visions of the future of communities in Batugade

Six female farmers from Lotan (Batugade) drew pictures of how they desired their community to look at some time in the future (Figure 16b). The notation on the pictures is yet to be translated from Tetum to English, but the introduction of new crop species is a prominent feature.

Figure 16a Photos of youths from Atauro drawing how they desired their communities to look at some time in the future.

Figure 16b Photos of female farmers from Lotan (Batugade) drawing how they desired their communities to look at some time in the future.

4.4 Evaluation of adaptation strategies from an economic perspective using decision-tree analysis and partial cost-benefit analysis

Activity:	**Decision tree analysis and partial cost-benefit analysis**
Aim/Key question:	What are the key decisions and design steps that need to be taken in order to progress an idea for adaption through to its implementation, and set it up for on-going iterative management? Given a range of possible designs for an adaptation strategy (produced above), what are the relative partial costs and benefits of each one?
Key stages in method:	Identify key decisions and design steps that need to be taken for each adaptation strategy and the full permutation of decision pathways that could be taken. Identify the costs and benefits associated with each decision and design stage to produce a partial cost-benefit analysis.
Key results:	<u>Atauro</u> • Fuel cost is the most important annualized cost items reported by fishermen in Atauro Island. • Traditional fishing and modern net fishing methods are viable adaptation options if appropriate regulation systems (formal and informal) are strengthened. • Comparative advantage and effectiveness of offshore fishing methods such as fish aggregating devices (Rumpong), pull landline and longline are unclear because they are subject to high uncertainty regarding climate change factors and availability of fisheries stocks in deep waters. • Pool landline, longline, and Rumpong fishing methods cannot be economically efficient fishing methods if operated in isolation, but can they can be integrated with other fishing methods to improve fisheries yields. <u>Batugade and inland communities in Balibo sub-district</u> • Aquaculture may be a viable adaptation to increase income and food production for poor local communities in Batugade and other villages in Balibo, Bobonaro district; • Aquaculture development is associated with issues of land convertibility. Costs associated with land use conversion are unknown so far. • Freshwater fishes are not traded in coastal communities and demand in inland community as well as trading systems haven't been established yet.

This section reports on two activities, namely decision tree analysis and partial cost-benefit analysis, conducted in participation with local authority community members in Atauro and Batugade, Timor-Leste. Decision tree analysis identifies the decision structures and range of possible decision pathways appropriate for planning, implementing, and iteratively managing specific adaptation actions. The subsequent partial cost-benefit analysis provides an assessment of the relative costs and benefits associated with each of the decision pathways (when climate and other uncertainties are taken into account). This method is aimed at providing information to stakeholders to enhance informed decision-making in their selection of adaptation actions, as well as guiding them through the key decisions or sequential set of decisions they will need to make to determine if an adaptation is appropriate to their needs, and how they will implement and iteratively manage it. Since climate change adaptation commonly requires sequential decisions to be made over time, and in the context of uncertain information, decision tree analysis is an appropriate and useful tool for considering multiple options for the planning, implementation and iterative management of adaptation actions in response to climate change. For further details on decision tree analysis, see Appendix 16.

4.4.1 Method:

The selection of adaptation strategies identified by the communities of Atauro and Batugade for further evaluation from an economic, social and environmental perspective (see Section 3.3 for details of how these were developed) was reviewed, and three strategies chosen for this initial pilot test of the decision tree analysis method in participation with community members. The chosen adaptation strategies were:

(i) Improve income and food production from non-fishing activities, such as aquaculture (specifically mentioned by Batugade communities);
(ii) Increase production of trees, crops and animals using sustainable agriculture techniques (including training) (mentioned by both Atauro and Batugade communities);
(iii) Enhanced exploitation of deep water fisheries (e.g. echo sounders and FADS, and also including training and knowledge via courses and overseas trips). (specifically mentioned by Atauro communities).

Prior to departure to Timor-Leste and engagement with community members, we drafted structures of adaptation decision trees for each of the above adaptations. This activity was conducted as a prior test of the decision tree concept. The decision tree structures were based on identifying alternative adaptation decisions, and identifying key issues for structuring each adaptation action decision tree. The project team used their own expert knowledge and consulted with other colleagues, as well as using published literature to produce the trees. A survey was drafted as a template for collecting the necessary values for populating all the variables included in the decision pathways, in readiness for data collection in Timor-Leste and subsequent partial cost-benefit analysis. This pilot test enabled a proof of concept assessment of the decision tree method to be conducted prior to applying it in the field, and it was concluded that the activity had a moderate chance of being successfully applied in participation with stakeholders in Timor-Leste.

The method used to develop the decision trees and collect data for partial cost-benefit analysis in Atauro and Batugade was tailored to fit the time and resources available, and spanned three and two days, respectively.

Development of decision trees and collection of data in Atauro

Day one - Development of decision trees: The identified adaptation actions and strategies (as categorized above) were reported back to local stakeholders in a one-day meeting attended by local authority level representatives of the communities (selected by the in-country NGO partner). The aim of this activity was to identify which adaptation strategies the community members were interested in considering in terms of decision tree and partial cost benefit analyses. The participants choose to develop a decision tree for the adaptation strategy relating to enhancing exploitation of deep water fisheries via equipment such as FADs and echo sounders. In an activity facilitated by the project team members, the participants drew the decision tree, including the full range of decision pathways. During this activity, the participants worked through: (i) brainstorming the key decision points; (ii) ordering decision points in time logic, and (iii) noting assumptions associated with each decision and any links to climate events (whenever possible).

Day two - Decision tree elaboration and training of local interpreters/facilitators: The local interpreters/facilitators were engaged in: (i) determining the key variables and appropriate units of measurement, (e.g. crop yield, fish yield, the ocean health index) that were required to determine relative differences in the payoff resulting from the full range of decision pathways identified during day one (above); (ii) identifying those variables that could be populated with secondary data (and where this may be obtained from), and (iii) for the remaining key variables, refining the pre-developed list of survey questions (produced by the project team prior to arriving in Timor-Leste) aimed at collating the necessary primary data to complete a partial cost-benefit analysis on all decision-tree options. In-country partners were then 'trained' to collate the primary data via the survey.

Day three - data collection for partial cost-benefit analysis of decision pathways: Focus group discussions were conducted with community members in two fishing villages in Atauro, (Maquili and Biqueli). The survey produced the previous day was used to collate the necessary data for partial cost and benefit analysis of the adaptation strategy. The project partners (WorldFish project team and in country interpreters) worked with fishermen and farmers to calculate costs and benefits (income) for different decision pathways in order to compare and recommend preferred adaptation strategies based on economic analysis. For each fishing decision alternative, the following questions were posted for focus groups to discuss:

- What are the input items and costs fishermen and community have to invest if they choose the fishing method (the decision alternative)? For each fishing method (decision alternative), detail cost items and duration of use were identified and estimated to provide information on what total partial cost would be if the decision adaptation option is taken for implementation.
- What are the benefits and harvest (products) fishermen and community can get if they choose the fishing method (the decision alternative)? Benefits were defined as income from fishing in a year.
- What are the risks and uncertain factors that may affect fishermen and community if they choose the fishing method (the decision alternative)?

Risks and uncertainties caused by climate change and other factors were identified by the fishers and were expressed as the probability of outcome occurrence, defined in percentage.

For each decision alternative, three outcomes were defined: a very successful fishing year, a normal fishing year, and an unsuccessful fishing year.

For cost and benefit comparison purpose, a straight line method was used to compute partial annualized costs for each decision option included in the decision tree. For ranking and identifying preferred decision alternatives in terms of cost and benefit analysis, partial net benefit, gross benefit-cost ratio, and net benefit-cost ratio were computed.

Development of decision trees and collection of data in Batugade

Fieldwork in Batugade, Balibo sub-district was conducted from 22 to 26 October 2012. An authority level meeting was arranged in Batugade on 22 October to develop the decision tree. Decision tree development and data collection for partial cost and benefit analysis in Batugade were conducted in a two day process:

Day one - Development of decision trees: Similar to Atauro (above), a meeting was held with authority level community members in Batugade to develop decision tree structures. Decision trees were developed for: 1) Increase production of trees, crops and animals using sustainable agriculture techniques (including training); and 2) Improve income and food production from non-fishing activities, such as aquaculture.

Day two - data collection for partial cost-benefit analysis of decision pathways: Partial costs and benefits data were collected during focus group discussions conducted in Balibo sub-district, Bobonaro district, and Lotan village in a similar manner as decribed above for Atauro.

[Note: as the surveys were already developed in Atauro, these only needed minor amendements in order for them to be applicable to Batugade. It was therefore possible to omit these activities from the Batugade application of this method.]

In addition to focus the group discussion method, in Batugade, Balibo sub-district we also use key informant interview method to collect data and information for partial cost and benefit analysis. Key informants were conveniently selected in consultation with local partners. Individual interviews were conducted with key informants such as the village chief, experienced farmers and fish farmers before the focus group discussion session started.

4.4.2 Results

Atauro

Figure 17a presents a decision tree on offshore fishing adaptation actions developed by participants attending the local authority level meeting held in Vila village, Atauro Island (see Table 61 in the appendix for a text version of this figure). The objective of the adaptation strategy is to increase fishers' income by applying alternative fishing methods. As depicted in Figure 17a, from the root decision, five fishing methods (decision alternatives) were identified by the participants namely:

- explore the rumpong (fish aggregating devices) fishing method;

- apply the pool landline fishing method;
- apply the modern net fishing method;
- apply the longline fishing method;
- continue the traditional fishing method.

For each decision alternative, possible cost items and possible fish species that fishermen might catch were identified by meeting participants. Due to time constraints there were no discussion on how climate change might affect decision alternatives and what sequential decisions might be taken, subject to updated information on climate change and other drivers of change. The simple decision tree created in Figure 17a was used for focus group discussions at community level to calculate partial costs and benefits of each alternative fishing methods chosen by the community.

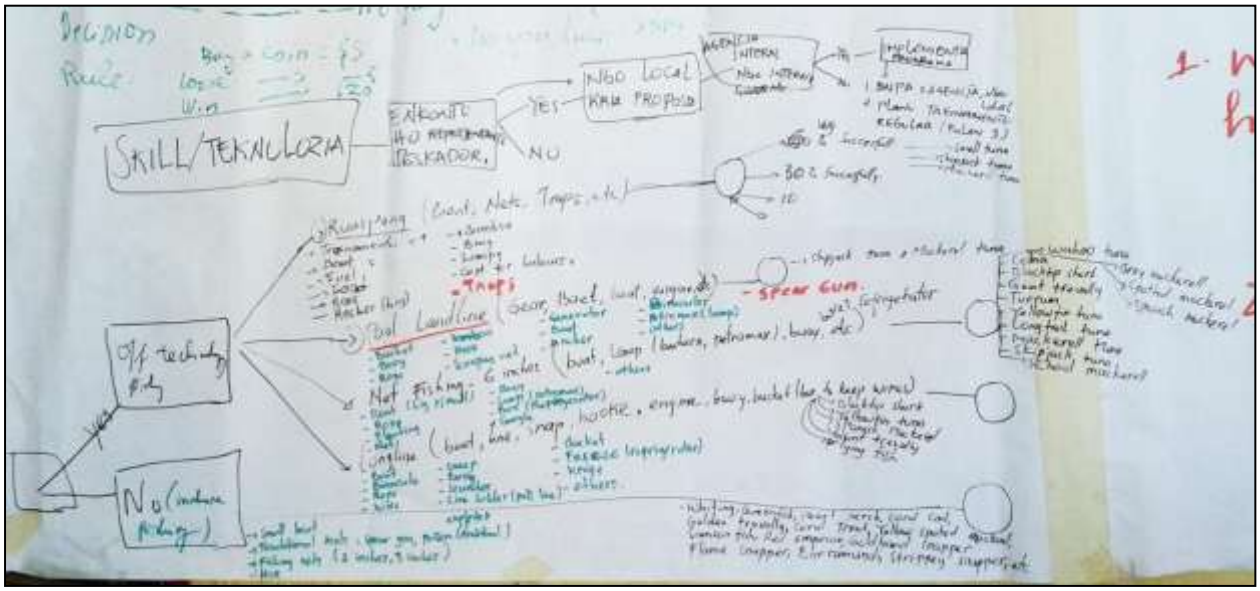

Figure 17 Decision tree for offshore fishing adaptation developed by local authority- level community members during the focus group discussion held in Vila on 14 October 2012.

Results of partial costs and benefits of alternative offshore fishing methods estimated by fishermen groups in Makili and Biqueli villages are presented in Figures 17b and 17c, respectively. Detailed information on cost and benefit for each alternative fishing methods are presented in Appendix 19, Tables 62-66 for Makili village and Tables 67 to 71 for Biqueli village.

As presented in Figures 17b and 17c, the decision trees developed during the authority level meeting were re-arranged by the fishers to reflect their priorities and experiences. The traditional fishing method is included as the present alternative for comparing with alternative offshore fishing methods (the modern net fishing method, the pool landline fishing method, the longling fishing method, and the rumpong (local name for the fish aggregating device fishing method).

For fishermen in Makili village, among five alternative fishing methods considered, total partial costs of the modern net fishing method and the traditional fishing method options were estimated at $4,105 and $5,600, respectively. Averaging over three possible outcomes (very successful, normal, and unsuccessful fishing years), expected gross benefit (income) of these two fishing methods were at $5,200 and $6,350 per year. Thus, net benefits of these two fishing methods are positive, estimated at $1,095 for the modern net fishing method and $749 for the traditional net fishing method. As presented in Table 62 and Table 66, for each dollar invested, a net benefit of $0.27 and $0.13 dollars can be expected for the modern net fishing method and the traditional fishing method respectively. In contrast to these two methods, the pool landline, longline and rumpong fishing methods required lower investment costs and also resulted in negative net benefit ratio (Tables 63-65). According to partial costs and benefits estimates provided by the Makili fishers, the modern net fishing method is the most economically beneficial adaptation decision

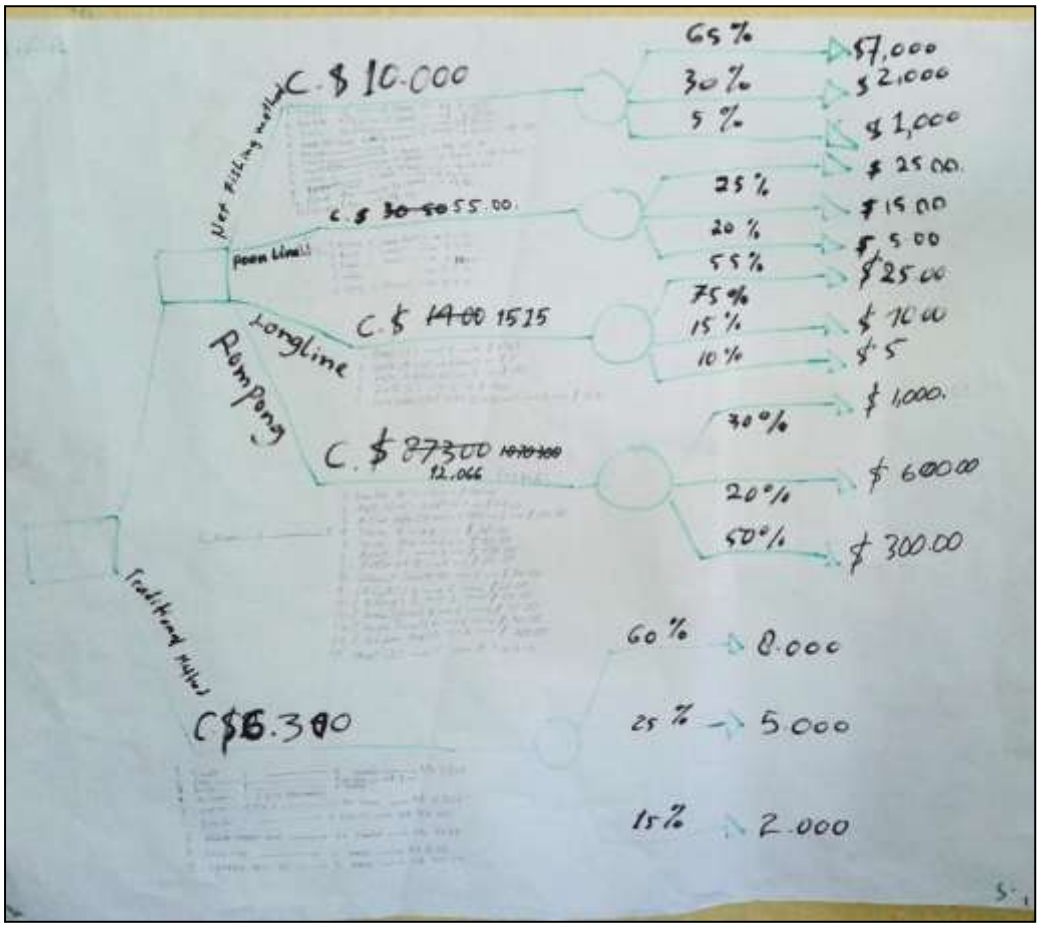

Figure 17b Partial costs and benefits calculated for the decision analysis of alternative offshore fishing methods by fishers in Makili village, Atauro.

Partial costs and benefits estimation for alternative offshore (deep water) fishing methods by fishers in Biqueli village are reported in Appendix 19, Tables 67 to 71. According to the estimates provided by the Biqueli fishers, two fishing methods produced positive net income ratios, these are the longline and traditional fishing methods (with total partial costs estimated at $17,178 for the longline method, and $4,250 for the traditional fishing method). The modern net fishing and pool landline fishing methods have negative net benefit ratios; for each dollar invested in these methods, a net loss of $0.13 and $0.30 are expected.

For the rumpong fishing method, total partial cost was estimated at $23,880. Benefit/income from the rumpong fishing method is subjected to fishermen perceptions of risks and uncertainties, which were expressed in terms of probability of outcome occurrence (i.e. very successful, normal, and unsuccessful harvest). At first, the group assigned a positive outcome occurrence (80% very successful, 15% normal and 5% unsuccessful) and after discussions the group changed the outcome occurrence belief in the opposite direction. Consequently the net benefit ratio of the rumpong fishing method changed from a negative figure (-$0.69), to a positive one ($2.52). This shows that the rumpong method is sensitive to risks and uncertainties, and is dependent on the expected income fishers can get from this fishing method. Thus, in terms of partial costs and benefits ratio, the traditional fishing method seems the preferred decision option for fishermen in Biqueli, with a total partial cost estimated at $4,250, for each dollar invested, and a net benefit of $0.33.

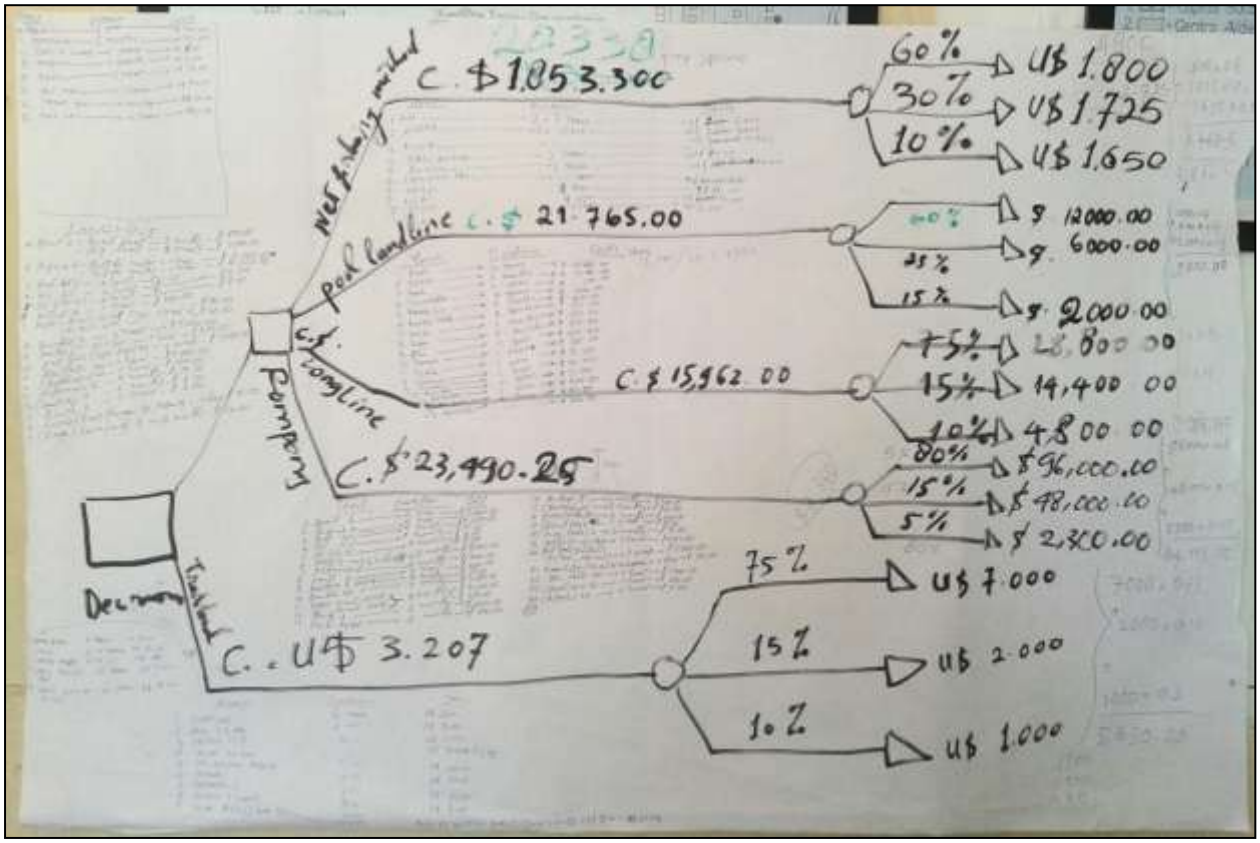

Figure 17c Partial costs and benefits calculated for the decision analysis of alternative offshore fishing methods by fishermen in Biqueli village, Atauro.

Batugade, Balibo sub-district

The decision tree developed by participants during the authority level meeting in Batugade on 22 October 2012 is presented in Figure 17d. In comparison to Atauro, data and information collection activities in Batugade faced several constraints, including a poorer proficiency of English by the local interpreters, and as local farmers were mostly involved in subsistence production, it was not always possible to obtain estimates on income and costs.

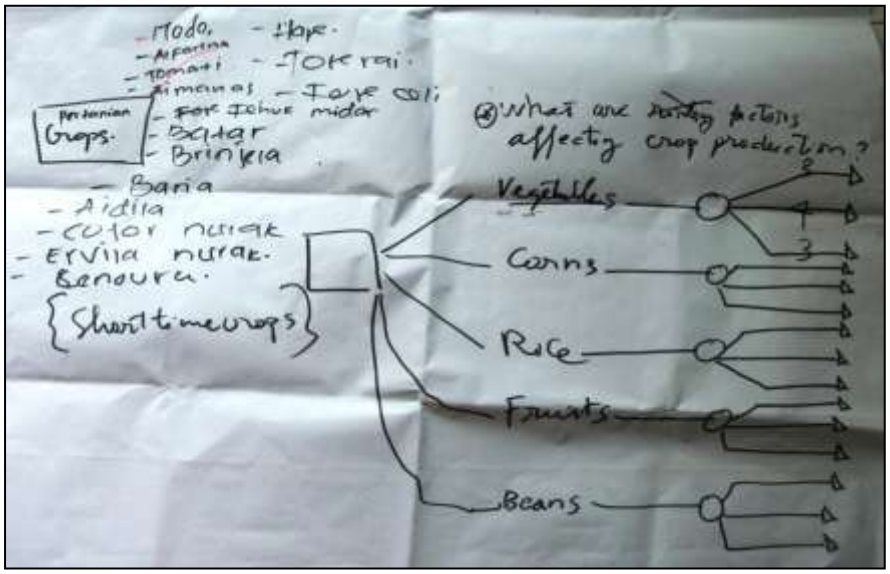

Figure 17d The decision tree developed for agriculture crop production evaluation by local authority stakeholders in Batugade 22 October 2012.

Agriculture crop production in Lotan village (suco), Balibo sub-district.

A decision tree developed for agriculture crop production evaluation by farmers in Lotan village is presented in Figure 17e. The decision tree captures the following decision alternatives:

- rice production;
- corn production;
- long beans production;
- vegetable production.

Efforts were made by farmers and facilitators/interpreters to estimate partial costs and benefits for agriculture crop production of an average household in the village with an average farm size of 0.5 ha, including 0.3 ha of rice, 0.2 ha of corns, 0.1 ha of beans and vegetables. Partial costs and benefits data estimated by farmers joining the focus group discussion in Lotan village are reported in Appendix 19, tables 72-75. Unfortunately partial cost and benefit analysis of agricultural crop production cannot be undertaken due to insufficient data collected, especially with regards to benefit information.

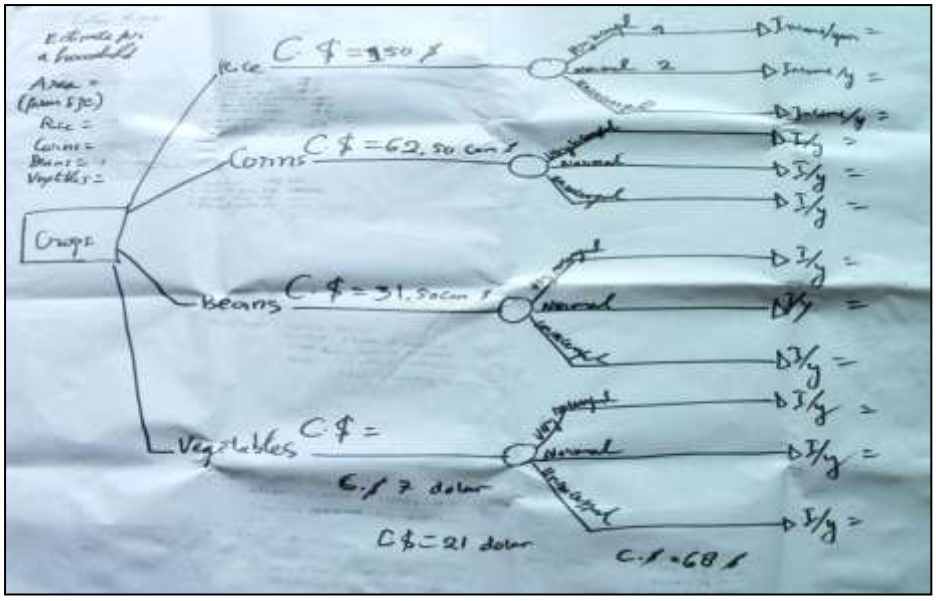

Figure 17e The decision tree for agriculture crop production evaluation developed by farmers in Lotan village (Aldeia), Batugade, Balibo sub-district, Timor-Leste.

Batugade, Leohito and Batugade villages (suco), Balibo sub-district

Key informant interviews and focus group discussion and were conducted in Batugade and Leohito villages to collect data and information for partial cost and benefit evaluation of aquaculture development as an adaptation strategy for improving income and food production for local communities. Interviews with two farmers who had already installed pond based fish culture in their gardens revealed that about 4-5 households in the Batugade village had dug ponds for aquaculture currently operating. They estimated that in Batugade there are about 40 households which have rice fields that can be used for developing aquaculture. Aquaculture development progress however depends on how the early aquaculture adopters perform. Presently freshwater fishes have not been marketed in coastal communities such as Batugade and coastal people have not experienced eating freshwater fishes. Interviewed farmers considered that the potential markets for fresh aquaculture products, are likely to be inland communities such those in Maliana.

A focus group discussion were held in Leohito village (aldeia) to assess aquaculture development as an option for income and livelihood diversification in response to climate change. Personal interviews with fish farmers attending the group meeting suggested that there are about 200 households living in the village. On average a household in Leohito has a farm size of 0.8 to1 ha; the largest farms can be 2 ha and the smallest about 0.5 ha. About 20 households in the village have developed ponds for fish culture. Each fish farmers have 2 to 3 fish ponds with a common pond size of 7x10 m, the max size of 7 x 15 m; and the smallest pond size is at 5x7 m. The first fish pond was dug in 1982 by the chief of the village. During the 1992-1999 period, all ponds were destroyed and with support from UNDP fish culture were renewed and re-developed since 2001. Land for making fish ponds was originally used for rice production. Farmers produce two rice crops per year. The first rice crop lasts from December to February and the second crop is from March to May. After rice crops, rice field can be used for fish culture.

Factors constraining aquaculture development identified by local fish farmers include limited fish breeding capacity, market access, and intensive aquaculture technical know-how. Fish culture was successful during 2006 to 2009 when NGOs came and bought fingerlings to deliver to their aquaculture project participants. During that period, about 10 households in the group were able to sell fingerlings with an estimated fish income of $500-$600/ household/year.

A decision tree developed for evaluating aquaculture development by fish farmers attending the group meeting in Leohito village is presented in Figure 17f. As shown, there are three alternative decisions farmers considered:

- use land for pond aquaculture;
- use land for rice culture;
- use land for rice and fish culture.

For the aquaculture development option, there are three alternative decisions farmers can make:

- develop intensive aquaculture;
- adopt semi-intensive aquaculture;
- practice the traditional aquaculture method.

Partial costs and benefits analysis for aquaculture development options are reported in Appendix 19, Tables 76 and 77. The cost and benefit data were estimated for a pond/rice field of 100 m^2.

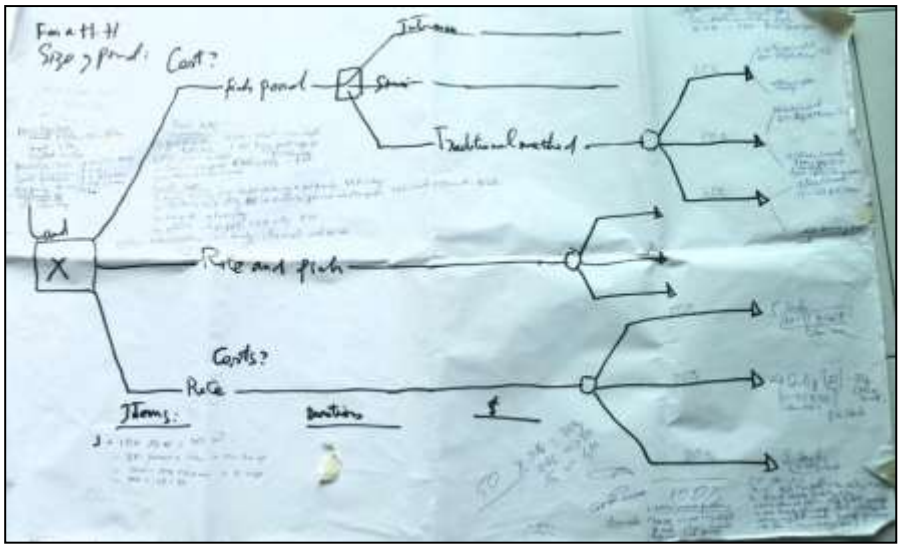

Figure 17f The decision tree for aquaculture development evaluation developed by fish farmers in Leohito village, Balibo sub-district, Timor-Leste.

As reported in Table 76 (Appendix 19), annual partial cost for operating a fish pond of 100 m^2 in Leohito village is estimated at $195 and partial gross benefit averaging for very successful, normal, and unsuccessful years were at $250. This results in a net benefit of $55 per year; for every dollar invested in pond fish culture, fish farmers are expected to get a net benefit of $0.28. It is important to note that the benefits accrued to family nutrition as a result of consuming fish are not included in this net benefit estimation.

In contrast to fish culture, partial cost for a field of rice approximately 100 m^2, is estimated at $90 and averaged partial net benefit is estimated at $66. Consequently, rice production incurs a net loss of $24; every dollar invested in farming the rice field therefore results in a net loss of $0.27. It is however noted that partial cost estimated for rice production can be reduced if the cost of buying food and drink for people coming to help with land preparation and harvesting can be limited to only the helper themselves (labourers coming to help with rice production may bring their children along, thereby requiring farmers to buy food and drink for these dependents too).

4.4.3 Discussion

Adaptation actions and strategies identified by communities, partners and the WorldFish project team for economic evaluation have direct and indirect links to climate change and other drivers of change. As reported by Abernethy et al. (2012) climate change has clearer direct impacts on the agriculture sector and unclear indirect impacts on fisheries. Climate change just adds a compounding factor with other drivers of change such as natural resource depletion, and degradation due to poor management and regulation. Climate change adaptation actions and strategies therefore must be considered in a wider social, economic and environmental contexts faced by communities. The concept of adaptation deficit in economic language and thus the concept of no regret adaptation in sociological language are implied in this report.

As presented in the result section, the offshore fishing adaptation strategy in Atauro Island, and sustaining agriculture production and aquaculture development were selected by local participants for decision tree and partial economic analysis. Simple decision trees involving one decision node, one chance node, and one outcome node were developed for the three selected adaptation strategies. By applying the logic of decision tree development, sequential decision trees can be developed sequencing through time scale and climate thresholds, linking identified adaptation actions and strategies together to provide a diagrammatic figure of adaptation implementation structure. This process requires complex and dedicated social and economic analysis however can provide realistic adaptation implementation scenarios to communities.

We elaborate the above point by discussing the results of the offshore/inshore fishing decision tree and partial cost and benefit analysis developed by Atauro fishing communities. The results show that the traditional fishing method and modern net fishing method can both be viable adaptation options given the partial cost and benefit estimations produced. However, sustaining these livelihood activities requires that inshore and offshore fisheries are regulated to ensure that stocks are sustainably harvested. Similarly, offshore fishing technologies such as the Rumpong, pull landline, and longline fishing methods also need enhanced informal and formal regulations to regulate behaviors of fishers and related actors. It is also noted that the Rumpong fishing method cannot be operated by individual fishers, but must be operated by a group of fishers. This will make decision making, and

consequently the decision tree and economic analysis associated with this adaptation option more complex, and not unlike many other joint decisions faced by communities.

In communities in Balibo sub-district, such as Batugade and Leohito, most of the farmers carry out subsistence production and do not have much experience with market-oriented production systems. Many products, including agriculture products and farmed fish, are grown for family consumption, with only a limited amount traded in local markets. In those cases where products are traded, they tend not to be sold by weight but by a local measuring system, such as a sack or a barrel, per fish, or a string of fish. In the case of maize, a sack can be sold for $30; and a big barrel of maize (1.5 m length x 0.6 m diameter) can be sold for $70. Where these situations exist, limited costs and benefit data can be collected for partial cost and benefit analysis.

As a traditional way of growing livestock, local people in Batugade regularly allow farmed animals, such as pigs and goats, free-range and remain un-tethered. Local people don't feed livestock and livestock have to go around finding food. Many problems are associated with this way of livestock farming such as the destruction of crops. Livestock management practices can be adapted to sustain agriculture crop production and boost yields (see Section 4.8).

The results of partial cost and benefit analysis of aquaculture development option presented above suggested that aquaculture might be a viable adaptation option to increase income and food production for poor local communities in Batugade and other villages in Balibo, Bobonaro district. However, aquaculture development is associated with land convertibility issues. Costs and benefits associated with this conversion are not completely known so far. Similarly which villages and which households have suitable land for aquaculture development are also unknown and need to be carefully assessed. Aquaculture development might face social acceptability and market access constraints. If aquaculture development is to be realized, feasibility studies (considering economic, social and environmental aspects) need to be undertaken.

4.4.4 Conclusion

We have used the decision tree analysis and partial cost and benefit analysis methods to evaluate climate change adaptation actions and strategies identified by local communities in Atauro Island and Batugade, Timor-Leste. By adopting the participatory evaluation approach, the assignment provides communities with a method for building capacity for planning and implementing adaptation actions in response to climate change. The decision tree approach helped in-country partners and farmers understand what adaptation actions and strategies look like and what is the relative cost and benefit associated with alternative decision pathways if they are chosen for implementation. Partial cost and benefit analysis implies that we use rapid data collection techniques and analysis method to provide communities with cost and benefit data associated with selected adaptation actions.

4.5 Evaluation of adaptation strategies from a social perspective using social network analysis

Activity:	Social network analysis
Aim/Key question:	Who is necessary in farming and fishing social networks to facilitate the effective planning, implementation, and on-going application of selected adaptation actions?
Key stages in method:	• Produce baseline social networks by identifying key actors (agents) that influence the capacity of farmers/fishers to produce food for consumption and cash sales • Understand the links that exist between the farmers/fishers and other actors in their networks in terms of the flow of information, physical support (e.g. equipment), financial support (cash and loans), and services (e.g. training, marketing) • Identify what additional actors may need to be included in the baseline networks if a specific adaptation strategy is to be effectively planned, implemented and iteratively managed.
Key results (preliminary):	<u>Atauro fisheries</u> • The National Environment Department, Suco Chiefs, Local Authority, Catholic Church, and Protestant Church are seen as the most influential actors within the Atauro fishing network. • The Local Authority includes the District Administrator, the Sub-District Administrator, and National Sectors: education, health, police, rural development, fisheries and agriculture. This group are a source of information for the community, especially regarding agriculture and fisheries. • Both the Catholic and Protestant Churches serve as an important source of moral guidance in addition to socializing (distributing) information. • The fishers are seen as the least influential actors in the fisheries network. • International organisations, the Maritime Police and the Defence Force were all considered actors needing to be integrated into the fishing network if special regulations are to be implemented and enforced to enhance the condition of nearshore (coral) fisheries or for enhance opportunities for further exploiting deep water fisheries. <u>Atauro agriculture</u> • The Sub-District Administrator, Suco Chief, Ministry of Agriculture and Fisheries, and the Catholic and Protestant Churches are seen as the most influential actors within the Atauro farming network. • Described as the centre of all information, the Sub-District Administrator receives information from the community and distributes it and ensures programs are implemented according to the needs of the community. • The Suco Chiefs provide an important link between the community and above levels of governance, raising information and issues from the community level up to the sub-district and district levels. • The Ministry of Agriculture and Fisheries provides programs, training and equipment, such as seeds and hand tractors. implement programs. • The Catholic and Protestant Churches provide moral guidance on how members of the community should behave. • The Farmers of Atauro are seen as the least influential actor in the

	agriculture network. • The national water services were considered important for improving the collection of water (during the wet season), its storage, and delivery to crops and animals. It will be important to establish links with this national department via their local representative as they are not presently operating in the farmers' network. <u>Batugade fisheries</u> • Moris Rasik (credit supplier) was listed as the most influential actor within the Batugade fishing network. The next most influential actors within the network were the Middlemen and the 'Whole Community' (fishers were identified as a separate actor from the 'Whole Community'). • The fishers (alone) were seen as having zero influence over their fishing decisions and network; however the Whole Community was identified as the second most influential actor in the fisheries network. • If the fishers wish to implement either of the adaptation actions selected in Section 3.3, no additional actors were considered necessary. <u>Batugade agriculture</u> • The Ministry of Agriculture (national level) and the Farmers (community level) were identified as the most influential actors within the Batugade farming network. Farmers are important because they produce food for their families and sometimes pass on food to government officials if these officials have not been able to plant crops for themselves. • The Ministry of Agriculture is seen as having control over making things happen. • If the communities wish to increase production of trees, crops and animals using sustainable agriculture techniques (including training), additional actors are considered necessary within the farming network. These are needed to provide technical knowledge. Liking them to the farmers will be necessary to facilitate planning, implementing and iteratively managing the practices.
Recommen-dations (preliminary)	Preliminary recommendations for all networks: • Consideration should be given to improving information, support and problem solving links where these have been identified as presently hindering the effectiveness of farmers' and fishers' livelihood activities. • Consideration to be given to how new actors required for implementing and iteratively managing adaptation actions can most effectively be linked into the existing networks.

Social network analysis was undertaken in participation with fishing and farming-related local authority level stakeholders and members of communities in Atauro and Batugade. This analysis was chosen (as noted in Abernethy et al., 2012) as it has been demonstrated that strong social networks are an important factor in cases where stakeholders collectively seek to address issues of natural resource management that across scales and location (Hahn et al 2006, Olsson et al 2006, Bodin & Crona 2009). “Simply visualizing these networks can then help stakeholders to understand local relationships by demonstrating the interactions between different groups and identifying the most influential actors. It has been shown to be a useful participatory method where actors in the focus group learn about their position in their network (Schiffer & Waale 2008).”

The aim of this activity was to capture in-country perspectives of the key actors that currently influence farming and fishing livelihoods and the decision-making and power relationships that operate within these networks. This was done with a view to qualitatively assessing the capacity of the networks to facilitate adaptation. More specifically, the analysis sought to identify what agents are necessary in the social networks of farmers and fishers in Atauro and Batugade for facilitating the planning, implementation, and on-going application of selected adaptation actions.

4.5.1 Method

The method used for the social network analysis was based on that described in Abernethy et al., (2012). In summary, the underlying methodology was developed by Carrington et al. (2005), and Bodin and Crona (2009). The key argument in this method is that the ability of farmers and fishers to adapt is strongly linked:

(a) their information, support and problem solving networks (size and structure);
(b) the influence of different actors within the network (structure and attributes);
(c) the attitude (supportive nature) of different actors within the network (attributes).

Participatory network mapping activities were undertaken with small groups of members of the communities of Atauro and Batugade. Separate activities were undertaken with those members identified (by the in-country government and NGO project partners) as local authority decision-makers, and fishers, and farmers. In this preliminary report of analyses, we detail only the four networks produced in participation with local authority members relating to fishing and farming networks in the two locations. The number of participants included in each of these four activities is shown in Table 15.

Table 15 Number of men and women attending the community workshops in Atauro and Batugade.

	Farming Communities		Fishing Communities	
Location	**Men**	**Women**	**Men**	**Women**
Atauro	7	0	5	7
Batugade	9	2	10	2

Baseline social networks were produced with each focus group by facilitating the participants to identify:

(a) the actors considered important for decision making and successfully maintaining/improving income or food production from fishing and gleaning/farming (amended as appropriate to the focus group) activities;
(b) the goals/functions of each actor and their importance to specific fishing/farming activities;
(c) the existing links between actors in respect to the flow of information, provision of support (split into financial, physical /technical, and services), and pathways for problem solving. This included discussions on influential relationships and the boundary of the network;
(d) the actor attributes specifically relating to power and influence, and the extent of their support each actor offers for maintaining/improving fishing/farming activities;
(e) how the existing social network may need to change for specific adaptation actions to be effectively planned, implemented and iteratively managed.

Analysis of the social networks

Net-Map (Shiffer & Hauck, 2010; Schiffer & Waale, 2008; Schiffer, 2007) was used to reproduce a visual representation of the social network and consider the complexities and gaps in the present network to facilitate effective and long-term adaptation to climate change. Each of the social networks has been analyzed separately and preliminary qualitative results presented.

4.5.2 Results

Farming – Atauro

Figure 19 shows the social network as perceived by the participating, farming-related, local authority representatives from Atauro. Each of the circles in the network represents an actor (also referred to as nodes). The different coloured lines indicate the current relationships existing between the actors in terms of the flow of information, provision of support (split into financial, physical /technical, and services), and pathways for problem solving. Table 16 summarises the actors in the network.

Table 16 Summary of actors within Atauro farming community. Actors identified by farming-related, local authority representatives from Atauro as being important for decision making and successfully maintaining/improving income or food production from farming activities.

Atauro Farming Community	
Actor Name	**Actor Description**
Sub_Dist_Admin	Administrasaun Sub Distrito (Sub-District Administrator)- based on Atauro
Chefe_Suco_Lima	Chefe Suco Lima- 5 positions, 1 for each Suco
Lia_Hain	Lia Ha'in- traditional culture leaders based on Atauro
Political_Parties	Liderance Politica (Political parties)- 4 parties based on Atauro
M_O_Ag_Fish	Ministerio Agricultura e Pesca (Minstry of Agriculture and Fisheries)- includes Ministry of Forestry, national level
Extension_MOAF	Extention Officer, (Minstry of Agriculture and Fisheries)- 2 on Atauro, paid by M_O_Ag_Fish
M_O_Health	Ministerio Salide (Ministry of Health)- includes Timor Viatie, national level represented by 1 officer in Atauro
Farmers	Farmers- focus group
WorldFish	WorldFish Center
M_O_Environment	Diresaun Ambiente (Ministry of Environment)- national level
Alola_Foundation	Alola Foundation- national level NGO with a base in Atauro
Roman_Luan	Roman Luan, Sião, Move Forward- local NGOs on Atauro
FAO	FAO- international agriculture organisation, Dili-based
Permaculture	Permaculture- Dili-based organisation
Moris_Rasik_Credit	Azensia (Moris Rasik, Tuba Rai Metin)- credit suppliers based in Atauro, provide mostly to women, must be repaid
ICF	ICF- not currently active, possibly an NGO?
Belun	Belun- national level NGO with a base in Atauro
I_Catolica_Protestant	Igreja Catolica e Protestant- Catholic and Protestant Churches on Atauro
Water_Services	Servico Agua e San-Emento (Water Services), new actor

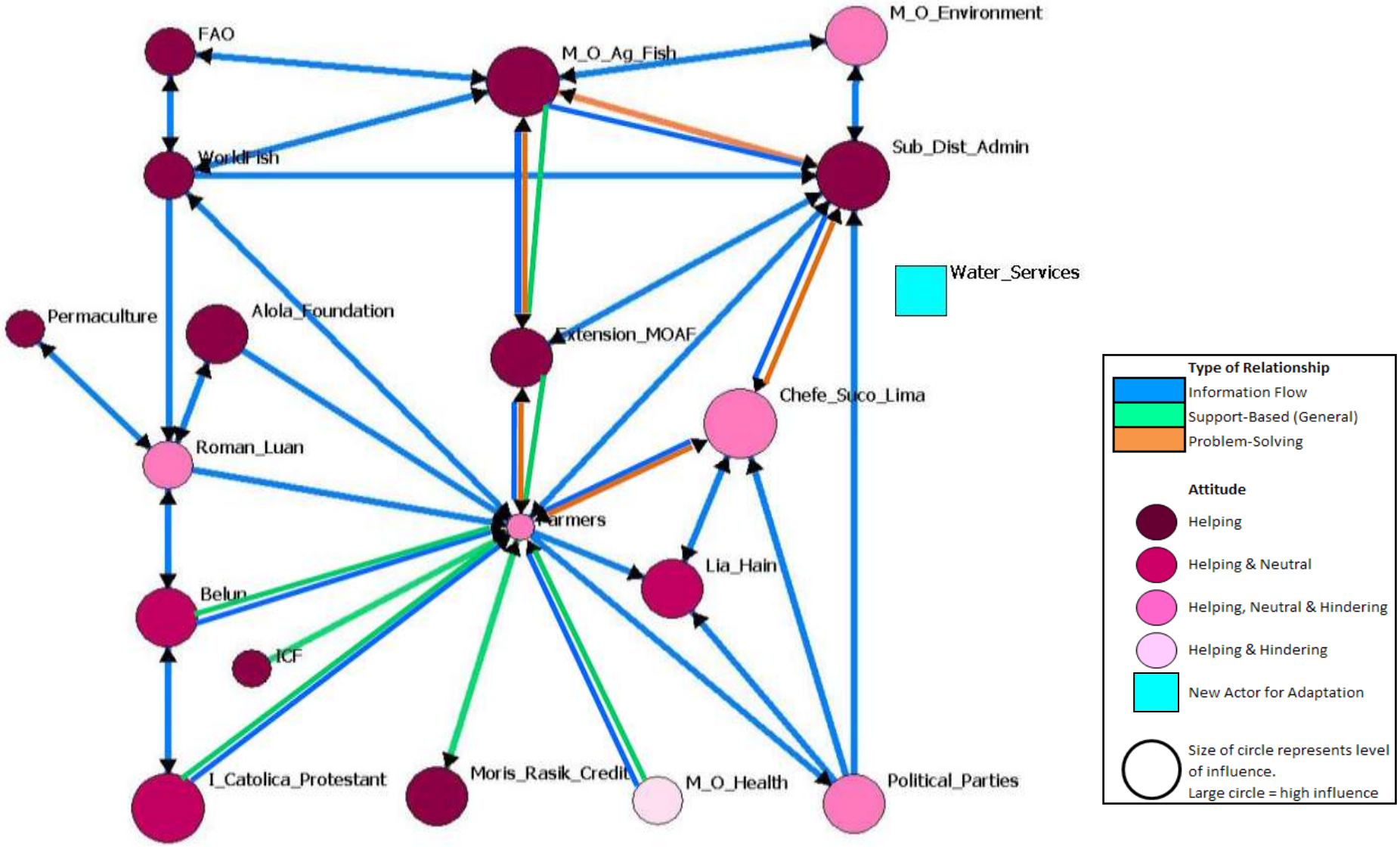

Figure 18 Social network relating to farming activities in Atauro, from the perspective of a focus group of farming-related local authority members in Atauro.

In addition to the visual networks and list of actors, we have also provided preliminary analysis of the perceived influence of the actors (Figure 20).

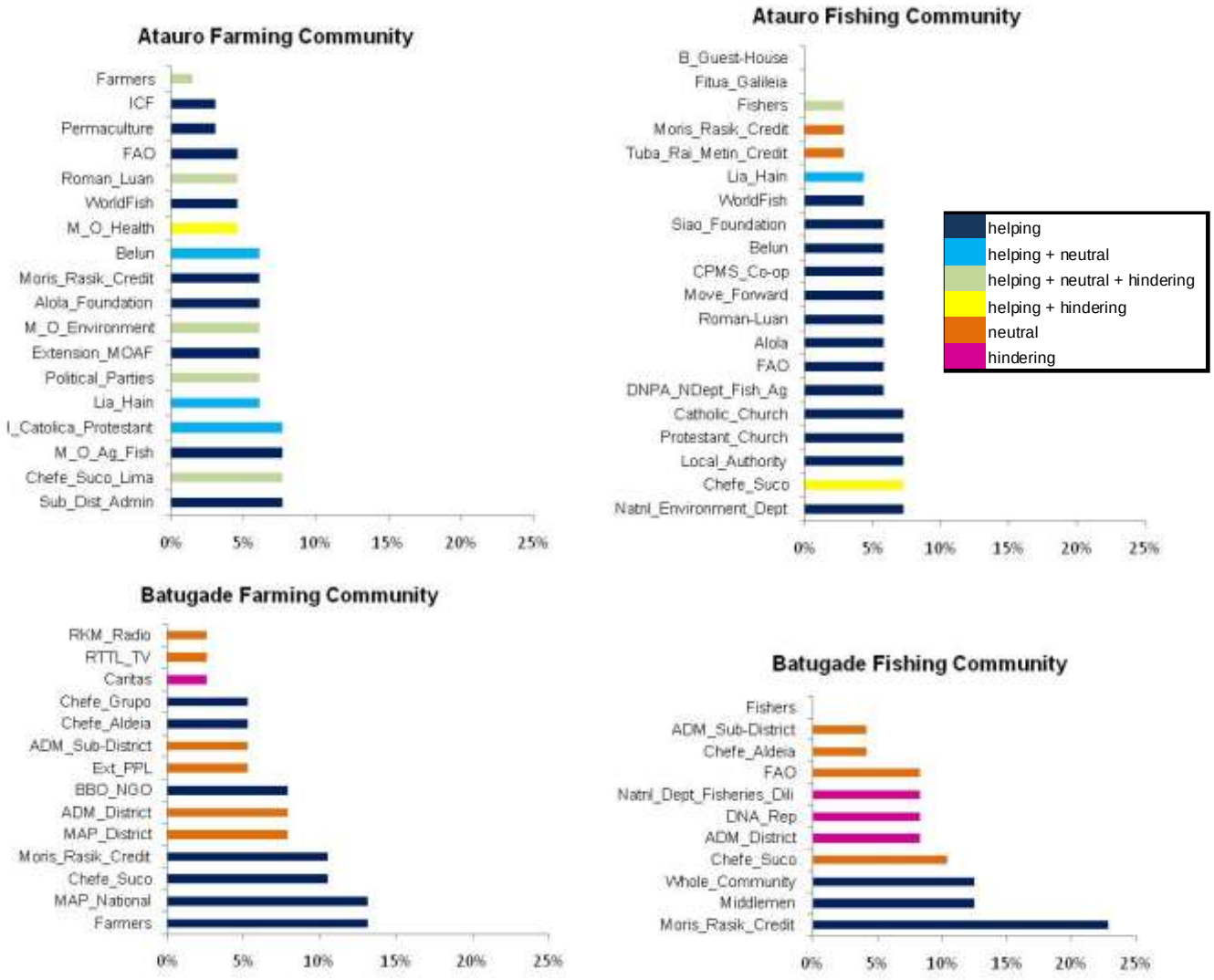

Figure 19 Influence of actors for each community. Scores are proportional and presented in percentage of influence across all actors. Colour of bars represents the attitude of each actor. See included legend for details. Dark blue represents actors who helped Fishers/Farmers achieve their goals, light blue indicates the actors who were identified as both helping and neutral, green indicates the actors who were identified as helping, neutral, and hindering, yellow indicates the actors who were identified as both helping and hindering, orange indicates the actors who were only identified as neutral, and pink indicates actors who were only identified as hindering.

From the network analysis (Figure 19) and histograms of influence (Figure 20), the following preliminary conclusions have been drawn regarding the farming networks in Atauro:

- The Sub-District Administrator, Suco Chief, Ministry of Agriculture and Fish, and the Catholic and Protestant Churches are seen as the most influential actors within the Atauro farming network. Each of these actors holds eight per cent of the total influence within the farmer network. All four were identified as helping the farmers to achieve their goals, the Suco Chiefs were reported as helping, neutral, and hindering; the Church was reported as both helping and neutral.
- Described as the centre of all information, the Sub-District Administrator receives information from the community and distributes it, and ensures programs are implemented according to the needs of the community. Though he does not have a source of funding to distribute, the Sub-District Administrator can instigate and submit proposals to the National Government. These proposals include requests for the community's seed needs for the forthcoming cropping season.
- The Suco Chiefs provide an important link between the community and above, raising information and issues from the community level up to the sub-district and district levels. Though they do not have funds to distribute, they have a role in 'making things happen' and can obtain seeds and equipment for distribution.
- The Ministry of Agriculture and Fish provide training and equipment, such as seeds and hand tractors. They also provide technical assistance and support in the form of helping implement programs.
- The Catholic and Protestant Churches provide moral guidance on how members of the community should behave. This was considered an important role because of the general lack of education.
- The Farmers of Atauro see themselves as the least influential actor in their network, with only two per cent of network influence. The attitude of the farmers was perceived as being both helpful and hindering.
- The national water services were considered important for planning, implementing and iteratively managing the collection of water (during the wet season), its storage, and delivery to crops and animals (see Section 3.3 for how this adaptation was identified as important to the farming communities of Atauro). It will be important to establish links with this national department via their local representative as they are not presently in the farmers' network.

<u>Fishing – Atauro</u>

Figure 21 shows the social network as perceived by the participating, fishing-related, local authority representatives from Atauro. Table 18 summarises the actors in the network.

Table 17 Summary of actors within Atauro fishing community. Actors identified by fishing-related, local authority representatives from Atauro as being important for decision making and successfully maintaining/improving income or food production from fishing and gleaning activities.

Atauro Fishing Community	
Actor Name	**Actor Description**
Natnl_Environment_Dept	State Secretariat Environment (National Environment Department)- has the mandate for climate change, communicates with other national departments
Tuba_Rai_Metin_Credit	Tuba Rai Metin- credit lender based in Atauro
Moris_Rasik_Credit	Moris Rasik- credit suppliers, provide only to women, fishers are only male, so they can't access this
Fishers	Fishing communities- also participate in agriculture activities
WorldFish	WorldFish Center
DNPA_NDept_Fish_Ag	National Department of Fisheries and Aquaculture
FAO	FAO- international agriculture organisation, Biqueli-based
Lia_Hain	Lia Ha'in Uma Lisan- traditional culture leaders based on Atauro
Chefe_Suco	Lider Komunitariu (Suco chiefs)- community-leaders besed in Atauro, oversee village heads
Local_Authority	Authorida de Lokal (Local Authority)- includes District Administrator, Sub-District Administrator, National Sectors-education, health, police, rural development, fisheries and agriculture
Alola	Alola Foundation- national level NGO with a base in Atauro
Roman-Luan	Roman Luan- local NGOs on Atauro
Move_Forward	Move Forward- local NGOs on Atauro
Fitua_Galileia	Fitua Galileia- shop selling fishing equipment, purely commercial
B_Guest-House	Loja Manutasi (Barry's Guest House)- business based on Atauro, brings tourists to reef
Protestant_Church	Igreja Protestant (Protestant Church)- based on Atauro
Catholic_Church	Catholic Church- based on Atauro
CPMS_Co-op	Koperativa Beata (CPMS)- cooperative baded on Atauro, provides credit to fishers
Belun	Belun- national level NGO with a base in Atauro
Siao_Foundation	Fundasaun Siao- NGO based on Atauro, similar to Rolu
FDTL_Defence_Force	F-FDTL- Timor Defence force, new actor
Maritime_Police	Maritime Police, new actor
International_Orgs	International organisations- new actor, needed to fund and train fishers

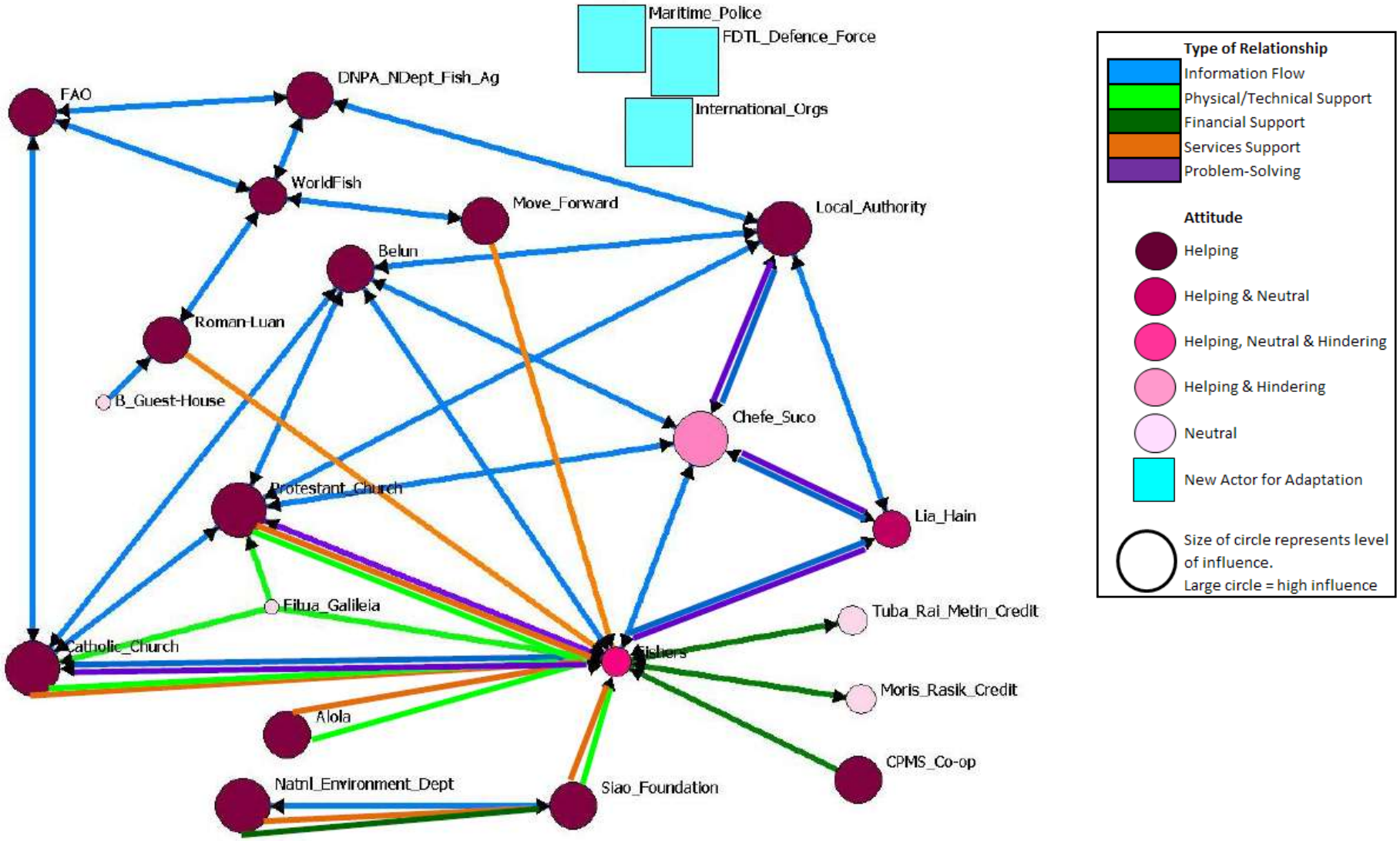

Figure 20 Social network relating to fishing activities in Atauro, from the perspective of a focus group of fishing-related local authority members in Atauro.

From the network analysis (Figure 21) and histograms of influence (Figure 20), the following preliminary conclusions have been drawn regarding the fishing network in Atauro:

- The National Environment Department, Suco Chiefs, Local Authority, Catholic Church, and Protestant Church were identified as the most influential actors within the Atauro fishing network. Each actor holds seven per cent of the total influence within the network (thirty-five per cent combined) and each was identified as helping the fishers to achieve their goals. Only the Suco Chiefs received mixed results of being both helpful and neutral in terms of facilitating/iteratively managing fishing activities.
- The National Environment Department has the mandate for climate change and communicates with other national departments, such as the National Department of Fisheries and Aquaculture.
- The Suco Chiefs are the community leaders based on Atauro who oversee the village leaders. They do not have funds of their own to distribute for fishing related adaptation.
- The Local Authority includes a number of positions and departments that the network analysis participants thought were better described as a single actor. This group includes the District Administrator, the Sub-District Administrator, and National Sectors: education, health, police, rural development, fisheries and agriculture. Based locally on Atauro this group of local authority members are a source of information for the community, especially regarding agriculture and fisheries. Though they generally do not distribute money directly, they help in skills training.
- Both the Catholic and Protestant Churches serve as an important source of moral guidance in addition to socializing information; as the community is predominantly Christian, there is the perception that when the church leaders speak people pay attention. They do not; however, distribute funds.
- The Local Authority focus group considered the fishers to be the least influential actor in their network, with only three per cent of network influence; their attitude ranged from helping to hindering.
- International organisation, the Maritime Police and the Defence Force were all considered actors needing to be integrated into the fishing network if either special regulation were implemented to enhance the condition of nearshore (coral) fisheries, or activities were undertaken to enhanced the exploitation of deep water fisheries.

<u>Farming – Batugade</u>

Figure 22 shows the social network as perceived by the participating, farming-related, local authority representatives from Batugade. Table 18 summarises the actors in the network.

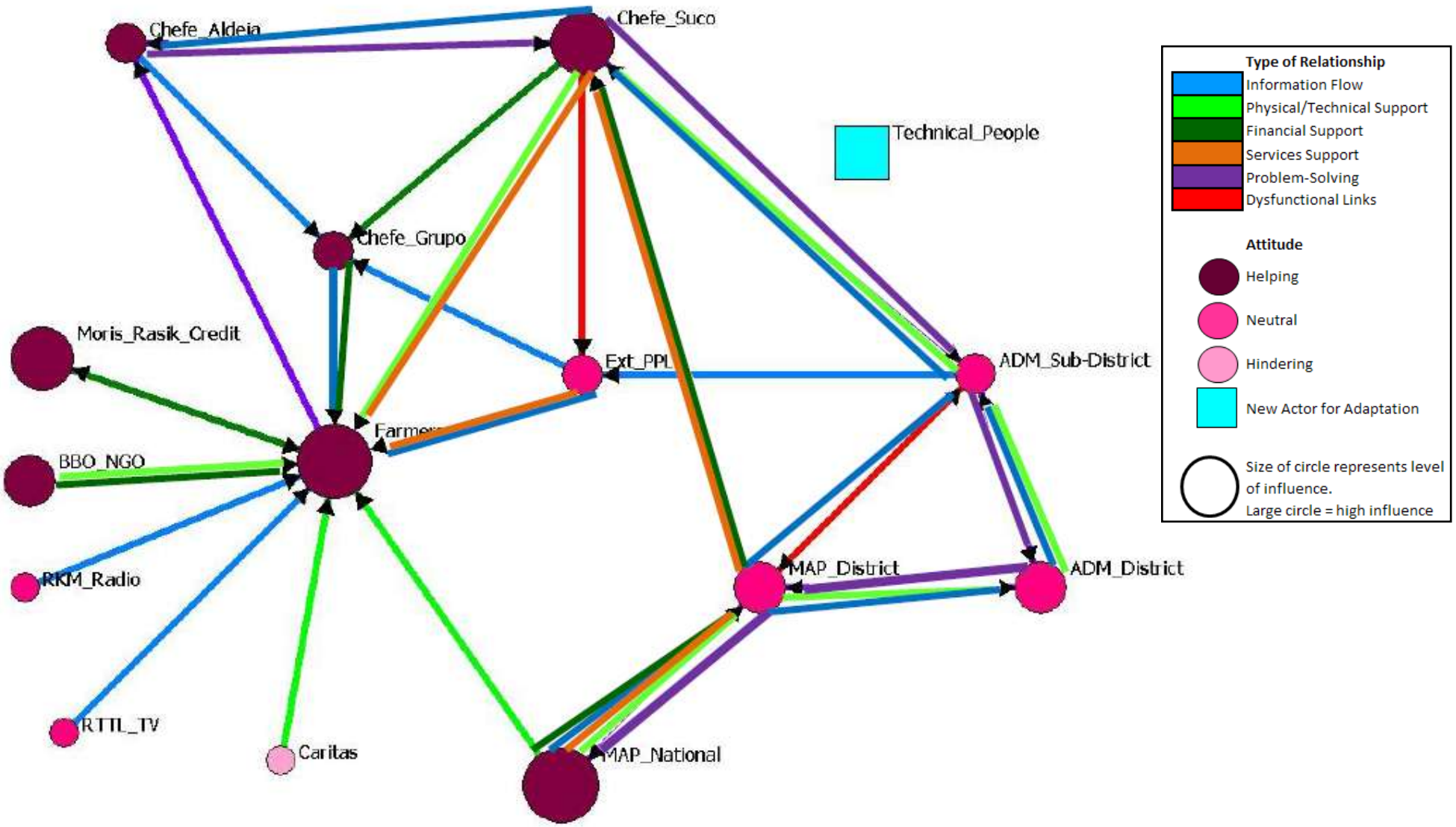

Figure 21 Social network relating to farming activities in Batugade, from the perspective of a focus group of farming-related local authority members in Batugade.

Table 18 Summary of actors within Batugade farming community. Actors identified by farming-related, local authority representatives from Batugade as being important for decision making and successfully maintaining/improving income or food production from fishing and gleaning activities.

Batugade Farming Community	
Actor Name	**Actor Description**
Farmers	Farmers
Ext_PPL	Extension Officer Ministry of Agriculture
Caritas	Australian NGO- not currently active
ADM_Sub-District	Sub-district Administrator- lives in Macadade
Chefe_Suco	Chief of the Suco- talks to everybody
Chefe_Aldeia	Chief of the village- has access to the Suco Chief
Chefe_Grupo	Head of the Agriculture Group
MAP_National	Ministry of Agriculture national level government
MAP_District	Ministry of Agriculture district level government
RTTL_TV	Television station funded by the National Government
RKM_Radio	Maliana-based radio funded by the community and NGOs.
ADM_District	District Administrator- in the lint up to the MAP_National
BBO_NGO	National NGO- have given cows, pigs and money to buy animals to farmers
Moris_Rasik_Credit	Moris Rasik- credit suppliers, provide only to women, must be repaid

From the network analysis (Figure 22) and histograms of influence (Figure 20), the following preliminary conclusions have been drawn regarding the farming network in Batugade:

- The local authority level participants in the network analysis activity identified the Ministry of Agriculture at the national level and the Farmers as the most influential actors within the Batugade farming network. Both of these actors hold thirteen per cent of the total influence within the network (twenty-six per cent combined) and each was identified as being helpful to farmers seeking to achieve their goals.

- Participants identified the national level of the Ministry of Agriculture as having control over making things happen.

- Farmers were identified as one of the two most influential actors in the network. This, in addition to their description as helpful, is in contrast to the Farmers in Atauro. (They are considered helpful because they produce food for their families and sometimes pass on food to government officials if these officials have not been able to plant crops for themselves.)

- If the farmers wish to implement sustainable farming practices (see Section 4.3.1 for how this adaptation was identified as important to the farming communities of Batugade), additional actors are considered to be needed within the farming network to provide technical knowledge.

Fishing – Batugade

Figure 23 shows the social network as perceived by the participating, fishing-related, local authority representatives from Batugade. Table 19 summarises the actors in the network.

Table 19 Actors identified by farming-related, local authority representatives from Batugade as being important for decision making and successfully maintaining/improving income or food production from fishing and gleaning activities.

Table 19 Summary of actors within Batugade fishing community.

Batugade Fishing Community	
Actor Name	**Actor Description**
Fishers	Fishers- a sub-set of the Whole_Community
Middlemen	They buy the fish off the fishermen and sell it in other locations
Chefe_Suco	Village Chiefs- connected to the community
Chefe_Aldeia	Sub-Village Chiefs- connected to the community
Whole_Community	Describes the whole village, Fishers are a sub-set of this
ADM_Sub-District	Sub-district Administrator- important in link to national level
ADM_District	District Administrator- important in link to national level
DNA_Rep	National Department of Fisheries representative- important link to national level
Natnl_Dept_Fisheries_Dili	National Department of Fisheries, Dili
Moris_Rasik_Credit	Moris Rasik- credit suppliers, provide only to women, fishers are only male, so they can't access this
FAO	FAO- international agriculture organisation, well known in the region

From the network analysis (Figure 23) and histograms of influence (Figure 20), the following preliminary conclusions have been drawn regarding the farming network in Batugade:

- The Moris Rasik credit supplier was listed as the most influential actor within the Batugade fishing network, with twenty-three per cent of total influence. Because the extension of credit is limited to women, while all fishers are men, this means that credit is channelled through the wives of fishers and middlemen. This results in the wives financially facilitating the purchase of supplies and equipment for their fisher husbands or fish from the Middlemen.

- The next most influential actors within the network are the Middlemen and the Whole Community, with thirteen per cent of total influence each (twenty-six per cent combined) and both identified as helping. The Middlemen buy fish from the fishers to sell in other locations. This provides money to the fishers. The Community also buys fish, from both the Middlemen and directly from the Fishers. Additionally, the Community helps to unload the catch when a lot of fish have been caught, so are considered helpful. Fishers give fish to Community members who help bring in the catch.

- The participants in Batugade identified the fishers as a separate actor in addition to the Whole Community. This is unlike the other four networks described above. The fishers (alone) were seen as having zero influence over their fishing decisions; however the Whole Community is identified as the second most influential actor in the network. Both the Fishers and the Whole Community are identified as helping.

- If the fishers wish to implement either of the adaptations identified in Section 4.3, no additional actors were considered necessary.

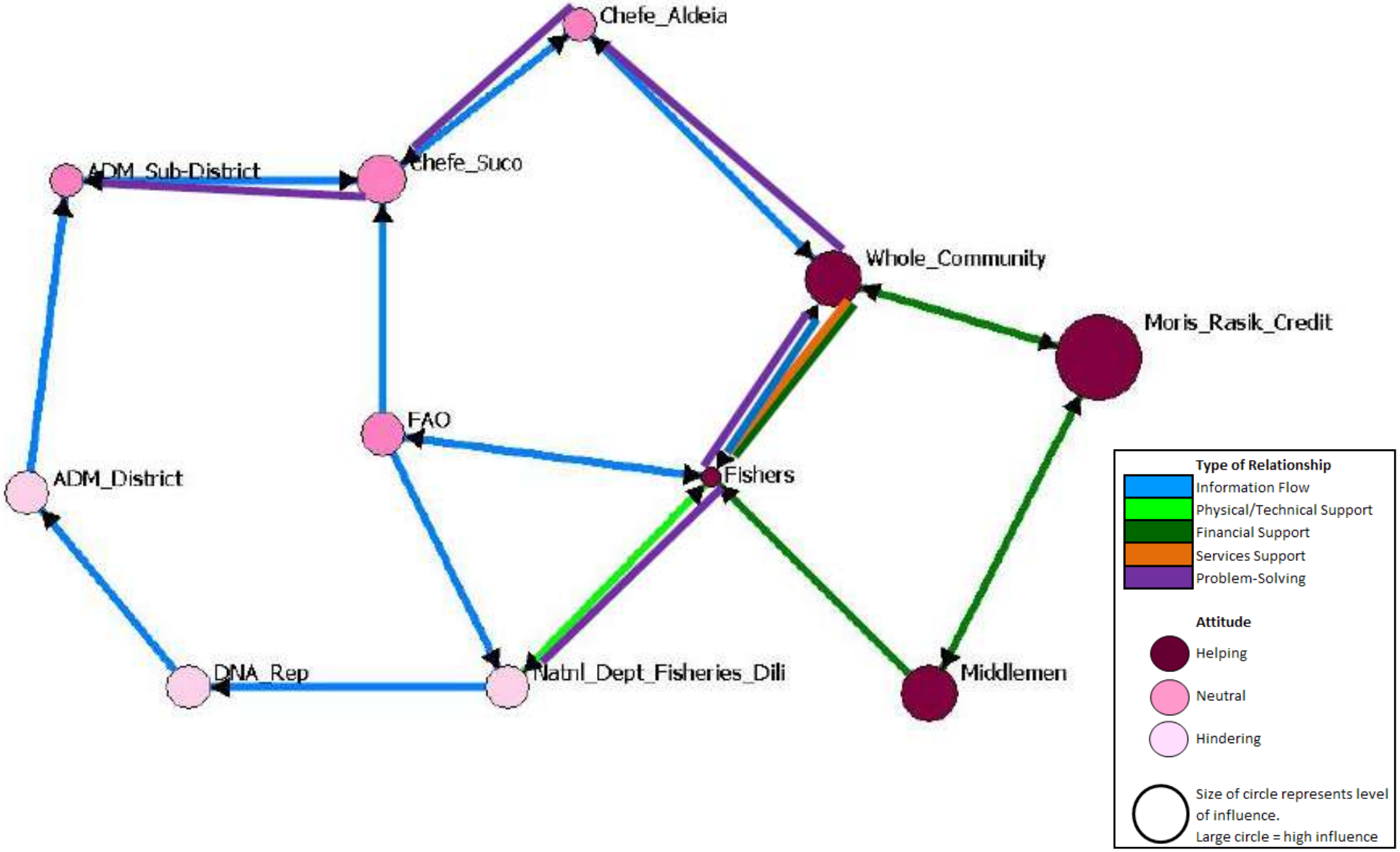

Figure 22 Social network relating to fishing activities in Batugade, from the perspective of a focus group of fishing-related local authority members in Batugade.

4.6 Evaluation of adaptation strategies from a social perspective using a governance and institutional effectiveness survey

Activity:	Governance and institutional effectiveness survey
Aim/Key question:	From a community level perspective, what is the present extent and nature of interactions aimed at supporting rural livelihoods, that occur between farmers/fishers and (i) representatives of national level ministries of farming and fishing, and (ii) NGO's?
Brief details of method:	Survey containing ten open-ended and multiple choice questions developed in collaboration with, and conducted by, in-country partners. A total of 150 fishers and farmers were included in the sample group. Data was analysed to produce descriptive statistics.
Key results:	• 55 fishers and 45 farmers in Atauro, and 19 fishers and 31 farmers in Batugade completed the survey. • There was no gender difference apparent in any of the results. <u>Rules and regulations</u> • The most commonly cited rules and regulations relating to agricultural production include not cutting down trees or destroying the forest/woodland, and not burning grass. On average, a greater proportion of farmers credited national government with rules and regulations, than traditional elders. • By far the most commonly cited rules for fishing in both Atauro and Batugade related to the need to limit practices that would deplete fish stocks or the natural resource base in some way. <u>Activities and projects in the community</u> • Whilst a greater proportion of farmers tend to see a regional extension officer more than an NGO representative around their communities, the frequency of visits by the two agents is generally similar. • Nearly two-thirds of the farmers knew of projects or activities that have been brought to their community by the national Agriculture Department. These projects more often related to physical support, but also include the provision of services. • The proportion of farmers that knew of projects or activities brought by an NGO was roughly half of that who knew about national government provided initiatives. NGO projects and activities favour physical support, but they also provide some training (i.e. service). • There were roughly equal proportions of community members seeing a regional fisheries extension officer, as those seeing an NGO representative. The frequency of visits by the two agents was also similar. • There was a wide range in the proportion of fishers (0–90%) that knew of projects or activities brought to their community by the national Fisheries and Aquaculture Department. These projects provide information, physical support and services. • Only fishers in Atauro knew of projects or activities that were brought to their communities by an NGO, (i.e. no fishers in Batugade claimed to have received such projects).

	Decision-making • Those responsible for making decisions relating to the management of land, soil, sea and rivers for farming activities, differed in the two locations; traditional elders (Lia Nain) were the main decision-makers in Atauro, whilst local authority (e.g. Chefe Suco and Chefe Aldiea) were the key decision-makers in Batugade. • Those responsible for making decisions relating to the management of land, soil, sea and rivers for fishing activities, differed markedly in the two locations; traditional elders (Lia Nain) were the main decision-makers in Atauro, whilst the national Fisheries Department was the key decision-maker in Batugade. • All farmers knew who was on their Suco Council, with the vast majority (91%) considering that they also knew what tasks the council performed. In both Atauro and Batugade, the vast majority of farmers considered the council to be doing a good job. • All fishers knew who was on their Suco Council and knew the tasks that the council performed. In both Atauro and Batugade the majority considered the council to be doing a good job.

4.6.1 Method

A short survey of ten questions was developed in participation with two members of the Atauro-based, Roman Luan NGO. The questions aimed to providing a snapshot of community-level perspectives on farmers' and fishers' interactions with the government departments and NGOs associated with providing support to rural livelihoods. A first version of the questions was established and the NGO members undertook a pilot survey with twenty respondents. The responses to the pilot survey were assessed, together with feedback from the interviewers. This assessment highlighted: (i) a number of refinements were required to the survey questions (these were largely around the need to use contextually-relevant terms and phrases), and (ii) there was a need for a more standardized procedure to be undertaken by the interviewer when asking the questions. As a result of this pilot test, a second version of the survey was produced and role-play activities conducted with the two NGO members to develop a standard interview technique. Table 20 shows the final version of the survey questions that were developed.

Communities in the two foci locations (Atauro and Batugade) were identified as target sample groups. The selection process aimed to include a range of communities with either a focus on farming or fishing. Tables 22 and 23 provides a list of the communities that were included in the survey. Before conducting the surveys in these communities, the interviewers (i.e. the two NGO members in Atauro, and a local community member in Batugade), sought permission from the local community leader (usually the Chief of the Aldeia or Suco). Once permission had been obtained, opportunities such as village market days, and the daily gathering of fishers and middlemen were used to identify and engage individual community members in the survey. Where these opportunities were not possible, the survey was conducted by visiting households. The survey responses were analysed using descriptive statistics.

Table 20 Survey questions aimed at providing a snapshot of community-level perspectives on farmers and fishers interactions with government departments and NGO's.

Question	Format of answers
Do you know of any rules or regulations that come from the national government that you must follow for using the land, soil, sea and rivers for fishing / farming activities? If so, what are they?	Open-ended
Do you know of any rules or regulations that come from Traditional elders (e.g. Lia nain) you must follow for using the land, soil, sea and rivers for fishing / farming activities? If so, what are they?	Open-ended
Have you ever seen a regional extension officer from the national Fisheries/Agriculture Department in your village? If so, how often do you normally see him?	Multiple choice [Every month / Every six months / Once a year]
Have you ever seen a NGO person in your village? If so, what NGO were they from? How often do you normally see them?	Multiple choice [Every month / Every six months / Once a year]
Do you know of any projects or activities that have been brought in to your community by the national Fisheries/Agriculture Department? If so, what were the project's and activities?	Open-ended
Do you know of any projects or activities that have been brought in to your community by an NGO? If so, what were the projects and activities?	Open-ended
Who in your community makes decisions on issues related to the land, soil, sea and rivers for fishing / farming activities?	Open-ended
Do you know who is on your Suco Council?	Multiple choice [Yes / No]
Do you know what the Suco Council does?	Open-ended
How well does the Suco Council do its job?	Multiple choice [Good / Sometimes good, sometimes no good / No good]

4.6.2 Results

A total of 150 community members completed the survey. These included 55 fishers and 45 farmers in Atauro, and 19 fishers and 31 farmers in Batugade. The distribution of fishers and farmers across the villages is shown in Table 21 and Table 22, respectively. A summary of the responses is shown in Appendix 11 (Tables 46–55). A summary of the key findings are listed below.

Table 21 Villages and number of fishers included in the sample group.

Sub-district	Suco	Aldeia	Number of fishers
Atauro	Bikeli	Dotan, Pala, Iliknamu	3, 7, 5
Atauro	Beloi	Usu Bemasu, Il Maker	5, 10
Atauro	Makili	Fatulela, Macelehu	8, 2
Atauro	Vila	Ill Iletekarquia	15
Balibo	Batugade	Batugade	5
Balibo	Batugade	Nuu Badak	14

Table 22 Villages and number of farmers included in the sample group.

Sub-district	Suco	Aldeia	Number of farmers
Atauro	Bikeli	Pala	5
Atauro	Beloi	Usu Bemasu, Il Maker	2, 3
Atauro	Makili	Fatulela	10
Atauro	Vila	Ill Iletekarquia	5
Atauro	Macadade	Anartuto, Bite	19, 1
Balibo	Balibo Vila	Fatululi	15
Balibo	Batugade	Lotan	16

General findings

- There was no gender difference apparent in any of the results.

Rules and regulations

- The most commonly cited rules and regulations relating to agricultural production include not cutting down trees or destroying the forest/woodland, and not burning grass. On average, a greater proportion of farmers credited national government with rules and regulations (87%), than traditional elders (63%) (Table 53–Table 54). Traditional elders were credited with a broader range of rules/regulations relating to agricultural production, and Tara Bandu was only cited in connection with traditional rules/regulations (i.e. not rules and regulations emanating from the national government). The proportion of people citing traditional rules is notably high (i.e. two-thirds of the respondents) as there is no official government strategy to promote Tara Bandu.
- The lack of female respondents to the fishing survey reflects the general trend for women not to be involved in fishing in Atauro or Batugade, so all respondents in the survey are from male fishers. At least 87% of the fishers interviewed from Bikeli, Beloi and Vila knew of rules or regulations from the national government relating to how they use the land, soil, sea and rivers for fishing activities (Table 58). A notably lower proportion (40%) of fishers from Makili knew about national government rules and regulations. All fishers interviewed from the Batugade location (including Balibo Suco) knew of rules and regulations. By far the most commonly cited in both Atauro and Batugade related to the need to limit practices that would deplete fish stocks or the natural resource base in some way. For example, through destructive practices, such as poisoning fish, or bombing coral, or through the use of specific fishing gear, such as spears, or small net mesh sizes.
- A generally lower percentage of fishers (72%) knew about rules or regulations from Traditional elders (e.g. Lia nain), than from the national government Fisheries Department (88%) (Table 59).
- Tara Bandu was only specifically mentioned by fishers in Batugade and Balibo, in contrast to villages in Atauro where there was no specific mention of the informal governance system.

Activities and projects in the community

- Approximately 87% of the farmers interviewed had seen a regional agricultural extension officer in their community, the frequency being roughly equal between monthly, semi-annually, and annually (Table 55). Approximately half (49%) of the farmers had seen an NGO representative in their village, the frequency being roughly equal between monthly, semi-annually, and annually (Table 56). The NGOs mentioned included: FAO, Biahula, Belun, Roman Luan, US AID, One Child Fund and Care. Whilst a greater proportion of farmers tend to see a regional extension officer more than an NGO representative, the frequency of visits by the two agents is generally similar.
- Approximately 80% of fishers from sucos in Atauro and the Balibo Suco in Batugade had seen a regional fisheries extension officer, whilst only 7% (one fisher) in the Batugade Suco had seen an officer (Table 60). In Atauro, visits by extension officers most commonly occur once a year and, somewhat curiously, approximately 25% of those fishers that had originally said they had seen an extension officer, then went on to say they had never seen one. In Batugade visits generally seem to occur more frequently (i.e. every month).
- Nearly two-thirds (59%) of the farmers knew of projects or activities that have been brought to their community by the national Agriculture Department (data not shown). These projects more often related to physical support (e.g. providing seeds, tree saplings, hand tractors and hoes), but many also provided services (e.g. ploughing the land). There was no difference between men and women's knowledge of projects and activities provided by the government.
- The proportion of farmers that knew of projects or activities brought by an NGO was roughly half (i.e. 30%) of that who knew about national government provided initiatives (data not show). Similar to national government support, NGO projects and activities favour physical support (e.g. installing rainwater tanks, providing seeds, tree saplings, and equipment), but also provide some services (e.g. training for land management, making toilets and feeding primary school children). There was no difference between men and women's knowledge of NGO provided projects and activities.

Similar to the results above for extension officer visits, fishers in Batugade (Nu Badak Aldiea) appear to see notably fewer NGO representatives than other sucos and aldieas (14%) (

- Table 61). The majority of visits in all communities are either every six months or once a year. The NGOs mentioned as visiting the communities were cited as including FOA, the Catholic Church Mission, Belun, Roman Luan and WorldFish. There were roughly equal proportions of community members seeing a regional extension officer, as those seeing an NGO representative. The frequency of visits by the two agents was also similar.
- Across the communities surveyed, there was a wide range in the proportion of fishers (0–90%) that knew of projects or activities brought to their community by the national Fisheries and Aquaculture Department (data not shown). These projects were roughly equally split between those providing information, physical support (i.e. fishing equipment such as fridges, boat motors, lamps, solar panels, nets, and boats) and services (e.g. registering of boats).
- Only fishers in Atauro knew of projects or activities that were brought to their communities by an NGO, (i.e. no fishers in Batugade had received such projects) (data not show). The services brought by the NGOs to Atauro was approximately evenly split between physical support (included maps, 'hang up' items, and equipment for farming seaweed) and services (such as training about fisheries, how to 'split' (i.e. gut) fish and farm seaweed).

Decision-making

- Those responsible for making decisions relating to the management of land, soil, sea and rivers for farming activities, differed in the two locations; traditional elders (Lia Nain) were the main decision-makers in Atauro, whilst local authority(e.g. Chefe Suco and Chefe Aldiea) were the key decision-makers in Batugade (Table 59)
- Those responsible for making decisions relating to the management of land, soil, sea and rivers for fishing activities, differed markedly in the two locations; traditional elders (Lia Nain) were the main decision-makers in Atauro, whilst the national Fisheries Department was the key decision-maker in Batugade (Table 62).
- All farmers knew who was on their Suco Council, with the vast majority (91%) considering that they also knew what tasks the council performed (data not show). These tasks included collating information from the community and passing it on to the government (sometimes in the form of proposals or reports), general administration of the village, communication, attending to community needs and promoting development, and working with the church. In both Atauro and Batugade, the vast majority of farmers (78% and 84%, respectively) considered the council to be doing a good job.
- All fishers knew who was on their Suco Council, with the vast majority (87%) considering that they also knew what tasks the council performed (data not shown). The two key tasks identified by the fishers were collating information from the community and passing it on to the government (sometimes in the form of proposals or reports), and general administration. In both Atauro and Batugade, the vast majority of respondents (85% and 87%, respectively) considered the council to be doing a good job. None of the fishers thought that the council was doing a bad job.

4.7 Evaluation of adaptation strategies from a social perspective using governance capacity analysis

Activity:	Governance capacity assessment
Aim/Key question:	What is the current governance context (formal and informal) in which farmers and fishers operate? What actions would best support the development of long term capacity to reduce community vulnerability (particularly in respect to managing the natural resource base underpinning fishing and farming livelihood)?
Key stages in method:	• Collect information on the formal and informal governance and institutional environment from: (i) semi-structured interviews with national, regional and community level stakeholders, identified through a snowball sampling strategy; (ii) literature review; (iii) network analyses (see Section 3.5); (iv) survey of fishers and farmers (Section 3.6). • Synthesize the above information using the CORE and modified PROFOR frameworks.
Key results:	<u>Overall and national level</u> • There is relative governance vacuum at the level of National and District government. Inadequate budgets, human resourcing, capacity, communications and logistics means extension functions do not provide much capacity or support to rural fishers and farmers. • Governance is in transition with projected moves towards decentralization and the creation of new municipal structures and the phasing out of the district/sub-district model. The aim is to increase the resources and services available at the local level, but the precise mechanics of this are not yet known. • It is vital for projects to work with existing formal mechanisms for service delivery and representation from national though district, sub-district and suco levels (and the emerging decentralized municipalities), but emphasis will need to be placed on building capacity of government representatives and strengthening mechanisms wherever necessary to ensure that this does not bottleneck services received by communities. • Strengthening local governance and the links to state service delivery needs to be identified as a key strategy to ensure local adaptive capacity. Supporting local agencies to gradually improve and increase service delivery is the best point of entry in order to build long term capacity. • Short term investments in service delivery and reliance on non-state actors should not undermine long term objectives of decentralization and state-building.

	Aldeia and suco level • Governance at the aldeia and suco level has considerable legitimacy, and supporting decision-making at this level is key to community adaptation. • The suco council includes chefe aldeia, women and youth representatives and a traditional elder and is clearly the essential body to engage with for adaptation interventions. • Consideration needs to be given to the long term context in which communities will need to adapt, requiring improved services and delivery mechanisms at sub-district and national levels. • It is important to consolidate a core of long-term community-development planning and monitoring (as initiated in this project) which builds ownership, increases transparency and community understanding of prioritization and budgeting processes, as well as building relations with central government. • Information provision is a relatively straightforward service that state authorities could improve with support from adaptation projects.

4.7.1 Method

The underlying principles of the approach being taken in this analysis of governance capacity are drawn from a process known as “Collaborating for Resilience” or CORE (Ratner and Smith, 2012). CORE is based on bringing key stakeholders into the assessment process to ensure that multiple perspectives are represented, that local actors have opportunities to influence each other’s understanding, and ultimately build commitments to action that would not be possible through an outsider’s analysis alone.

The CORE approach entails: active listening to deepen awareness of the problem, the possibilities, and the perspectives of different groups; sharing and debating competing points of view to ensure a full understanding of the forces at play; and, finally, narrowing in on the particular realm of actions within an individual’s or group’s control. As applied to governance assessment, these three phases focus on:

1. identifying obstacles and opportunities in the governance context (the ‘listening’ phase);
2. debating alternative courses of action, or strategies for influence to address these obstacles or take advantage of these opportunities (the ‘dialogue’ phase);
3. planning and undertaking collaborative actions (the ‘choice’ phase).

The ‘rapid’ governance assessment detailed in this section is embedded in the broader project methodology which addresses the ‘listening-phase’ and starts to address the ‘dialogue phase’ as defined by Ratner and Smith, 2012. The governance analysis in this section draws on interviews with key informants. For a list of the affiliations of key informants and for those participating in informal interviews see Appendix 16. In addition, information was drawn from other social analysis conducted in this project, namely the use of social network analysis conducted at the local authority level (Section 4.5), and the survey of governance and

institutional support conducted at the community level (Section 4.6). Ethical consent was obtained from all participants involved in providing information and data in these four studies (see Appendix 6 for an example of the consent form used).

In this governance assessment we describe and apply two analytical frameworks that allow a clear discussion of governance issues, highlighting key obstacles and opportunities and the identification of potential adaptation-related interventions. Two frameworks were selected to conduct this government assessment; the analytical framework described in CORE (Ratner and Smith 2011, Ratner 2012) and the FAO forest governance assessment tool (PROFOR 2011 Kishore and Rosenbaum 2012). For a review of these two approaches see Appendix 12. In both cases these frameworks originally include guidance on participatory diagnostic processes, which though not adhered to explicitly in this case study for Timor-Leste, are not incompatible with the 'best practice' participatory process we have used here.

In addition to CORE and PROFOR, there is an abundant literature on alternative approaches to assessing governance and a few additional points from that literature relevant to this study are summarised below. Most notable in this body of literature is a comprehensive review conducted by Pahl-Wostl (2009). This work introduces the following four dimensions as a base for analyzing the characteristics of environmental governance regimes:

- Institutions and the relationship and relative importance of formal and informal institutions;
- Actor networks with emphasis on the role and interactions of state and non-state actors;
- Multi-level interactions across administrative boundaries and vertical integration;
- Governance modes—bureaucratic hierarchies, markets, networks.

The emphasis placed on informal and formal institutions through the CORE approach (Ratner and Smith 2012) and the recognition of the nuts and bolts aspects (manpower, financial or budgetary allocations etc.) provided by PROFOR, do not appear to cover adequately the four aspects proposed by Pahl-Worstl (2009), above. More emphasis on aspects relating to levels of governance and interactions between and across these, including networks and modes of governance in the private sector, would seem warranted for the study of governance in Timor-Leste.

More broadly, governance literature suggests that a number of elements must be addressed when identifying key governance issues, and in particular in identifying the way forward in the target communities. Those conducting assessments should ensure that the participatory consultations, and particularly the analysis, include (in addition to the areas discussed above by Ratner and Smith (2012) and PROFOR) some additional consideration of:

- Functional networks for governance and information dissemination;
- Institutional capacities including budgets, human resources and limiting factors;
- Governance functions of formal and informal actors at different scales.

The approach used in this study therefore seeks to take the above into consideration, and more specifically is based on:

Characterization of governance in the target districts: The analytical framework of Ratner and Smith (2012) is used to provide a first characterization using largely inputs from primary literature and key informants. It focuses on the three dimensions of governance (i.e. stakeholder representation, distribution of authority and mechanisms of accountability).

Identification of issues and opportunities: The issues and opportunities raised by interviewees and consultees regarding resource governance were scrutinized using a modified PROFOR framework. Thus the PROFOR three pillars of governance (policy, institutional and legal frameworks; planning and decision-making processes and implementation, and finally, enforcement and compliance) were further subdivided into levels of governance: aldeia (hamlet), suco (composite village), sub-district, district, and national.

In summary, the framework of Ratner and Smith (2012) is used to assess the available legislation and secondary sources relevant to governance. The results of semi-structured targeted interviews conducted with key institutional stakeholders at local, sub-district and national level, the social network analysis conducted at the local authority level (Section 4.5), and the survey of governance and institutional support conducted at the community level (Section 4.6), together with the and community level network analysis (Abernethy et al., 2012) are assessed using a modified PROFOR framework.

Timor-Leste is divided into 13 districts, 65 sub-districts, 442 sucos and 2,336 aldeias (National Census 2010). The sucos and population addressed in this study are shown Table 23. The sucos highlighted in Table 24 identify where community members participated in the assessment.

Table 23 The sucos and population addressed in this study shown in bold.

District	Sub-district	Suco
Dili (234,026) 6 sub-districts	Atauro (8,602)	**Suco Beloi (1,774)**
		Suco Biqueli (1,656)
		Suco Macadade (1,486)
		Suco Maquili (1,946)
		Suco Vila (1,740)
Bobonaro (92,049) 6 sub-districts	Balibo (14,851)	**Suco Balibo Kota (3,892)**
		Suco Batugade (2,369)
		Suco Cová (1,570)
		Suco Leohitu (3,288)
		Suco Leolima (1,791)
		Suco Sanirin (1,931)

4.7.2 Results

Table 25 contains analysis of available legislation and secondary sources of information relevant to governance as considered using the framework of Ratner and Smith (2012).

Table 24 Characteristics of formal and informal governance mechanisms relating to community vulnerability based on desk study. Possible bottlenecks are highlighted in *bold italics* and strength and opportunities in bold.

Mechanisms	Stakeholder representation	Distribution of authority	Accountability mechanisms
Formal	National parliamentary system apportions seats to parties according to number of votes won and leads to a national rather than local constituency for elected representatives[1] **Suco council and chefe elected by list and relatively representative of local communities[1,2]** ***Representation of Suco Councils through Sub-District, District and National level is cumbersome and impedes community representation[1]*** **Women are guaranteed at least 2 representatives in the suco council[3] nearly 30% of parliamentary seats are occupied by women partly owing to a decree which requires one in every three candidates to be female[3]**	District- and sub-district-level civil servants are the closest formal state authority to the population while suco- and aldeia-level authorities are the most visible and accessible form of governance for the majority of the citizenry[4]. ***Formal authority for governance of natural resources is (de facto) centralized*** and isolated at national level owing to lack of resources and support at and below district / sub-district levels[7,8,9]. National laws on resource management exist but there is a large gap between government policy and enforcement or implementation on the ground[8,9] ***NDFA has low budget and capacity with little staff capacity at district level[7,8,9].*** **Decentralization is in progress and aims to improve the distribution of authority and increase means at a municipal level** but the way forward has yet to be adequately defined.[4] Land tenure is unclear and unsupported in policy, lacking institutionalized dispute resolution mechanisms at local level[5,6]. Coastal marine tenure is vested in the state but de fact customary tenure still exists[13] **Traditional mechanisms of resource management (e.g. tara bandu) are supported under the constitution and contemplated as a government strategy[10]** but this has not been practically tested yet[11].	Appointed district and sub-district administrators communicate directly with suco chiefs. ***The former are not clearly accountable to suco chiefs and these are not appropriately involved in the state authority[4]***. There is potential for lack of accountability between State and communities/population at large owing to the cumbersome and inadequate links between national, district, sub-district, suco and village levels[1]. Decentralization could increase accountability but may not do so if suco councils are not firmly integrated into proposed municipal structures[4].

Table 25 cont…

Informal	**Community institutions are strong, locally respected and provide the basic mechanisms for community participation and decision making[4].** Power and representation is defined to a great extent through traditional mechanisms relating to lineage and history and this determines to a great extent the leaders, elders and other stakeholders who are represented both informally and formally[4] ***Customary power relations and authority structures at the community level may limit consultation / representation of certain groups including women[3,4]***	Land and other dispute resolution mechanisms exist at local level and are recognized in the constitution. Nonstate institutions including traditional elders and chefes suco/aldeia are utilized as much if not more than police and state institutions, particularly in rural areas[12]. **Non-state dispute resolution mechanisms appear to function for fisheries conflicts[11]** but in the case of ***land these are unable to always avoid violence[5,6]*** The role of the church is important in development and has much potential in resolving disputes for instance[4]. There are relatively high levels of trust in and between communities though disputes are not uncommon[12]. **Existence of respected traditional mechanisms for resource management such as the tara bandu[11].**	Possibly the strongest accountability occurs at village level where the chefe aldeia is readily accessible to the community[1]. The chefe suco is recognized by law but not included in the Public Administration and their decisions are not binding upon the State[1,2]. Customary authority system based on lineages may leave accountability gaps for some sectors of communities[3,4]. Accountability mechanisms exist at the local level such as customary and community enforcement, conflict resolution and sanctions as well as civil society mediation – church, NGOs, networks[4]

1. Asia Foundation 2012. 2. LAW 3/2009, of 8 July 2009. 3. UN Women 2012. 4. Butterworth and Dale 2010. 5. Wright 2012. 6. ETLJB 2012. 7. Hanich and Tsamenyi 2011. 8.MAF 2012. 9.Fernandez et al. 2011. 10 MAF (draft). 11. AMSAT International 2011. 12 Dale et al 2010. 13 McWilliam 2003

The results of the semi-structured interviews, local authority level social network analyses (Section 4.5) and community level social network analysis (Abernethy et al., 2012), and a governance and institutional support survey (Section 4.6), assessed using the modified PROFOR framework, are presented in Tables 26 and 27.

Table 25 Analysis of natural resource governance issues arising at the local and informal community level using a modified PROFOR (2011) framework. Features and issues raised by interviewees (IA or IB) in Atauro and Batugade, respectively; or key informants (KI); or identified in the literature (ref). Symbols: strengths (+),weaknesses (-) and Priority Issues for action.

	Policy, regulatory, institutional and legal frameworks	Planning and decision-making processes	Implementation, enforcement and compliance
Community level (Suco and Aldeia) [largely informal]	+Persistence of locally recognized customary land and sea tenure, rules or rights [IA,IB] and examples of local rule setting (e.g. tara bandu)[IB] +Traditional and community leadership institutions strongly recognized(suco council)[IA,IB] -Tenure undocumented and potential for disputes [ref 2,3] -Suco council and aldeias do not have budget (this is projected to change [KI1]) and limited capacity [IA,IB] -Community influence on district or national policy and decision-making depends on a cumbersome chain village-suco-sub-district-district [IB,ref 1]	+Strong village and suco processes for planning, decision making[IA,IB,KI1] and dispute resolution [ref4]. Communities are clear on the role of the council and supportive. +Traditional and local knowledge is relied upon [IA,IB] +/- Provision of information from higher levels relies on effectiveness of government bodies and levels of administration as well as the chefe suco. This works better in Atauro [IA] but is deficient in Batugade [IB] -Community influence on district or national policy, decision-making and information flows susceptible to poor links between chefe suco and sub-district [IB] -Inadequate tenure system creates potential for disputes and these currently resolved locally putting pressure on local systems [ref 2,3] +Churches provide information and guidance and have potential for networking in Atauro [IA] but not in Batugade [IB]	+Customary and community implementation, enforcement, conflict resolution and sanctions are carried out. Traditional elders are key in Atauro while Chefes (suco/aldeia) were more important in Batugade [IA,IB, ref 2,4] -Inadequate or uncoordinated support from national or sub-national agencies demotivates attempts to introduce local resource management [IA,IB,KI2] -Suco councils and villages do not receive funds of their own and generally lack capacity [KI3] +Suco councils are projected to receive a yearly budget of US$50,000 or above starting in 2013 [KI1].

1. Asia Foundation 2012, 2. Wright 2012, 3. ETLJB 2012. 4. AMSAT International. KI1 - MS, KI2 - MB

Table 26 Analysis of natural resource governance issues arising at the subnational and national level using a modified PROFOR (2011) framework. Features and issues raised by interviewees (IA or IB) in Atauro and Batugade, respectively; or key informants (KI); or identified in the literature (ref). Symbols: strengths (+),weaknesses (-) and Priority Issues for action.

	Policy, regulatory, institutional and legal frameworks	Planning and decision-making processes	Implementation, enforcement and compliance
Sub-district, district and national scale [State administration]	-Land laws are unclear and lack institutionalized dispute resolution mechanisms at the local level [ref1,2]. +/-Coastal marine tenure is vested in the state but communities do exercise de facto customary rights [ref3, IA,IB] +National rules on fishing and agriculture exist and are known at the community level [IA, IB]. -Current budgets and resourcing are not adequate at national, district or sub-district needs [KI5,KI7, KI8, ref9] -Inadequate coordination mechanisms for government, NGO and donor support	+NDFA has the intention to increase support in aquaculture and coastal fisheries management (building on traditional bodies and mechanisms) [KI5, ref7] -NDFA does not currently have appropriate mechanisms or capacity to support community based management [KI4, ref6] +Agriculture extension services theoretically make provision for one officer per suco nationwide [KI7] -Inadequate flow of information from government to communities [IA,IB] +Some civil society organizations (NGOs) exist that can provide support and oversight though their engagement with government varies [IA,IB, KI7] +/- Planned decentralization moves are an opportunity but much remains to be defined [KI1] and if suco councils are not adequately included then communities may not be any better engaged in decision-making [ref7] -Challenges in handling of land disputes at the institutional level [ref1,2]	+Agriculture extension officers are active in distributing information and supervising projects, NGOs are also active but considerably less [IA,IB]. +/-Fisheries extension officer in Atauro is relatively active while in Batugade he is not perceived to be active [IA,IB]. -Effective fisheries extension is challenged by lack of rurally based staff, finance, logistics and low capacity [IA,ref4, 5] as well as low salaries and lack of direct support to state staff KI7 -Despite knowledge of national laws communities do not necessarily comply [IA,IB,KI3], this may be because the basis or intent of the laws is not understood [KI2] and/or they are not integrated into community or customary processes [ref4]. -Challenges for district or sub-district coordination or support for resource management, land use planning, extension services include financial resources, communications and staffing [KI1] +National departments of fisheries and agriculture are undergoing institutional strengthening and capacity building to provide better local services [KI7,KI6,ref5,6]

1. Wright 2012. 2. ETLJB 2012. 3. McWilliam 2003 4. AMSAT International 2011. 5. MAF 2012. 6. Fernandez et al. 2011. 7. Butterworth and Dale 2010. 8. MAF (draft) Strategic Plan. 9. GOTL.2010. Budget 2010

4.7.3 Discussion

The assessment recognizes the distinct differences in governance at various levels, namely local community, sub-district/district and national. In addition, the long timeframe over which adaptation is developed and supported suggests that potential adaptation strategies need to consider not only the current governance context but also its evolution and how to build or sustain appropriate supportive governance into the future. Thus the identification of issues includes consideration of the temporal as well as the spatial dimensions.

4.7.4 Overall and national level

There is relative governance vacuum at the level of National and District government. This is particularly visible in the fisheries sector, but also to some extent in the agriculture extension services - extension functions are poorly resourced and limited in their scope and do not provide much capacity or support to rural fishers and farmers. Inadequate budgets, human resourcing, capacity, communications and logistics are at the heart of this obstacle.

The aldeia and suco level has considerable legitimacy and supporting decision-making at this level and is key to community adaptation. There is a large body of project implementation experience to draw on at this level, however the long term processes implied by climate change will require building long term support, particularly from government service providers, which is not usually contemplated under project modalities. Thus, though the short term actions will be carried out by communities, an appropriate long term context in which these evolve and are improved or spread will require improved services and delivery mechanisms at sub-district and national levels.

Governance is in transition with the projected moves towards decentralization and the creation of new municipal structures and the phasing out of the District/sub-district model. The aim is to increase the resources and services available at the local level but the precise mechanics of this are not yet known; nor are the 5 pilot areas which will lead the way in 2013. This process will be both a challenge and an opportunity and may increase the burden on district governance processes overall while potentially allowing an opportunity for municipal governance to include elements essential to adaptation, resource management and extension services.

4.7.4.1 Immediate strategic considerations

It is vital for projects to work with existing formal mechanisms for service delivery and representation from national though district, sub-district and suco levels (and the emerging decentralized municipalities) but emphasis will need to be placed on building capacity of government representatives and strengthening mechanisms wherever necessary to ensure that this does not bottleneck services received by communities.

4.7.4.2 Long term strategic considerations

The long term adaptive capacity of communities will require timely and responsive inputs from government service deliverers over the long term and far beyond the life of projects. The capacity building and institutional strengthening that is required to ensure short term success must be placed in the context of developing institutions and mechanisms that can fulfill these roles into the future.

The process of institutional strengthening and human resource development that the NDFA is embarking on and, more broadly, the national policy of decentralization to the municipal level are examples of two long term governance initiatives that need to be considered and integrated into project strategies.

Strengthening local governance and the links to state service delivery need to be identified as a key strategy to ensure local adaptive capacity. A careful balance needs to be achieved as ignoring informal non-state authorities can considerably undermine any effort to reform local governance, whereas exclusive reliance on non-state authorities in service delivery can undermine efforts to strengthen state capacity and legitimacy in local arenas (Kyed and Engberg 2008).

Supporting local agencies to gradually improve and increase service delivery is the best point of entry in order to build long term capacity, these services could be those the adaptation initiative envisages, providing they are relatively modest and within the expected future scope of work of such agencies. Short term investments in service delivery and reliance on non-state actors should not undermine long term objectives of decentralization and state-building (Kyed and Engberg 2008).

4.7.5 Aldeia and suco level

The suco council and in particular the chief suco is considered to be the most important stakeholder for the various governance functions including decision-making, representation and communication. The potential role of the chief suco in liaising with government and ensuring a flow of information to communities is so vital that a poorly performing chief suco can be a major impediment to community adaptation.

Chief aldeia have high accountability to, and communication with, hamlet inhabitants and this would be vital to the successful planning and enforcement of community based natural resource management but alone may be insufficiently connected to higher levels of governance.

Customary power relations and authority structures at the community level may limit consultation, representation and information flow concerning certain groups (including women) which may disadvantage these or reduce cohesiveness for joint implementation or enforcement. In addition, inadequate composition of and engagement with local project committees in past interventions was cited as a major impediment.

Traditional elders have important roles including traditional knowledge and authority, many of their functions may not be explicit to outsiders[1] but nonetheless vital to successful adaptation or project implementation. Traditional elders will be vital to the imposition and enforcement of custom based management rules and potentially in the resolution of conflicts arising.

[1] This might explain the fact that the LiaNain are not mentioned consistently between network mappings eg Abernethy in Batugade but not Atauro and the more recent mapping the reverse.

4.7.5.1 Strategic considerations

The suco council includes chefe aldeia, women and youth representatives and a traditional elder and is clearly the essential body to engage with for adaptation interventions. Though chefe suco would frequently be the only contact with interventions, close care is needed to ensure that the council is functioning and that information is flowing between aldeia inhabitants, their chefe, women, elders and the chefe suco. This may require engaging directly with the council and/or building the chefe and council members' capacity to perform their expected functions. The capacity and performance of the chefe suco needs to be carefully assessed and monitored.

Where separate project committees are formed it will be essential to ensure that the appropriate representatives are chosen and that these match the aldeia and suco structure as well as including the key representatives from other stakeholders. Agriculture and related interventions may be able to build directly on the existing system of agricultural extension that delivers directly to suco level.

Community based management of common resources such as fisheries or water will need careful attention to interactions between villagers, chefe aldeia and chefe suco/suco council. Probably this will require careful inclusion and empowerment of the local community along with the appropriate traditional elders as well in addition to the suco council and chefe. Though the chefe is a key figure, enforcement and implementation will be highly reliant on the local community having ownership of the intervention as they will be the most affected.

It is important to consolidate a core of long-term community-development planning and monitoring (as initiated in this project) which builds ownership, increases transparency and community understanding of prioritization and budgeting processes as well as builds relations with central government (cf. Butterworth and Dale 2010).

4.7.5.2 Balibo[2]

Results from Balibo indicate that there will need to be a particularly high degree of attention placed on building linkages between the suco council and the aldeias represented and also between the suco and the sub-district administrator as there appears to be little interaction with national and district levels. Increased capacity may well be vital at all these levels.

4.7.6 Sub-district and district level

The district and sub-district administration are the formal state authority connection with communities. This conduit and its evolution into a decentralized municipal structure is vital for the provision and coordination of services and other governance aspects like representation and accountability.

[2] Abernethy et al 2012 report: Table 2–3—Important stakeholders to include in decisions related to water and fisheries in Atauro and Balibo suggests that the emphasis placed in network mapping on suco/aldeia chefes in Atauro is not matched in Balibo. Network maps (Fig 16 et seq.) suggest that the representative of the fishers has more of a role in Batugade than chefe suco and this latter has similar status to the chefe aldeia. The sub-district administrator is not mentioned in Batugade.

Communities consistently emphasized the importance of ensuring access to information. Provision of information would appear to be a basic function of the sub-district administration and the other government services that should coordinate with the sub-district administrator.

4.7.6.1 Strategic considerations

The evolving institutions are an opportunity to ensure that adaptation and natural resource management are better integrated into the sub-district strategies. Integrating customary rules developed at the aldeia and suco level into sub-district regulations may be a first opportunity and marine resource management / MPAs were considered a good place to start given community interest (AMSAT International, Sub-district administrator Atauro).

Information provision is a relatively straightforward service that state authorities could improve with support from adaptation projects. This could include an active sub-district information office using a range of communication techniques (Butterworth and Dale 2010) and would allow staff and institutions to improve capacity for planning and service delivery while supporting the adaptation activities. Related to this would be a slightly more challenging initiative exploring how to ensure that sub-districts improve their communications with district and national government ensuring community information does filter back up.

4.7.6.2 Balibo

Notable differences in results between Balibo and Atauro suggest that in the former the apparently lower reliance on sub-district administrator, suco chefes and traditional elders may need closer examination.

4.8 Evaluation of adaptation strategies from an environmental perspective using Landscape Function Analysis

Activity:	Landscape Function Analysis (LFA)
Aim/Key question:	What is the current status of the natural resources underpinning agricultural production? From this baseline, identifying a range of simple management options which communities can use to increase the sustainability of their farming systems, and looking at how ecological function may change as a result of implementing these.
Brief details of method:	Identify the various types of home gardens that occur commonly throughout the focal regions (four were identified each for Batugade and Atauro—the four types in each location representing a point along a gradient of management intensification/modification). Soil function (i.e. soil structure stability, nutrient cycling and water infiltration/run-off) was assessed using Landscape Function Analysis (LFA). LFA uses a range of simple visual assessment methods in order to assess the function of a land use or natural system. Replicate transects were established in each garden type and the following data were collected: • Landscape arrangement of each land use element along the transect—this was used to examine the question of which garden type had the greatest structural and compositional diversity, and is related to resistant and resilience to threats; • Land use (garden) function from the perspectives of soil stability, nutrients and infiltration—this examines the question of which garden type functions more effectively, and which are most vulnerable to threats or reduced function, and therefore require adaptive intervention; • The contribution to function of each element within a garden type—this examines the question of which specific components of the gardens contribute to, or detract from, each function (soil stability, nutrients, infiltration), thus indicating which should be further adopted, modified or reduced as part of adaptation actions.
Key results:	Batugade: • Landscape arrangement—perennial gardens and native woodland were more structurally and compositionally diverse than the plantation and the annual garden. • Landscape function—nutrient cycling and water infiltration greatest in plantation and perennial gardens and low in annual garden; soil stability highest in plantation and woodland, perennial garden consistently higher function index score than annual gardens. • Landscape element function—leaf litter and crop trash contributed greatly to all functions, bare ground detracted from all functions, perennial crops very effective at maintaining soil structure (e.g. through root architecture).

	Atauro: • Landscape arrangement—perennial village gardens and perennial hills gardens both exhibited similar diversity of composition and structure (hills garden had more bare ground), and both appeared more diverse than the fallow gardens. • Landscape function—All three land use types appear to function well, fallow garden exhibits marginally more function than other garden types, village gardens show marginally better function than hills perennial garden. • Landscape element function—bare soil detracts from function; leaf litter, crop trash, dead wood all contribute to function, banana leaves (as litter), in particular, contribute to function .
Recommen-dations	Batugade: Landscape arrangement: • Continue to manage perennial gardens as a resilient food source and potential source of natural pest control; • Improve spatial juxtaposition of perennial and annual gardens in order to increase natural pest control in annual gardens; • Introduce greater complexity (e.g. more plant types, intercrops, tree cover) into annual gardens. Landscape function: • Introduce elements of perennial garden (e.g. less bare ground cover, greater diversity, litter cover) into annual gardens; • Plantation under-utilised, trial shade-tolerant perennial crops as an understorey component in plantations. Landscape element function: • Increase ground cover in annual gardens, through introducing leaf litter, canopy cover, mulching with leaf litter, composting leaf litter (e.g. from plantations); • Reduce bare ground in annual gardens; • Better integrate livestock management into cropping (e.g. chickens for manure and pest removal); • Improve water harvesting (during wet season), storage and distribution, especially in annual gardens; • Retain leaf litter and crop trash; • Do not burn off ground cover post-harvest; • Increase maize use, as may be more drought tolerant; • Avoid overgrazing with livestock in native vegetation; • Use coarse woody debris to intercept resources flowing out of production systems. Atauro: Landscape arrangement: • Continue to manage perennial gardens as a resilient food source and potential source of natural pest control, pollination, etc; • Avoid the loss of perennial gardens from the production system. Landscape function: • Reduce bare ground, increase litter cover, better integrate livestock (e.g. for manure, pest control, weed removal), cease garden burning

	post-harvest, determine optimum period for cropping and fallow, improve water harvesting storage and distribution. Landscape element function: • Reduce bare ground cover, increase leaf litter, crop trash cover, use banana leaves as cover, mulch and compost, use woody debris to intercept resource flows.

4.8.1 Background to LFA and the importance of considering 'function'

A traditional form of agricultural production that occurs throughout much of the tropics, including Timor-Leste, is the tropical home garden. Tropical gardens vary greatly in different world regions, but are generally of small size, relatively proximate to dwellings (often adjacent), are intensively managed, are cultivated several times per year, and are highly diverse botanically (containing a range of perennial and annual plants) and structurally (often consisting of several vertical layers (Niñez, 1985)). According to the same author, such gardens provide a number of essential functions for communities, including:

- Producing large amounts of food with marginal labour on land too small for other agriculture;
- Supply of nutrients generally lacking on production land;
- Providing food in non-farm settings, aiding food distribution;
- Augmentation/support of other agriculture (e.g. in times of crop failure);
- Providing animal fodder and other household items (e.g. firewood, fencing materials);

The similarity between the home garden and native vegetation in terms of a) composition, b) structure and, perhaps most importantly, c) function, has been highlighted by a number of authors, including Niñez (1985), Soemarwoto et al. (1985) and Gliessman (1992). Features, identified by these authors, that confer robust ecological function on tropical home gardens include:

- Extremely high botanical diversity—e.g. 179 plant species identified in gardens in Banten, West Java;
- Very high diversity 'weed' species also exhibited; used extensively by communities (e.g. as medicinal plants);
- Low incidence of pest (e.g. insect herbivore) outbreaks, despite lack of pesticide use by communities. 'Natural' forms of nitrification in form of (domestic) animals frequenting gardens and defecating, and through build-up of leaf litter;
- Opportunities for daily harvest of produce rather than complete periodic harvest;
- Continual ground cover, thus leading to a) reduced water loss, b) increased soil nutrients, c) increased diversity and densities of beneficial insects and other arthropods, d) very low levels of soil erosion.

Not only do the 'native vegetation-like' aspects of the home gardens render the gardens themselves more resistant and resilient to impacts, but they may also: a) confer function (e.g. pest control, pollination) on nearby monocropping systems, b) reduce negative impacts (e.g. agrochemical drift on adjacent communities, native habitats and waterways/water sources, and c) provide habitat for a range of native fauna species (e.g. insectivorous birds and microbats).

Assessing the functional attributes of garden types.

One of the most successful aspects of home gardens is their purported high level of ecological function. Why and how the gardens function so effectively in many instances, which components of the gardens contribute the most to different ecological functions, how best to manage gardens for a) persistence and b) increased yield (but, crucially, not at the expense of function), and understanding the threats to gardens and their functions, are all important areas for research (Kumar and Nair, 2004). The aim of our research is to examine the environmental condition and function of home gardens in two locations in East Timor, using a method developed in Australia, called Landscape Function Analysis (LFA). The LFA approach will be used to:

- Determine a baseline of condition/function in garden types of increasing intensification. This is especially important when attempting to determine possible trajectories of condition/function change in response to either changes caused by climate change, or changes attributable to adaptation strategies undertaken by the community in order to adapt to climate change.
- Determine which individual components or elements of each garden type contribute the most/least to specific ecological functions. This is important in making recommendations as to which components of a garden might be better minimised and which should be encouraged or expanded.
- Establish which garden types are the most structurally and compositionally diverse, in order to inform which garden types might be the most resistant and resilient to perturbations.

4.8.2 Method

Landscape function analysis (LFA) is a monitoring procedure that uses rapidly acquired field-assessed indicators to assess the biogeochemical functioning of landscapes at the hillslope scale' (Tongway and Hindley, 2004). LFA provides simple measures of vegetation cover and soil structure to assess how well an ecosystem works in terms of: i) stability of soil structure, ii) nutrient cycling and iii) water movement (e.g. moving into soil or surface run-off). LFA measures whether resources (e.g. water, nutrients) are kept in a system (a functioning system) or lost from a system (a less functional system). LFA can be used to measure the current health or function of a system and then track changes to that system's health over time (through repeated measuring). LFA is based on three basic questions: i) what are the components of the landscape (e.g. different land uses, vegetation types, habitats), ii) how do they fit together (what is their pattern), and iii) how do they work together (process and function)?

The LFA consist of two broad stages of data collection and analysis:

- The arrangement or organisation of the landscape. This is a quantitative description of the landscape that describes the type, number, length and width of each landscape element. Landscape elements are divided into two types: patches, that intercept or store resources (e.g. leaf litter, woody debris, vegetation) and inter-patches, generally represented by bare soil, where resources are lost.

- The ‘function’ or ‘health’ of each landscape element from the perspective of: i) nutrient cycling, ii) soil stability and iii) water infiltration. The individual measures are described in the field process, below.

The data was then put into a specially developed MS Excel table that calculates the scores for soil stability, nutrient cycling and water movement. Finally, an interpretation tool interprets the scores in terms of system function, system vulnerability and on-ground management options.

We followed the methods detailed in Tongway and Hindley (2004), ‘Landscape Function Analysis: Procedures for Monitoring and Assessing Landscapes’ (http://www.csiro.au/en/Organisation-Structure/Divisions/Ecosystem-Sciences/EcosystemFunctionAnalysis.aspx). A summary of the process for assessment is contained in Appendix 17.

Statistical analysis

Overall function. The total LFA index score for each function (stability, infiltration, nutrients) and for each transect within a land use/garden type (e.g. annual garden), was averaged to provide a mean score for each function for each garden type. These scores were then plotted for Batugade (where there was no replication other than the within-site transects) with the standard error of the mean between transects calculated in order to illustrate within-site variability. For Atauro, the mean of each function for each site was calculated for each replicate of a treatment (n = 3). Standard error of the mean was calculated for each treatment to indicate among site variability. No statistical analysis could be conducted for Batugade due to lack of replication.

For Atauro, one way analysis of variance (ANOVA) was calculated for each function (stability, infiltration, nutrients) in order to determine if there were any among land use differences in function. Where a significant difference was found, t-tests were used to determine which land uses differed from one another.

Landscape element contribution to function. In order to identify how much the individual landscape elements, within a land use/garden type, contributed to each of the three measured functions, we calculated the mean function score for each landscape element. For Batugade we calculated the mean score for each element for soil stability, nutrient cycling and infiltration for each land use/garden type, by taking the mean of all transects (two, except for native vegetation, which had three transects) within a land use/garden type. The standard error of the mean for each landscape element was also calculated to illustrate variability between transects.

The same procedure was conducted for Atauro, with exception that the mean of each site was calculated (n = 3). Standard error of the mean was calculated to illustrate variability among sites. No statistical analyses were conducted for Batugade or Atauro due to a) lack of replication in case of Batugade, and b) low sample size for many landscape elements in Atauro (many landscape elements were not present at all three replicates with a land use/garden type; thus n = ≤2.

Simpson's 1-D Diversity index. In order to examine the compositional and structural complexity of each land use/garden type, we used the following formula to calculate D for each set of landscape elements within a transect:

$$D = (\Sigma n*(n-1))/(n*(n-1))$$

where n is the sum of all occurrences of each landscape element within a transect.

The Simpson's 1-D index is then simply calculated using 1-D.The mean scores for Batugade were calculated using the mean of each transect within each land use/garden type. Standard error of the mean was also calculated to depict variability. The mean scores for Atauro were calculated using the mean transect scores for each site for each land use/garden type (n = 3). Standard error of the mean was also calculated.

No statistics were undertaken on land use diversity for Batugade due to lack of replication. For Atauro, one way analysis of variance (ANOVA) was calculated for each land use/garden type in order to determine if there were any among land use differences in diversity

4.8.3 Results—Batugade

4.8.3.1 Land use types—Batugade

In Batugade, four landscape/land use types were sampled, representing a gradient of land use intensification from native vegetation (woodland) to frequently tended gardens consisting of annual crops (e.g. vegetables). The four landscape/land use types sampled were:

*Annual crop garden (*Figure 23*)*—an actively and frequently managed garden of annual crops such as lettuces, tomatoes and chillies. Crop species planted in rows, generally segregated, but also paired as intercrops. There are considerable areas of bare soil between vegetable beds. Tree cover is very sparse, with leaf litter from trees adjoining the garden. Garden is management intensive with frequent watering of plants. This land use type provides a year round food supply of annual vegetables and fruit and is situated only a few metres from the family house.

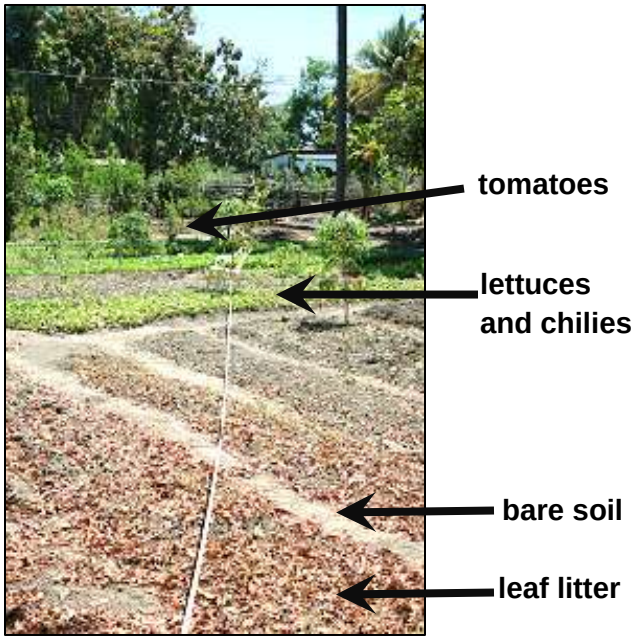

Figure 23 Transect #1 of annual crop garden in Batugade.

Perennial crop garden (Figure 24)—an actively planted and managed garden of perennial crops such as cassava, tunis beans and mangos, as well as annual crops (e.g. maize). Different species intermixed with bare soil occurring sporadically and non-uniformly, hence far greater ground cover than annual gardens. Woody vegetation cover dense, but largely consisting of perennial tree crop plants (e.g. cassava) or volunteer acacias. All trees were below 2.5 m in height and with breast height diameter less than 12 cm. High level of leaf litter/crop trash were present. This land use type provides a food supply of perennial vegetables and fruit, as well as maize. Volunteer native acacias provide nitrogen for the soil. The garden is situated only a few metres from the family house and adjoining the annual garden.

Figure 24 Transect #2 of perennial crop garden in Batugade.

Old plantation (Figure 25)—timber plantation, dominated by tree species for building construction. Palm wine trees also present. Very high density of leaf litter and moderate degree of coarse woody debris. Relatively high tree stem density and accordingly high canopy cover. Tree diameter at breast height often > 70 cm. Low heterogeneity in vegetation composition and structure. Presence of domestic pigs likely to lead to soil disturbance, vegetation breakdown and nutrient enrichment. This land use type provides hardwoods (growing to 10+ m in height in 30 years) for building construction. It also provides firewood and foraging for domestic pigs. The garden is situated about 70 m from the family house.

Figure 25 Transect #1 of old plantation in Batugade.

Native vegetation—open woodland with scattered tree cover or groves of trees with open areas of grass and/or low shrubs. Dominant tree species is palm wine tree (Figure 26 and Figure 27). Dominant shrub species is native castor oil shrub. Extremely high vegetation structural heterogeneity. Bare soil present in areas that are used as human tracks and areas that are heavily grazed by domestic goats. Domestic pigs also present, Tree DBH ('diameter at breast height') generally high. This land use type provides firewood and foraging for domestic pigs and goats.

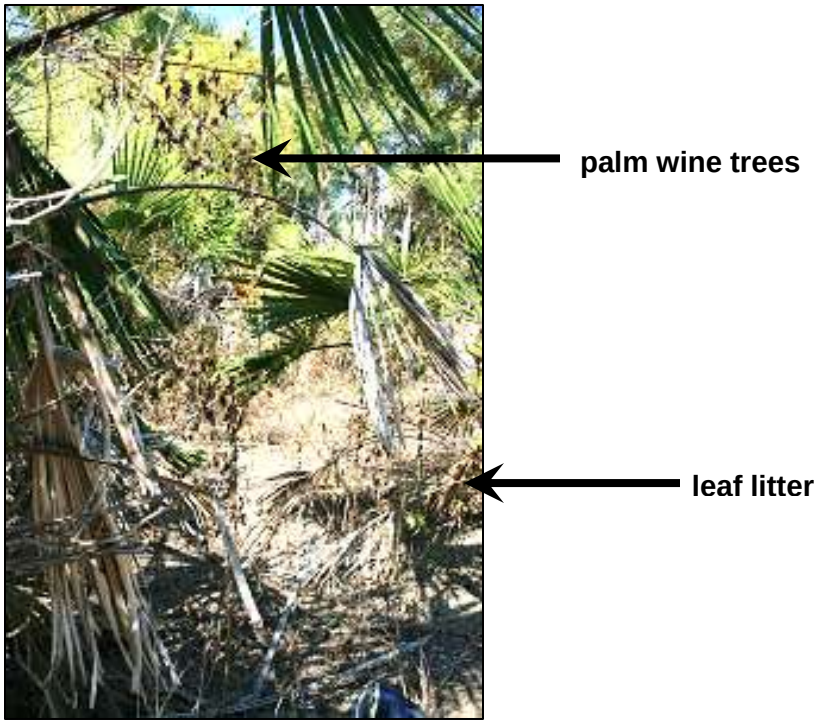

Figure 26 Transect #1 of native vegetation in Batugade.

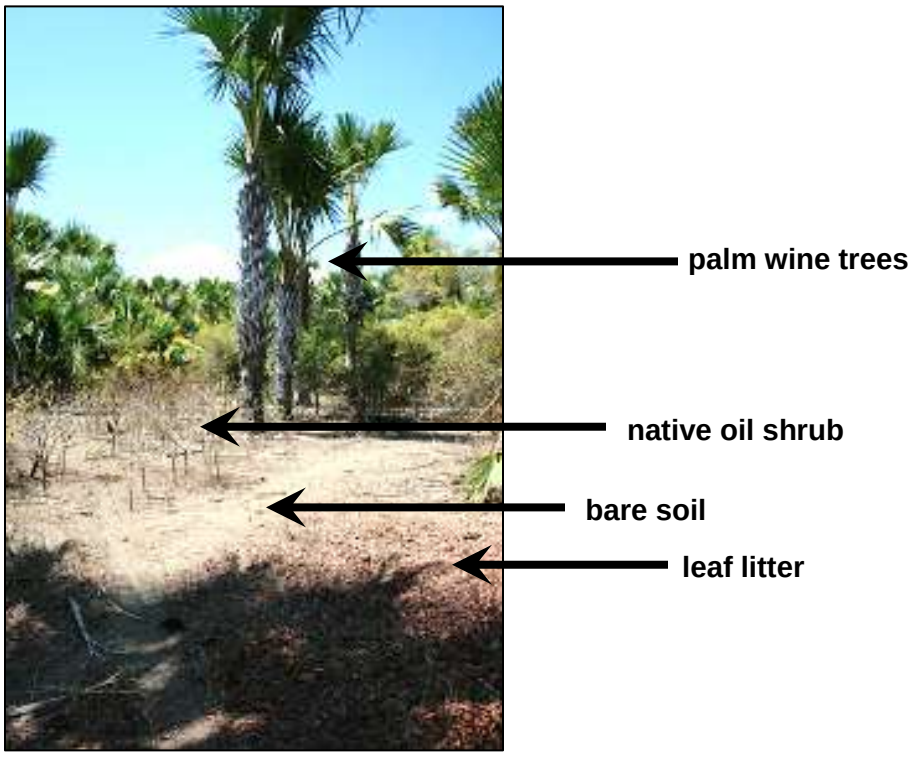

Figure 27 Transect #2 of native vegetation in Batugade.

4.8.3.2 *Landscape arrangement*

The structure and composition of each land use type is very different in terms of: (a) the number of different landscape elements that are contained in the land use type, and (b) the uniformity with which they are arranged. Figure 28–32 depict the diversity of one transect of each land use type, with the spatial arrangement of landscape elements within a transect depicted to relative scale.

The landscape arrangement of the annual garden (Figure 28) is relatively simple (few landscape elements, arranged in a relatively uniform pattern).

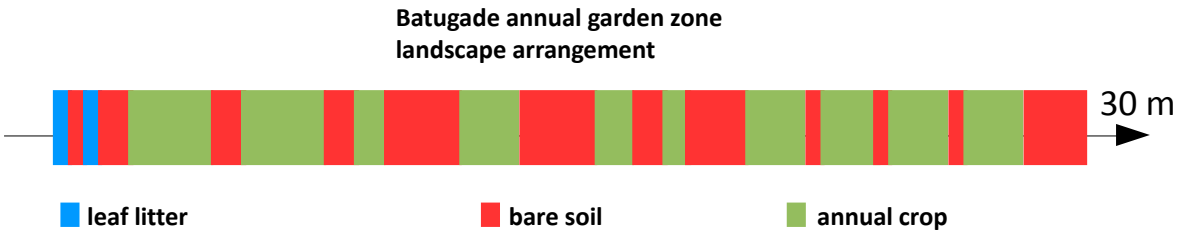

Figure 28 Landscape arrangement of annual crop garden (transect #1) in Batugade.

The landscape arrangement of the perennial garden is relatively complex (Figure 29) when compared to the landscape arrangement of the annual garden (six landscape elements as compared to three, arranged in a non-uniform pattern). It shows similarities with the native vegetation landscape arrangement in terms of several landscape elements and rapidly changing element spatial arrangement over a relatively short distance.

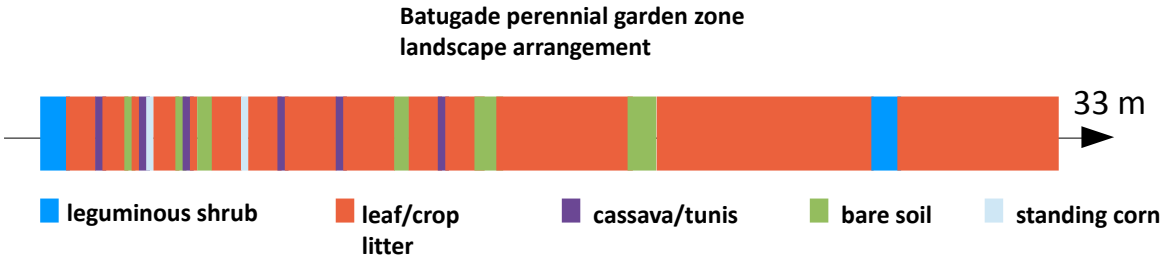

Figure 29 Landscape arrangement of perennial crop garden (transect #2) in Batugade.

The landscape arrangement of the old plantation (Figure 30) is relatively simple (few landscape elements, arranged in a relatively non-uniform pattern).

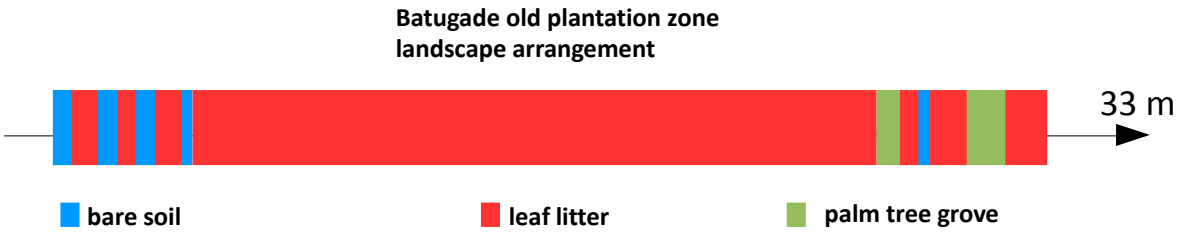

Figure 30 Landscape arrangement of old plantation garden (transect #1) in Batugade.

The landscape arrangement of the native vegetation (Figure 31) is highly complex and heterogeneous (many landscape elements, arranged in a highly non-uniform pattern).

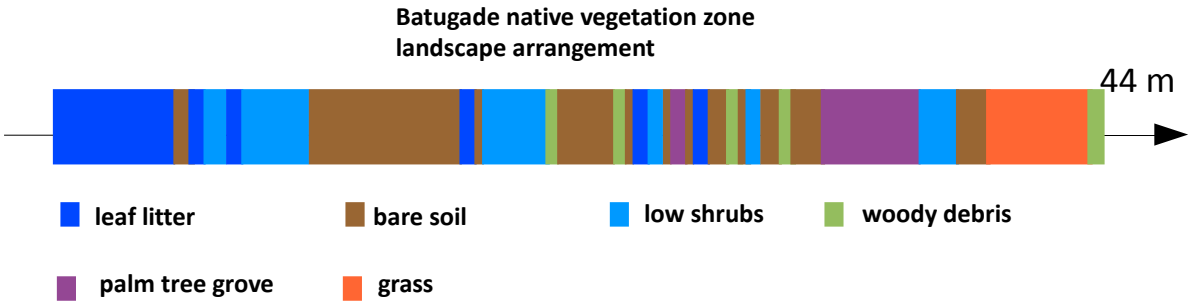

Figure 31 Landscape arrangement of old plantation garden (transect #2) in Batugade.

The compositional and structural diversity (Simpson's 1-D) was calculated for each land use type (Figure 32). Both the native vegetation and perennial garden land uses appear to show greater diversity than the old plantation and annual garden.

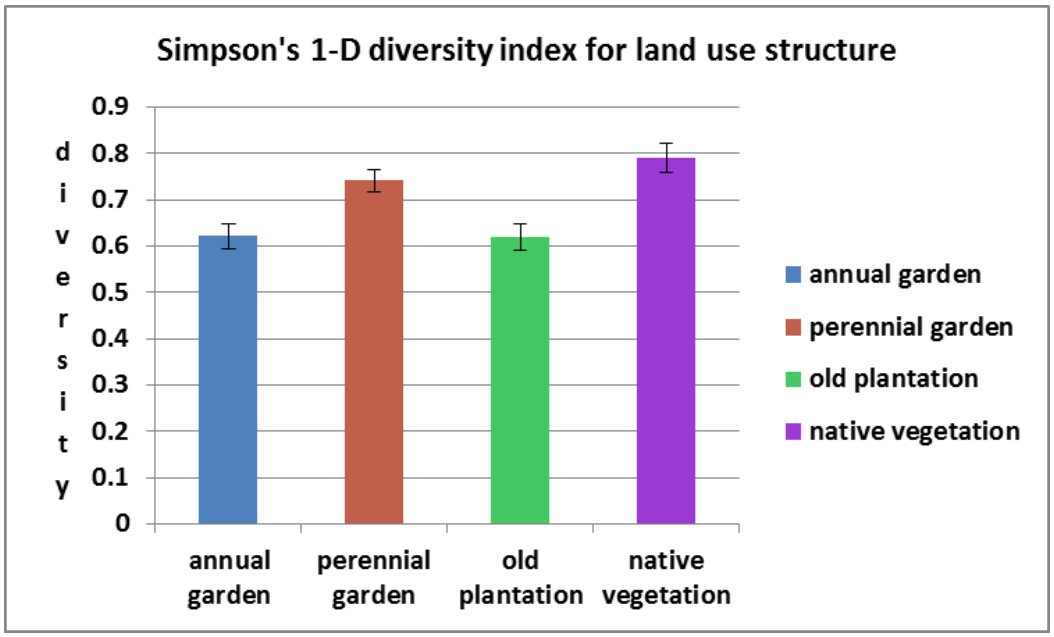

Figure 32 Land use diversity measured using Simpson's 1-D index for each land use in Batugade. Annual garden, perennial garden and old plantation are mean of two transects at each site; native vegetation is mean of three transects at site. Error bars are SE of mean and combined transects.

No statistical analyses were conducted due to insufficient replication.

Landscape arrangement—Key results:

- Although statistical analysis was not undertaken (due to n=1 for each land use type), Figures 28–31 and Figure 32 indicate the compositional and structural diversity of both the native vegetation and the perennial garden are greater than the annual garden and the old plantation. This is not surprising given that land use intensification often results in, and/or is attributable to, vegetation homogenisation (Benton et al. 2003).
- Perhaps the most telling result is that the spatial and compositional structure of the perennial garden is most similar to that of the native vegetation. This has two significant implications:
  - The greater compositional complexity (expressed as diversity of crops and other components) of the perennial garden renders it more resistant to negative impacts such as pests, drought and invasive plants (Lu et al. 2005; Kreyling et al. 2008; although see Munro et al. 2009) and more resilient post disturbance (e.g. greater number of species to maintain ecosystem functions in event of disturbance/change) (Walker et al. 1999; Hooper et al. 2005);
  - More complex habitat types harbour greater numbers and increased diversity of beneficial insects and other arthropods (Langellotto and Denno, 2004). There is also a general global trend, that as agricultural land use becomes simplified and management becomes more intense, the diversity and abundance of predatory and decomposer insects and other arthropods reduces (Attwood et al. 2008). This translates into the

perennial garden being less vulnerable to pest insect attack and having better soil nutrient status due to more decomposer soil fauna. It is also feasible (depending upon spatial juxtaposition, landscape permeability and species mobility) that this land use type could provide a source for populations of beneficial insects that could reduce insect pests in annual crops (see for instance Pearce and Zalucki, 2005 in relation to sources and movement of spiders in agricultural systems).

Landscape arrangement—Key findings and recommendations relating to adaptation:

- Promoting perennial gardens as a robust and resilient source of food and (potentially) ecosystem services through natural pest control.
- Considering spatial juxtaposition of perennial and annual crop gardens.
- Introducing greater compositional/structural complexity into annual gardens (e.g. more crop species, intercrops, trap crops, tree cover).

4.8.3.3 Landscape function

Comparison 1 – Overall function of each garden type in terms of nutrient cycling, soil stability, water infiltration (Figure 33).

N = 2 transects each for annual crop, perennial garden, old plantation and 3 transects for native woodland. Error bars are SE of mean. No statistics done due to insufficient replication.

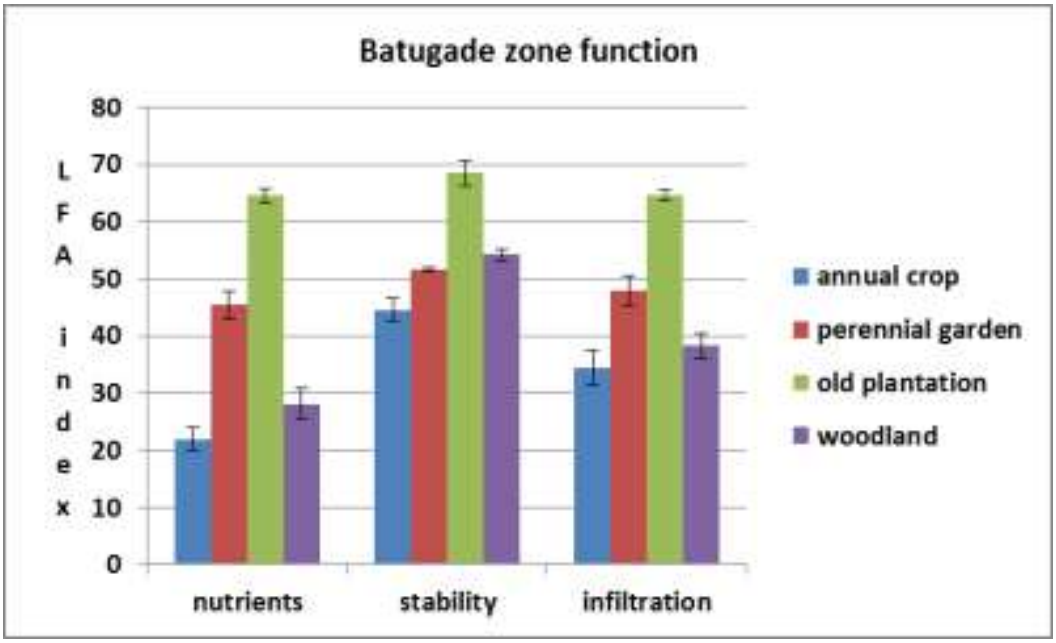

Figure 33 Results of garden type function in terms of nutrient cycling, soil stability and water infiltration in Batugade.

Landscape function—Key results:

- Nutrient cycling was greatest in the old plantation, but also relatively high in the perennial garden. By comparison, nutrient cycling in the annual crop and the native woodland was very low. This latter finding may be due to the often naturally poor nutrient status of open structured native woodland.
- Soil stability was greatest in the old plantation and the native woodland. Soil stability was slightly lower in the perennial and annual gardens. However, it was not especially low in these treatments, indicating that soil stability was generally high. We found very little evidence of major erosion in any of the sites, so this finding is supported through observation.
- Water infiltration was greatest in the old plantation, but also relatively high in the perennial garden. Water infiltration was lower in the native woodland and lowest in the annual garden. In the latter treatment, water management was very time and labour intensive, with hand watering of crops being conducted 2–3 times per day.
- The greater functional performance for nutrient cycling, soil stability and water infiltration of the perennial garden over the annual garden (due in part to more bare soil in annual garden and more canopy cover, less bare soil and more leaf litter/crop trash cover in perennial garden) is highly consistent with a review by Kumar and Nair (2004, see Table 3, p. 145). The review indicates that diverse gardens function more effectively than adjacent open areas in terms of litter decay, soil water holding capacity, soil porosity, soil bulk density, soil pH, soil organic carbon, C:N ratio, total soil N, soil P, soil microbiological properties.

Landscape function—Key findings and recommendations relating to adaptation:

- Land use function appears to be highly correlated with perennial vegetation, canopy and leaf litter cover (see landscape element sections for more detail). This indicates that increasing the cover of these elements may increase function in a number of areas in land uses where they are scarce or absent (i.e. annual crop garden). This is particularly evident in the comparison between the annual and perennial gardens.
- The old plantation had very high levels of function in comparison to the other land use types. However, the areas (often considerable in size) between timber stems appear largely underutilised. There may be opportunities to take advantage of the high levels of nutrient cycling, water infiltration and soil stability by planting perennial crops into the inter-stem spaces. This may be potentially suitable for crops that are more tolerant of low light levels (due to high canopy cover), such as cacao (although likely to be water limited), passion fruit, ginger, cardamom and turmeric.

Comparison 2 – function of each landscape element in annual garden in terms of nutrient cycling, soil stability, water infiltration (Figure 34). N = 1, (each data point on graph is mean of 2 transects). Error bars are SE of mean. No statistics done due to insufficient replication.

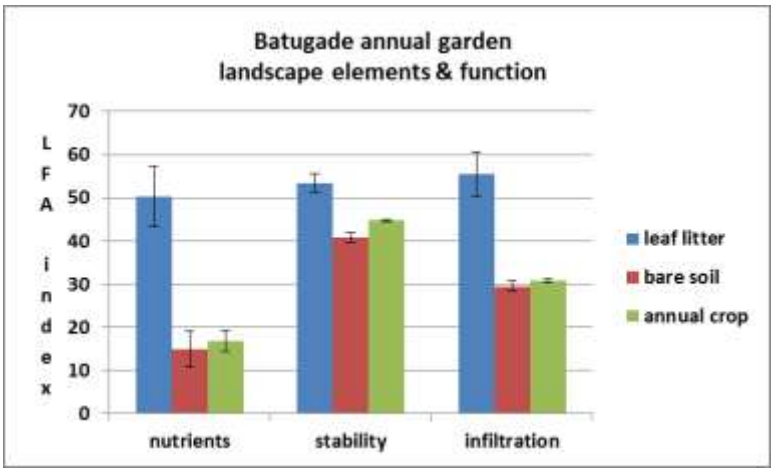

Figure 34 Results of landscape element function in annual crop garden in terms of nutrient cycling, soil stability and water infiltration in Batugade.

Landscape element (annual garden)—Key results:

- Leaf litter was by far the greatest contributor to all assessed functions in the annual crop garden. Leaf litter is a very important feature of tropical production gardens (Das and Das, 2010), as it confers on the garden a functional similarity to native forest systems (Kumar and Nair, 2004). In particular, the litter accumulation, decomposition and subsequent nutrient release is functionally reminiscent to forest system processes (Lavelle et al. 1993; Heal et al. 1997).
- Bare soil performed poorly, particularly in terms of nutrient cycling and water infiltration. However, having a cover of annual crops (e.g. tomatoes, lettuce), did not appear to increase functional status to any great extent. This is probably due to the actual cover of bare soil below the canopy of the crop being very similar in spatial cover to bare soil without an annual crop. This is likely due to the very low basal area cover of annual crops.

Landscape element (annual garden)—Key findings and recommendations relating to adaptation:

- The findings that a) leaf litter performs very well functionally (particularly in relation to nutrient status) and b) both bare soil and annual crops with a low basal area (and therefore high bare soil cover below the canopy) indicate that increasing leaf litter/vegetation ground cover is important in maintaining good nutrient cycling and water infiltration status. Leaf litter and other forms of low vegetation cover can reduce soil temperature, aid soil moisture retention and increase abundance and diversity of soil fauna and bacteria that drive ecosystem processes and functions. Leaf litter can also reduce the impact of rain on soil

structure and reduce erosion (Kumar and Nair, 2004). In terms of adaptation, farmers could increase their vegetative ground cover through a number of approaches:

  - Redistributing leaf litter from the periphery of annual gardens (where tree canopy cover tends to be greater) to the areas where crops are grown (mulching in essence);
  - Transporting leaf litter (again, as mulch) from surrounding land uses (for instance, leaf litter cover/depth in old plantation extremely high and only 50–100 m from the annual crop garden) to areas of annual crops.
  - Setting up composting (e.g. discrete areas of compost of different ages in order to maintain a continual supply) areas where leaf litter is placed/accumulated and allowed to break down (would require watering, covering, augmentation with other vegetation matter (e.g. crop trash, household organic waste).

- Minimise bare ground cover. At present, bare soil is performing poorly in terms of the measured functions, but also presents a physical barrier (e.g. in terms of high insolation and temperature) to carnivorous arthropods (e.g. spiders from the family Lycosidae, beetles from the family Carabidae and Staphylinidae) that are likely to inhabit surrounding perennial land uses and have the potential to remove pests (e.g. butterfly/moth larva) from annual crops. Increasing litter and other vegetative ground cover would increase habitat complexity at fine scales, and create conditions and a resource base more suitable for predatory arthropods to persist and migrate.
- More effective use of animal husbandry and animal manure. E.g. manure from chickens/pigs could be composted or applied directly to crops; chickens could be corralled and rotated around areas to be planted with crops in order to a) turn over soil, b) remove soil pests and c) nitrify soil with manure. Manure from animals would enable nitrogen to be incorporated with carbon from leaf litter in order to maintain productive C:N ratio.
- Increase tree cover as means of a) protecting annual crops from heavy rain events (projected to increase in the region due to climate change), b) maintaining soil structure, providing leaf litter cover.
- Need to maintain tree cover (in addition to leaf cover) to enhance soil stability (one of key impacts of increase in intensity of rainfall). Manage erosion.
- Even with increased water infiltration (through increased ground cover/improved ground cover management), there will still be a need for intensive water management of annual crops. This could potentially be achieved through:
  - Improved water harvesting and storage in wet season (projected to become wetter with more intense rainfall events). This could be achieved through the provision of water tanks to collect and store rain water from tins roofs. Many dwellings and larger public buildings have tin roofs amenable to guttering, downpipes and water collection, but very few buildings have this feature installed.
  - More efficient, less labour intensive distribution of water, via a reticulation/irrigation system from stored water (in tanks).

Comparison 3 – function of each landscape element in perennial garden in terms of nutrient cycling, soil stability, water infiltration (Figure 35). No statistics conducted due to insufficient replication.

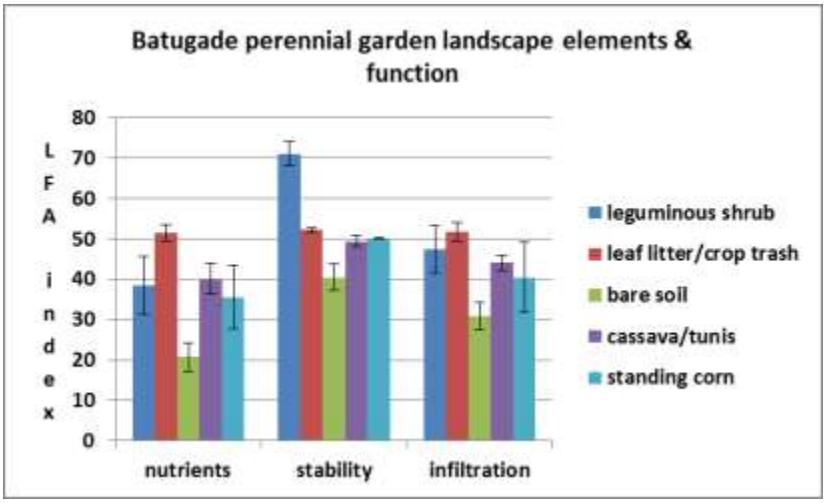

Figure 35 Results of landscape element function in perennial crop garden in terms of nutrient cycling, soil stability and water infiltration in Batugade. N = 1 but each data point on graph is mean of 2 transects. Error bars are SE of mean.

Landscape element (perennial garden)—Key results:

- Leguminous shrub (unidentified sp.) very effective at maintaining soil stability. This probably due to deep root system and fine filamentous roots binding soil.
- Leaf litter/crop trash contributed consistently highly to all assessed functions.
- Bare soil performed poorly, particularly in terms of nutrient cycling and water infiltration. However, nutrient cycling in bare soil in perennial garden appears to function slightly more effectively than bare soil in annual garden. This may be due to increased canopy cover and leaf litter/crop trash cover that protects the soil more effectively from rain events, and hence reduces the risk of erosion.
- Cassava, tunis beans and corn (maize) all contributed relatively well (higher scoring than bare soil, lower scoring than leaf litter/crop trash) to all functions. This is quite possibly due to the complex root system that develops from having several crop species intermingling and in close proximity to one another (i.e. often only a few cm between stems). This high density of roots may increase soil stability (ref) and reduce nutrient loss (Kumar and Nair, 2004) and increase nutrient uptake (Kumar and Divakara, 2001) from the soil.

Landscape element (perennial garden)—Key findings and recommendations relating to adaptation:

- Leave leaf litter and crop trash in situ; do not burn leaf litter/crop trash, but allow it to break down through natural decomposition. Fire will remove the leaf letter layer and other forms of ground cover, thus eliminating the nutrient cycling and other ecosystem services that it provides (Hochegger, 1998).

- Consider using chickens (corralled into discrete areas if necessary) to reduce pests and weeds after harvest and prior to next replanting (e.g. in case of maize). Chickens will also introduce nitrogen into soil, improving soil fertility.
- Consider introducing more leaf litter from old plantation sites or fallen litter from trees at boundary of gardens.
- Produce compost from leaf litter, domestic animal manure and household organic waste; use this to augment leaf litter and reduce bare ground cover.
- Minimise bare soil through leaf litter retention and maintenance of canopy cover from shrubs, trees and woody crops (e.g. cassava).
- Consider improved water capture (e.g. rain tanks from roofs in wet season) and improved water distribution through irrigation/reticulation systems.
- Consider increasing (or at least maintaining) the cover of corn (maize) in the long term. Standing corn performed creditably in terms of function, but is also one of the few productive plants that uses a C4 photosynthetic pathway, which renders them more efficient at photosynthesising at current C02 levels (Zhu et al. 2008). C4 plants are also generally more able to tolerate dry conditions and high temperatures (Crafts-Brander et al. 2002; Lopes et al. 2011), which, given climate change projections for the region, may enable them to grow in future projected drier conditions.

Comparison 4 – function of each landscape element in old plantation in terms of nutrient cycling, soil stability, water infiltration (Figure 36).

No statistics done due to insufficient replication.

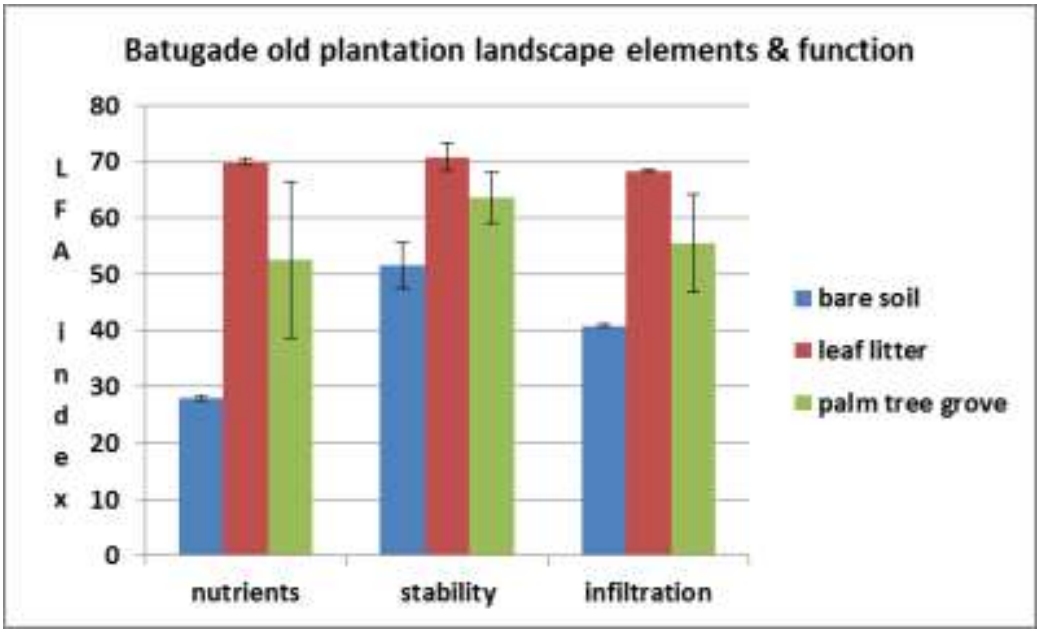

Figure 36 Results of landscape element function in old plantation in terms of nutrient cycling, soil stability and water infiltration in Batugade. N = 1 but each data point on graph is mean of 2 transects. Error bars are SE of mean.

Landscape element (old plantation)—Key results:

- Leaf litter contributed very highly to all assessed functions. The LFA function scores for leaf litter in the old plantation were greater than the scores for leaf litter in the other land use types (e.g. nutrient cycling in: old plantation = 69.95, annual garden = 50.23, perennial garden = 51.55, native woodland = 46.46). The data indicate that this is due to a) much greater depth of leaf litter (often >100 mm) and b) advanced state of decomposition (self-composting in essence) of older/lower layers of leaf litter.
- Bare soil performed poorly compared to other landscape elements, but much better than bare soil in other land use types. This may be attributable to high levels of canopy cover, and relatively higher levels of leaf litter on bare ground.
- Samples taken amongst palm trees also scored highly for all functions, potentially benefiting from the increased canopy cover and leaf litter fall.

Landscape element (old plantation)—Key findings and recommendations relating to adaptation:

- This land use appears to be very effective at maintaining function with (and perhaps, in part, because of) minimal management intervention. There are probably opportunities for using the ground layer to experiment with growing shade tolerant perennial crops in this land use and therefore increasing its productivity and output.

Comparison 5 – function of each landscape element in native vegetation in terms of nutrient cycling, soil stability, water infiltration (Figure 37).

No statistics done due to insufficient replication.

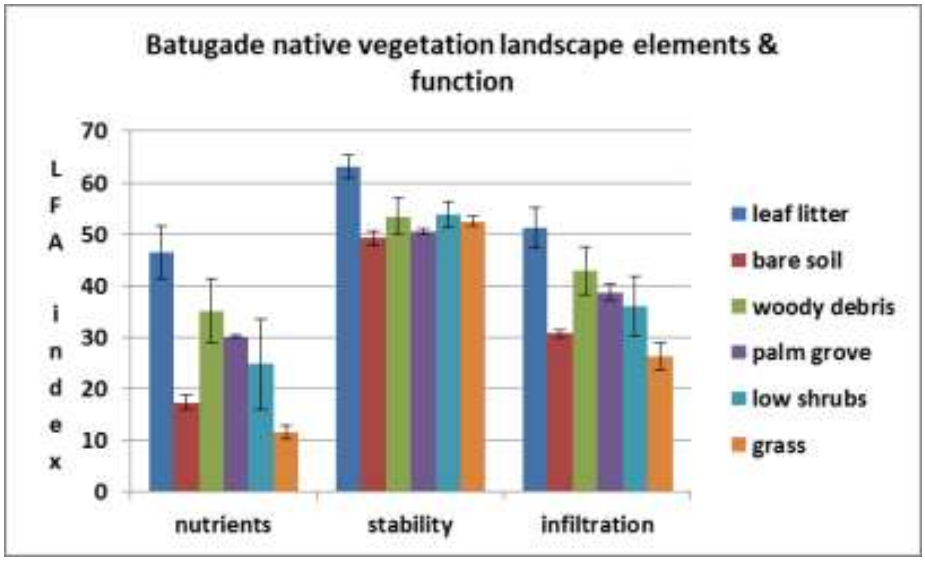

Figure 37 Results of landscape element function in native vegetation in terms of nutrient cycling, soil stability and water infiltration in Batugade. N = 1 but each data point on graph is mean of 3 transects. Error bars are SE of mean.

Landscape element (native vegetation)—Key results:

- Leaf litter made the greatest contribution to all assessed functions. The lower scores associated with the leaf litter in woodland compared to other land uses may be due to the sparse canopy cover of trees, leading to sparse and shallow (often <20 mm depth) litter cover on the ground.
- Bare soil and sparse grass cover performed poorly compared to other landscape elements, for nutrient cycling and water infiltration. It may be that the sparseness of grass cover did not greatly differentiate it from bare soil in terms of function.
- All land uses (excepting leaf litter) performed consistently well for soil stability. This may well reflect the fact that being native woodland (and hence never subject to cultivation), soil disturbance has been kept to a minimum regardless of the dominant landscape element in a given area of the woodland.
- Coarse woody debris (fallen trees, logs, sticks) contributed consistently well to all functions. This may be due to woody debris providing a 'trap' for nutrients and water, particularly those associated with overland flow across relatively impervious landscape elements (e.g. sun-baked bare soil with a hard soil crust).

Landscape element (native vegetation)—Key findings and recommendations relating to adaptation:

- Principally not an agricultural land use type, but a number of recommendations are:
  - Better management of livestock grazing in order to reduce risk of overgrazing. Grass cover was very sparse and grassy areas performed at least as poorly as bare ground in all functions measured. Whilst site was assessed during dry season, and therefore post-rain recovery was not assessed, there may be opportunities for sequentially grazing areas using temporary fencing as opposed to allowing pigs and goats to roam freely.
  - Coarse woody debris contributed well to all functions. Therefore, it may be worthwhile trialling the introduction of coarse woody debris in the perennial and annual gardens to intercept the flow of water and nutrients (woody debris should be placed at 90^0 to predominant flow direction. Woody debris is also known to provide habitat for beneficial insects, and therefore may be able to contribute to natural pest control.

4.8.4 Results—Atauro

4.8.4.1 Land use types—Atauro

In Atauro, three landscape/land use types were sampled, representing a gradient of land use intensification from fallow gardens (temporarily taken out of production in order to recover nutrient status) to frequently tended gardens consisting of perennial crops in the village of Beloi (e.g. cassava). The three landscape/land use types sampled were:

*Perennial crop garden in Beloi village (*Figure 38*)*—an actively and frequently managed garden of perennial tree and shrub crops such as coconuts, bananas and cassava. Non-uniform spatial arrangement of crops in most cases. Considerable areas of leaf litter with smaller areas of bare soil. Tree cover moderate. Garden is management is relatively intensive due to close proximity to dwellings in village.

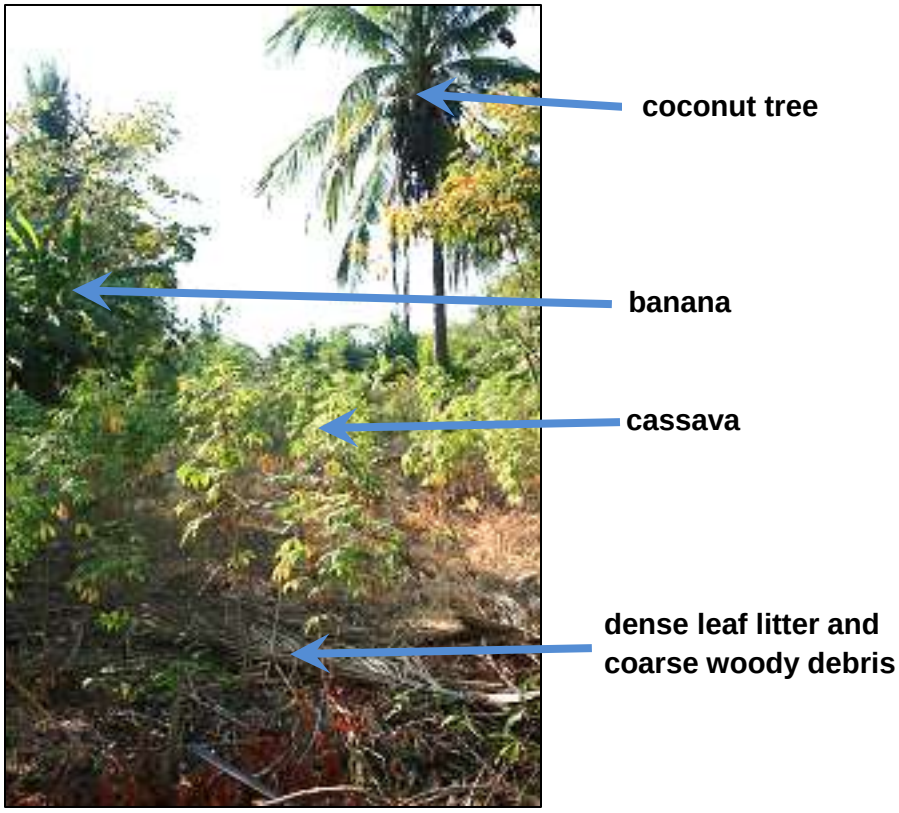

Figure 38 Site 2, Transect #1 of perennial garden in Beloi village, Atauro.

*Perennial crop garden in foothills above Beloi village (*Figure 39*)*—an actively managed garden of perennial tree and shrub crops such as palm wine trees, tunis beans and cassava and annual crops such as maize. Also nitrifying leguminous native acacias present. Non-uniform spatial arrangement of crops. Smaller areas of leaf litter than village garden, with smaller areas of bare soil. Tree cover moderate. Garden management is less intensive than village garden due to distance from village. Considerable grazing by goats.

Figure 39 Site 3, Transect #1 of perennial garden in foothills of Beloi, Atauro.

*Fallow garden in foothills above Beloi village (*Figure 40*)*—deliberately abandoned (rested) fallow garden consisting of palm wine trees, other palms, perennial grass species used for roofing, and volunteer native acacias. Highly non-uniform spatial arrangement of plants. Considerable areas of leaf litter, bare soil not present. Tree cover moderate to high. Sporadic grazing by goats.

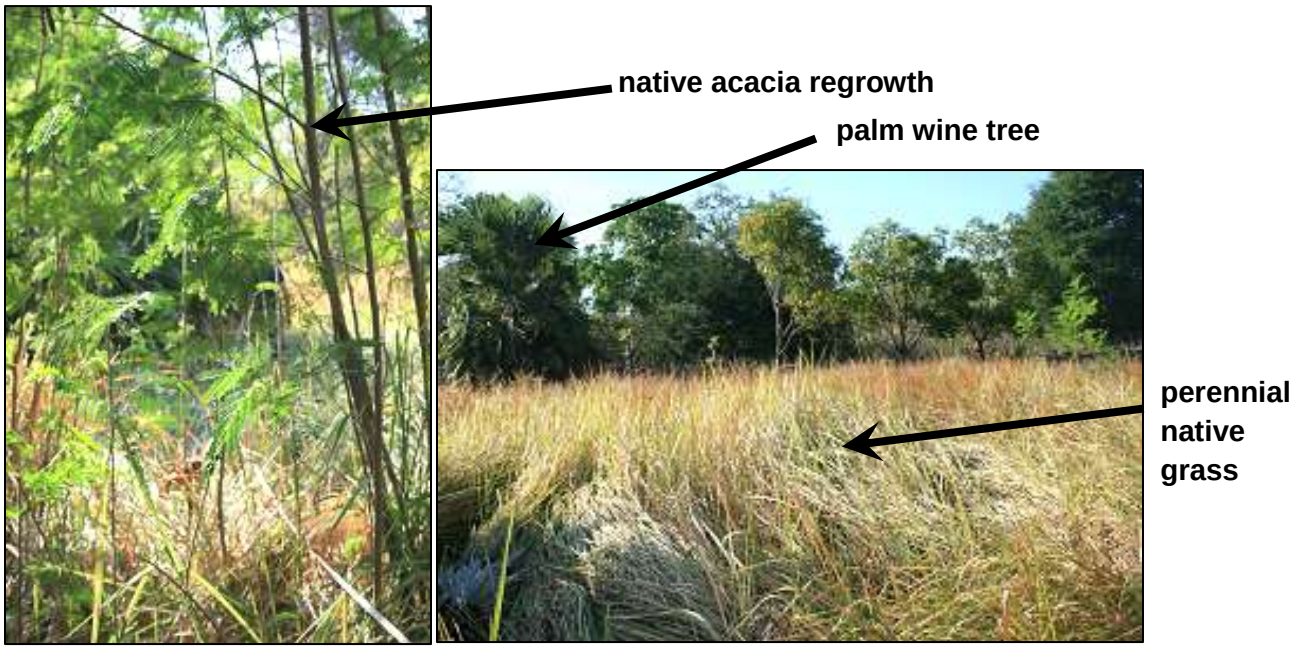

Figure 40 Site 2, Transect # 2 and site 1, transect 1 of fallow plantation in foothills of Beloi, Atauro.

Landscape arrangement

The structure and composition of each land use type is very different in terms of) the number of different landscape elements that are contained in the land use type, and b) the uniformity with which they are arranged. Figure 41–44 depict the diversity of one transect of each land use type, with the spatial arrangement of landscape elements within a transect depicted to relative scale.

The landscape arrangement of the perennial village garden (Figure 41), is moderately complex with several landscape elements present along the transect.

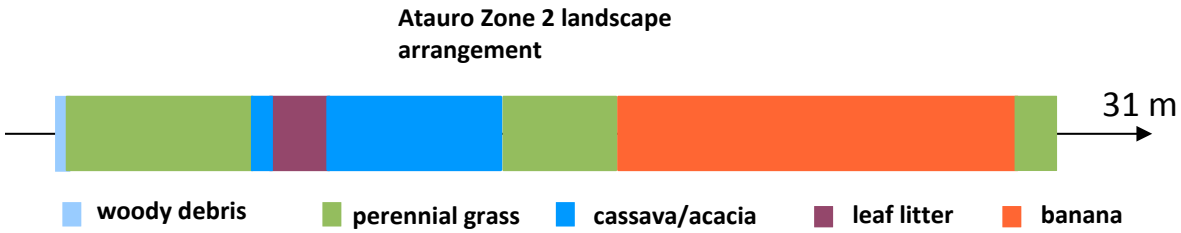

Figure 41 Landscape arrangement of village perennial crop garden in Beloi, Atauro.

The landscape arrangement of the perennial foothills garden (Figure 42), is moderately complex with several landscape elements present along the transect, although more bare soil was present than was generally found in the village perennial garden.

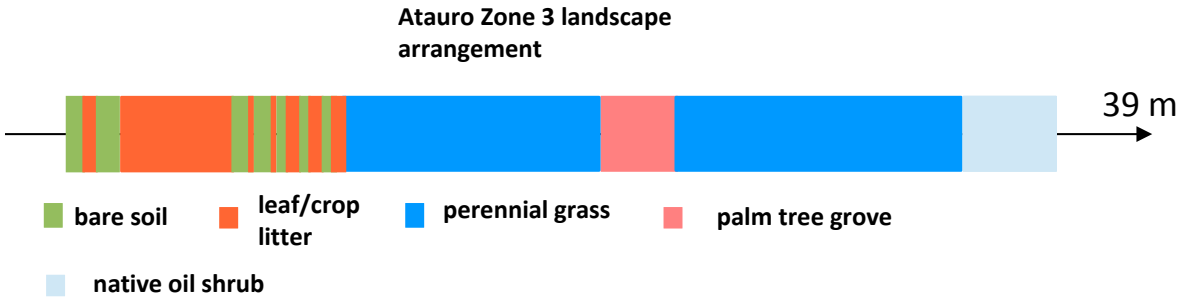

Figure 42 Landscape arrangement of foothills perennial crop garden in Beloi, Atauro.

The landscape arrangement of the fallow garden (Figure 43), is rather simple, with fewer landscape elements present along the transect.

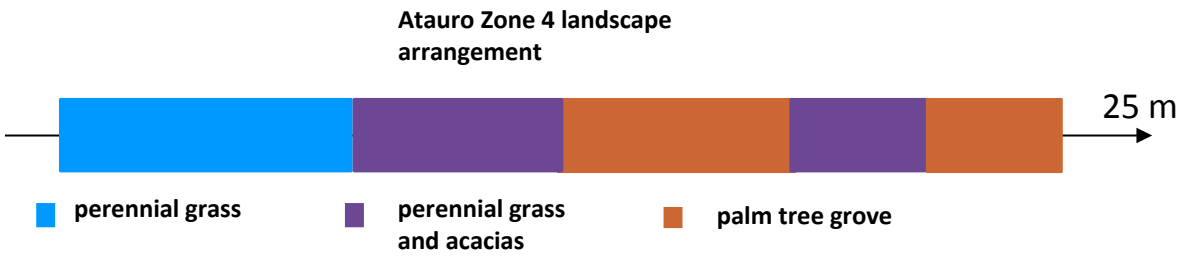

Figure 43 Landscape arrangement of fallow garden in Beloi, Atauro.

The compositional and structural diversity (Simpson's 1-D) was calculated for each land use type (Figure 44). Both the native vegetation and perennial garden land uses appear to show greater diversity than the old plantation and annual garden.

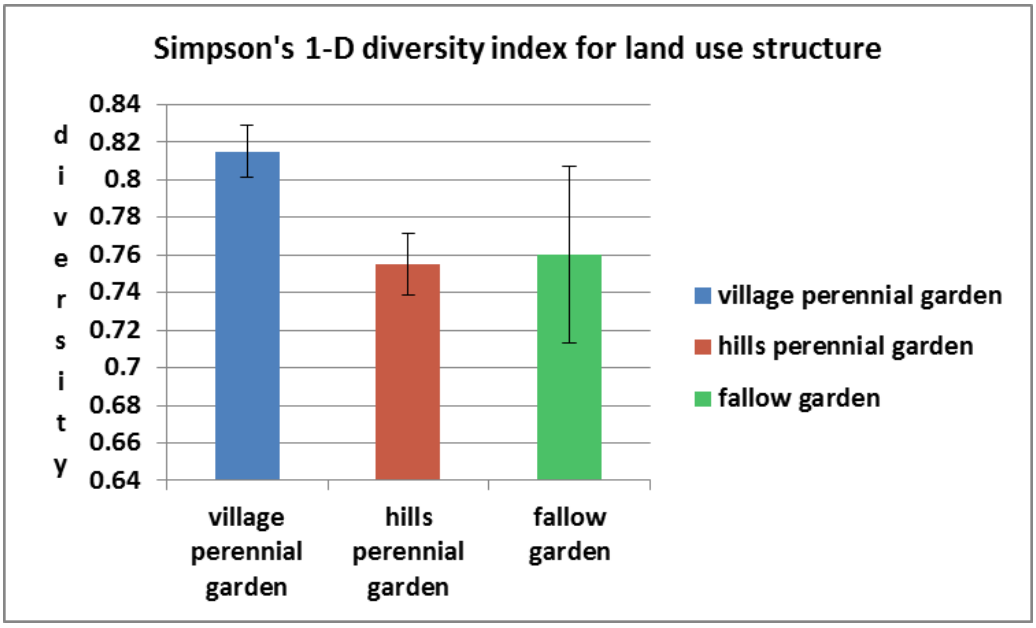

Figure 44 Land use diversity measured using Simpson's 1-D index for each land use in Atauro: perennial garden in village, perennial garden in village and fallow garden in hills. N = 3 replicates, with each replicate being composed of two transects. Error bars are SE mean of combined transects.

Statistics:

One-way ANOVA, Simpson's 1-D diversity: $F = 1.225_{2,6}$ $P = 0.358$. NS

No difference was found in the overall structural diversity of the garden types.

Landscape Arrangement—Key results:

- Although Figure 41–45 indicate that, there may be some difference in compositional and structural diversity among the three garden types, no difference was apparent. This is probably due to a) the overall compositional similarity of the village and hills active perennial gardens, and b) the biases of the Simpson's index in how it incorporates richness (number of landscape elements) and abundance (number of times each element occurs along the transect) into the calculation of the index. There are other measures of diversity and evenness that could be used to examine these relationships, but a thorough examination of measuring spatial heterogeneity with various diversity indices is beyond the scope of this report.

Landscape Arrangement—Key findings and recommendations relating to adaptation:

- Both village and perennial gardens seem to exhibit levels of heterogeneity/diversity that are comparable with the perennial garden in Batugade, and are therefore likely to be robust in the event of threats/disturbance and resilient post-disturbance.

- Diverse home gardens of this nature are known to be in decline in some parts of the world. For instance, market changes and government policies have led to a decrease in the number of home gardens (e.g. to coconut and rubber plantations) in Kerala (Ashokan and Kumar, 1997), and a loss of structure and function of gardens, due to commercialisation of production, has been noted in Indonesia (Abdoellah et al., 2001). Consequently, these diverse gardens in Timor-Leste need to be encouraged and supported. Means of support could include research to determine how gardens can be productively improved without reducing diversity or function, and extension and outreach of any research findings and lessons learned to growers within and among regions. Another important action is to ensure that government policies do not undermine diverse gardens, and that opportunities are explored to support diverse gardens through payments for ecosystem services PES). However, there are recognised obstacles and impediments to locally managed/utilised ecosystem services (which are by definition decentralised) and PES which are often part of a centralised governmental process or initiative (Janzen, 1998). Such potential conflicts require carefully navigation and management.

4.8.4.2 Landscape function

Comparison 1 – overall function of each garden type in terms of nutrient cycling, soil stability, water infiltration (Figure 45).

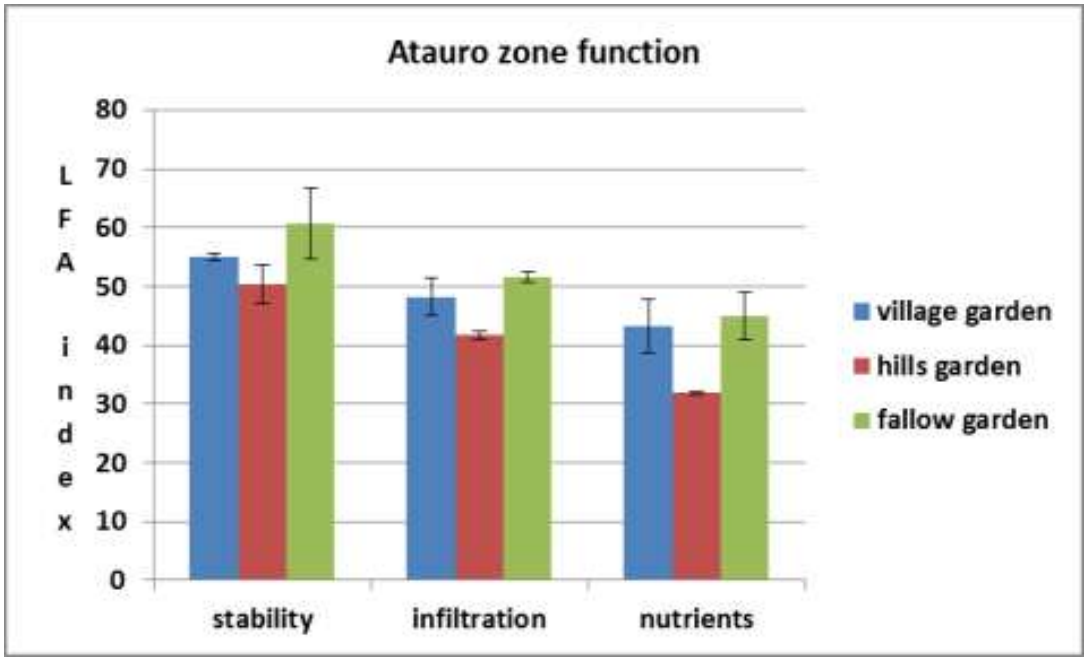

Figure 45 Results of garden function in terms of nutrient cycling, soil stability and water infiltration in Atauro (Beloi). N = 3 replicates of 2 transects each for perennial garden in Beloi village, perennial garden in Beloi foot hills and fallow garden in Beloi foot hills, Error bars are SE of mean.

Statistics:

1) *One-way ANOVA*, Soil stability: $F = 1.656_{2,6}$ P = 0.267. NS
2) *One-way ANOVA*, Infiltration: $F = 6.778_{2,6}$ P = 0.029.Significant difference

   T-test comparisons:

   Village garden compared to hills garden P = 0.171 NS

   Village garden compared to fallow garden P = 0.397 NS

   Hills garden compared to fallow garden P = 0.00077 Significant difference

3) *One-way ANOVA*, Nutrient cycling: $F = 4.167_{2,6}$ P = 0.073. NS

Landscape function—Key results:

- All three land use types appear to perform reasonably well in relation to all three measured functions.
- The only statistically significant difference found among land use types was for water infiltration, where the fallow garden scored higher for this function on the LFA index than the perennial hills garden. This may be due to a) the length of time that vegetation in the fallow garden has remained relatively undisturbed, thus allowing for advanced root development, and thus aiding infiltration, and b) the complete absence of bare soil (which contributes to surface run-off and lateral water movement) in the fallow gardens, whereas bare soil occurred frequently in the perennial hills garden. The bare soil in the perennial hill gardens may be due to a combination of livestock grazing and post-harvest burning.
- Although not statistically significant, the village perennial garden averaged higher LFA index scores than the perennial hills garden and fallow garden for soil stability, nutrient cycling and water infiltration. This is an interesting finding, in that one might reasonably anticipate environmental function to decline with management intensity (the proximity of the village gardens to dwellings renders frequent management more feasible). There are a number of reasons why the annual gardens may function well:
  - More frequent watering may promote greater, and deeper, root growth, increasing water infiltration into a more porous and well-structured soil;
  - Livestock were present in greater densities than was seen in the hill gardens; this may lead to higher quantities of animal manure, which in turn increases nutrient status of the soil (e.g. nitrogen) and can lead to enhanced primary production;
  - The presence of bananas in this land use which appear to contribute to increased soil function in a number of ways (see comparison # 2, below);
  - The hills perennial gardens are often burnt after harvest (and prior to onset of the wet season when new plantings occur). This is due to a) a desire to manage pests and weeds in the garden and b) a cultural association with burning gardens.

Landscape function—Key findings and recommendations relating to adaptation:

- Whilst there are recommendations for each individual land use (discussed for each garden type, below), it appears that each garden type is functioning effectively in respect of all the measured landscape functions. This said, there are a few generalisations that can be made that lead to recommendations:
  - Bare earth leads to a reduction in function in the two active garden types (and as seen in all land uses in Batugade); therefore, strategies need to be adopted to reduce the incidence of bare earth. Four main strategies are a) retention/collection/distribution of leaf litter that is high in nutrients and is likely to lead to a broader and deeper ground cover (e.g. leaf litter), b) composting of leaf litter/crop trash and subsequent distribution, in order to create ground over, increase nutrients in the soil (e.g. C:N ratios), reduce soil surface temperature, increase soil moisture retention, c) strategic distribution of coarse woody debris in gardens in order to reduce bare ground cover or intercept flow of resources (e.g. water, nutrients) across bare ground (i.e. woody debris placed at 90^0 to flow direction), d) cessation of burning of crop aftermath.
  - At present, livestock are not managed in gardens. This can lead to a) overgrazing/excessive browsing in certain areas, and b) a missed opportunity in terms of pest control, weed control and manure composting. Therefore, recommendations in relation to animal husbandry include improved maintenance of fences around gardens, collection of manure for composting or immediate distribution on gardens and use of chickens to remove weeds/pests from harvested gardens.

Comparison 2 – function of each landscape element in perennial garden in village in terms of nutrient cycling, soil stability, water infiltration (Figure 46).

N variable depending on frequency of occurrence in this garden type, but each reading is mean of two transects in each garden replicate. Error bars are SE of mean.

No statistics done due to insufficient replication of each landscape element.

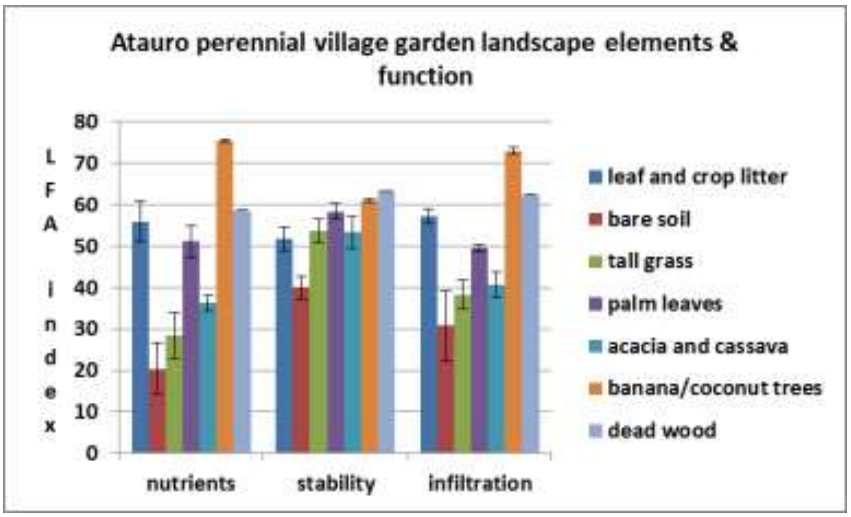

Figure 46 Results of landscape element function in village perennial garden in terms of nutrient cycling, soil stability and water infiltration in Atauro.

Village perennial garden—Key results:

- Bare soil contributes poorly to all three measured functions.
- Leaf litter, crop trash, dead wood and palm leaves all contribute well to the measured functions.
- The presence of coconut and (in particular) banana trees greatly increases nutrient cycling and infiltration. The litter below banana trees was extremely deep (>120 mm) and highly decomposed in parts, indicating that the soil immediately below the banana trees has a very active soil fauna (e.g. bacteria, collembolan, other micro-, meso- and macro-arthropods), that drive nutrient cycling and the maintenance of soil porosity. Such litter volume observations are consistent with the studies that have found greater litter volumes in some tropical production gardens than in native forest systems (Gajaseni and Gajaseni, 1999).

Village perennial garden—Key findings and recommendations relating to adaptation:

- Minimisation of bare soil cover (see recommendations in comparison 1, above).
- Increase in leaf litter and crop trash as ground cover (see recommendations in comparison 1, above).
- Placement of woody debris in strategic locations to intercept overland flow of resources (see recommendations in comparison 1, above).
- Increase in production of bananas, or more proactive and strategic harvesting of banana leaves and distribution around garden. This could be done by directly placing banana leaves in areas of garden where they are absent (e.g. amongst cassava or tunis beans), or by experimenting with composting approaches and subsequent distribution of leaves. Such approaches have been used in (for instance) banana/intercropped systems in Uganda, where banana leaves have the potential to recycle up to 25 kg ha^{-1} yr^{-1} of nitrogen, and banana leaves and pseudostems have the potential to recycle up to 43 kg ha^{-1} yr^{-1} of potassium (Lekasi et al. 1999).

Comparison 3 – function of each landscape element in perennial garden in hills in terms of nutrient cycling, soil stability, water infiltration (Figure 47).

N variable depending on frequency of occurrence in this garden type, but each reading is mean of two transects in each garden replicate. Error bars are SE of mean.

No statistics done due to insufficient replication of each landscape element.

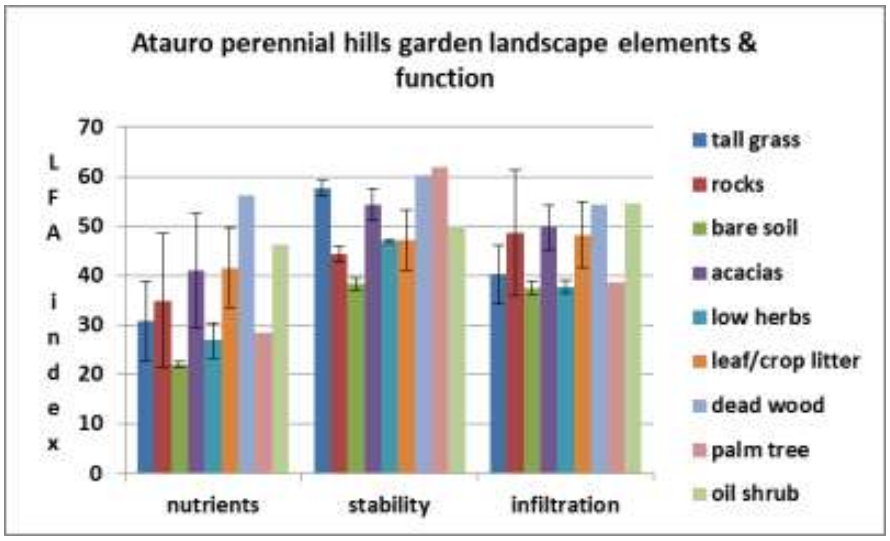

Figure 47 Results of landscape element function in foothills perennial garden in terms of nutrient cycling, soil stability and water infiltration in Atauro.

Hills perennial garden—Key results:

- Bare soil contributes poorly to all three measured functions.
- Leaf litter contributes well to the measured functions.
- Whilst tall perennial grasses (generally used for roofing thatch) contribute well to soil stability, they are poor for nutrient cycling and less effective than some other landscape elements (e.g. leaf litter/crop trash).
- Coarse woody debris appears effective at maintaining all measured functions.

Hills perennial garden—Key findings and recommendations relating to adaptation:

- Minimisation of bare soil cover (see recommendations in comparison 1, above).
- Increase in leaf litter and crop trash as ground cover (see recommendations in comparison 1, above).
- Placement of woody debris in strategic locations to intercept overland flow of resources and aid infiltration of water (see recommendations in comparison 1, above).
- Explore opportunities to reduce the cover of perennial grasses and replace with more perennial crops planted into leaf litter. This could be conducted in small discrete areas of a garden as a test prior to broadscale application. See comparison 1 recommendations for information on collecting, processing and distributing leaf litter and crop trash.

Comparison 4 – function of each landscape element in fallow garden in hills in terms of nutrient cycling, soil stability, water infiltration (Figure 48).

N variable depending on frequency of occurrence in this garden type, but each reading is mean of two transects in each garden replicate. Error bars are SE of mean.

No statistics done due to insufficient replication of each landscape element.

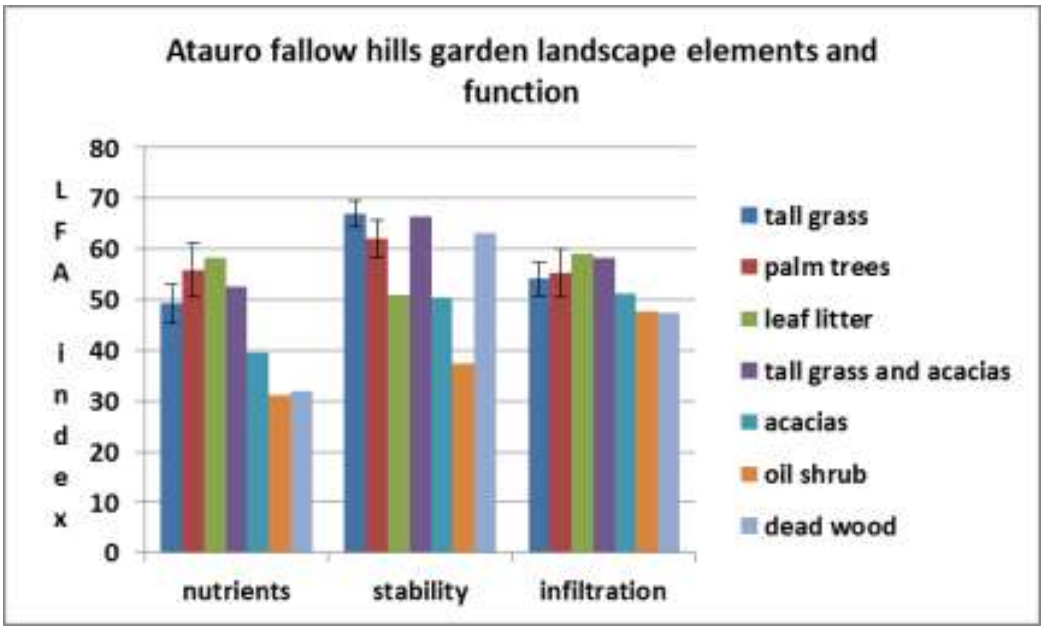

Figure 48 Results of landscape element function in fallow garden in terms of nutrient cycling, soil stability and water infiltration in Atauro.

Fallow garden—Key results:

- Leaf litter, perennial thatching grass and palm trees contribute well to the measured functions.

Fallow garden—Key findings and recommendations relating to adaptation:

- Fallow gardens might be an effective source of litter to distribute on active garden types.
- It is not known how rapidly fallow gardens recover their function after being used as perennial gardens in the hills. Farmers could experiment with taking land out of fallow after a shorter period than the 5–6 years that is presently the norm.
- Given that a) the fallow gardens are unmanaged, and b) no landscape elements performed exceptionally well or exceptionally poorly in maintaining function, no other recommendations are made with regard to fallow management.

4.8.5 Conclusion

The different forms of land use in Batugade and Atauro, as represented by the home gardens, provide a wide range of crops for both subsistence and commerce at local markets. They also provide a variety of other materials such as timber for construction and thatch for roofing. That the home garden is a traditional feature of these communities is a testament to: a) their ability to provide a wide range of produce, and b) their resistance and resilience to long term environmental changes and short term climatic events. Perennial gardens in particular appear to function very effectively in terms of nutrient cycling, soil stability and water retention. This is likely due to a combination of factors (e.g. diverse range of plants, complex spatial structure, deep rooted plants, continual ground cover), but is, in a broader sense, potentially attributable to the structural, compositional and functional resemblance to native systems in which environmental function tends to be high.

The diversity of the perennial systems may also confer other desirable functional attributes on the system such as invertebrate mediated pest population control and pollination. This in turn is likely to confer such functional traits at scales greater than that of the individual garden, thus conferring improved environmental function on the wider landscape. As well as the active perennial gardens, it appears that the measured functions may be slightly greater in the areas rested from production (fallow gardens). This indicates that the practice of periodically resting gardens may give them an opportunity to recover.

Whilst we have found that the perennial gardens function well, there are a number of recommendations that we can make based upon this research:

i) Annual gardens do not appear to function as well as perennial gardens. This appears to be largely attributable to the large areas of bare soil present in these gardens. We suggest that growers should consider utilising leaf litter to reduce bare ground cover, or begin producing compost or mulch from leaf litter in order to distribute around the annual gardens;
ii) Perennial gardens function well, but some elements function better than others. Efforts should be taken to reduce any bare ground cover, increase litter cover and in particular use leaf litter from banana trees to increase ground cover;
iii) Plantations function well, due in part to high levels of canopy and ground cover; however they appear under-utilised. We recommend that communities experiment with planting shade-tolerant perennial crops into inter-stem spaces in plantations as another means of production;
iv) Any activity that increases bare ground should be reduced. In particular, the burning off of crop trash at the end of the harvest should be discouraged as this a) increases bare ground, b) reduces certain soil nutrients, c) eliminates beneficial soil fauna;
v) Fallow areas appear to recover effectively from cropping activities. However, a research priority should be to determine if there is an optimum cropping period where function begins to fall off, but does not become significantly depleted, and conversely whether there is an optimum resting period, whereby functional attributes recover, thus allowing cropping to resume.

Overall we found that the Landscape Function Analysis approach worked well in a) determining relative function of different land use types and b) establishing which specific components contributed to, or detracted from, system function. From this, some clear and relatively straightforward management recommendations have been made. Whilst we have provided a snapshot of the land use condition and function of the various types of home garden, it was apparent that the LFA approach is relatively easy to conduct, analyse and interpret. Consequently, it could be used by local NRM officers to a) establish baseline function, b) track function over time in response to climate change (e.g. altered rainfall, increased temperatures) and c) track function over time in response to specific adaptation actions, such as those suggested in this report.

4.9 Evaluation of adaptation strategies from an environmental perspective using marine and coastal ecosystem service analysis

Activity:	Ecosystem service assessment using InVEST
Aim/Key question:	• Presently, what and where are the most important natural assets in terms of utility to the community in question (i.e. which natural assets contribute the most to ecosystem services that the community relies upon)? • Under the various adaptation strategy/management portfolio scenarios, how may the presence, extent and distribution of those priority natural assets change? • How may the services provided by those natural assets change under the various adaptation strategy/management portfolio scenarios? • Is it possible to: a) determine which are natural assets that most require protection/retention b) determine whether a management or adaptation action move the community towards/away from their desired future?
Brief details of method:	Using data for Atauro only (i.e. Batugade) as a pilot study: • Fisheries mapped and ranked for the entire island; • Fisheries and other resource bases mapped for the entire island; • Recreation mapped and ranked for the entire island; • Fisheries and other resource bases mapped for each focal community (five in total); • Natural habitats and resource use mapped for each focal community; • Foreshore structure and vegetation ground-truthed and mapped for Beloi (approx. 3 km of coastline). All data to be analysed using InVEST software to determine: a) ecosystem services baseline, and b) potential changes to natural assets and ecosystem service delivery as a consequence of adaptation actions being implemented.
Key results:	• All data collected from two or more community sources, or mapped on-ground. • All other data required for InVEST (e.g. bathymetric data) has been collected or in the process of acquisition. • Analysis is on-going.

4.9.1 Background to the analysis of ecosystem services using InVEST software

Globally, ecosystem services in the form of environmental goods, and regulating, supporting and cultural services (Waage et al. 2008) have been valued at approximately US$33 trillion per year, more than the entire global GDP (Costanza et al. 1997). The importance of ecosystems for the rural poor, communities who often live in close connection to their natural surroundings, are also well documented (e.g. Swallow et al. 2007), as is the need to develop reliable measures of community vulnerability to ecosystem decline (Hughes et al. 2012). Despite the importance and value to humanity of the goods and services delivered by the natural world, however, the stock upon which they are based continues to be eroded with likely concomitant impacts upon human wellbeing (MEA, 2005; Swallow et al. 2007). By determining the current state of ecosystems, and the services they provide in a community or region, a baseline can be established, against which changes in service provision can be measured in the context of possible future climate change impacts and associated adaptation strategies.

An Ecosystem Services (ES) assessment process and associated software has recently been developed by the Natural Capital Project (http://www.naturalcapitalproject.org/). The InVEST (Integrated Valuation of Environmental Services and Trade-offs) modelling software, which is a plug-in to ARC GIS, enables site specific data to be incorporated into a spatially explicit model that a) sets a baseline for ecosystem service delivery within the area of investigation (e.g. community, region, country), b) identifies the most important natural assets for maintaining ecosystem services, and c) enables a predictive assessment to be made of how natural assets and the services they deliver may change due to, for example, climate change and climate change adaptation strategies.

4.9.2 Method

The InVEST modelling software Marine Model requires a considerable amount of data to be collected in order for it to quantify and spatially represent ecosystem service provision and potential change. Appendix 18 shows the data that is either required or recommended (where feasible) to populate the model that will be used in this project's analysis. Much of the data required to populate InVEST is either provided with the software itself or is available through internet-housed global datasets such as Digital Elevation Data. The remainder of the data was required to be collected in the field.

Field data collection

The following data were collected using an in-field mapping technique with local stakeholders:

- Fisheries—mapping of main fishery areas for each Suco on Atauro Island and relative importance of each.
- Recreation—mapping of 'top-five' eco-tourism locations on Atauro Island.
- Natural habitats and how they are utilised by community (ecosystem services and threats impacting).

Two primary stakeholders (eco-tourism operator Barry, manager of Barry's Place, and NRM officer for local NGO Roman Luan, Marcello Soares) were asked to mark the above elements on clear plastic A3 sheets overlaying satellite images of the island and each Suco. These images were transferred from the sheets to Google Earth as RASTA layers. These, in turn, were then transferred to ARC Map for analysis using InVEST.

Data on foreshore vegetation structure were collected by the author for the area of Beloi village. The coastline was traversed by bicycle for approximately 2 km to the north and south of Beloi village. Descriptions of vegetation structure and foreshore protection (e.g. vegetation width, height and density, obstacles such as logs, rocks, foreshore height) were marked on a satellite image and accompanied by photographs of the features.

Detailed depths around the Atauro coastline were obtained from Barry and Mario (employee who is also in 3rd year of NRM B.Sc. At Dili University) at Barry's Place by photographing sounding charts undertaken by Russian researchers. These are thought to be the most accurate depth readings for the region.

InVEST analysis will be undertaken in early 2013 and findings will be in the final project report.

4.9.3 Results (preliminary)

The interim results are able to provide a detailed assessment of natural asset locations.

Fishery locations

Figure 49 depicts the location of fisheries as indicated by Barry and Mario (order of importance not annotated). Each Suco has its own areas of fishing emphasis (e.g. Beloi fishers tend to patrol middle sections of island on both east and west coastlines), but there is a great deal of crossover into neighbouring areas (e.g. Biqueli and Beloi coincide a great deal). They also indicated a good deal of pelagic fishing (for tuna) in the waters to the south of the island.

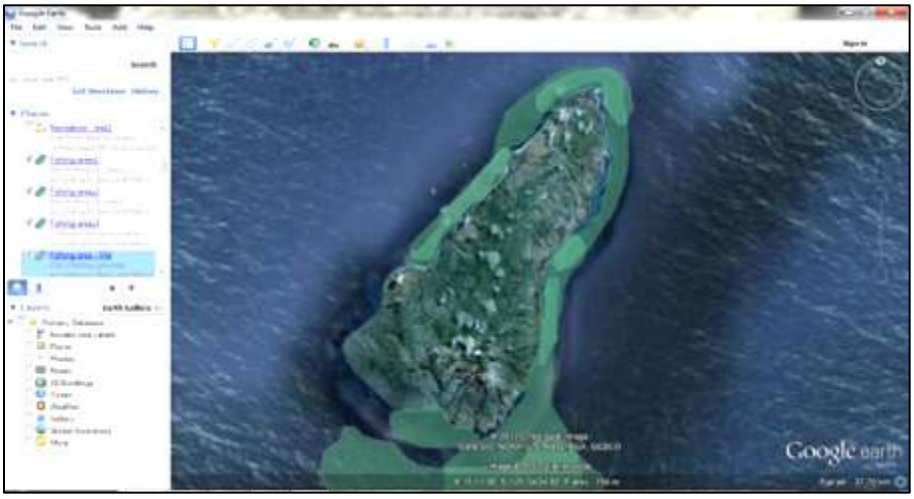

Figure 49 Atauro Island fisheries (in relation to suko) as depicted by Barry and Mario of Barry's Place.

Figure 50 meanwhile, depicts the location of fisheries as indicated by Marcello of local NGO Roman Luan. Marcello's interpretation of priority fishing grounds also indicated that each Suco tends to patrol certain areas, with similar patterns of crossover among neighbouring areas as reported by Barry and Mario. The main differences, however, are that a) Marcello depicts the entire coast of the island (including the far south-western corner) being utilised for fishing, b) the southern part of the island not being used for pelagic fishing (as reported by Barry and Mario), and c) pelagic fishing from Biqueli village occurring to the far north east of the island, including the waters of the south-western coast of Pulau Wetar.

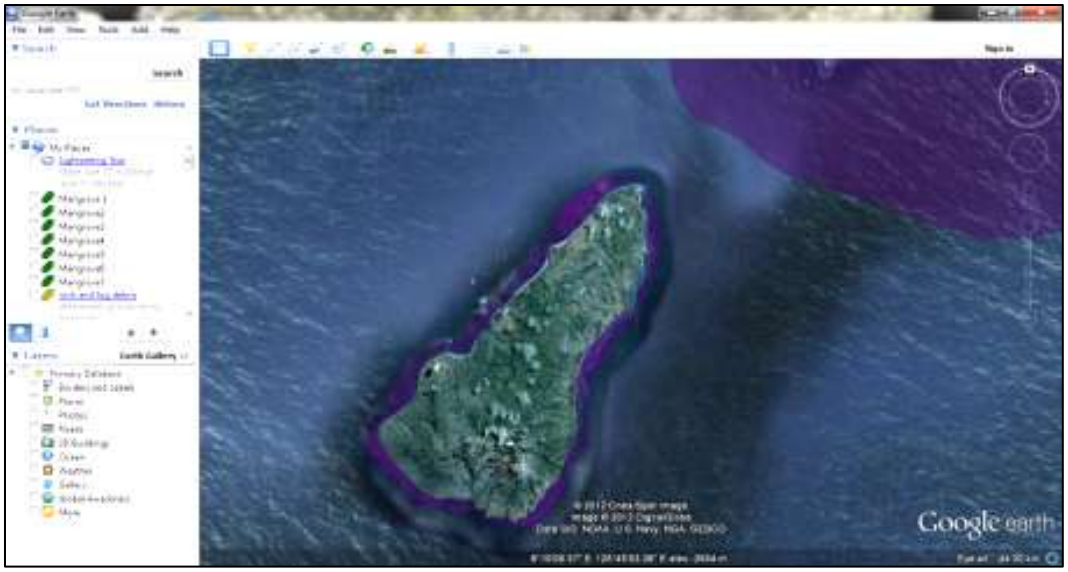

Figure 50 Atauro Island fisheries (in relation to suko) as depicted by Marcello of local NGO Roman Luan.

4.9.4 Eco-tourism/recreation locations

Figure 51 illustrates the localities of major sources of recreation and eco-tourism as annotated by Barry of Barry's Place. The recreation activities, which include snorkelling, trekking and picnicking areas, were ranked in terms of importance (not illustrated), as required by the InVEST modelling software. The most prominent nature-based recreation activities were related to the Beloi Suco, namely snorkelling off the Beloi coastline, trekking to Adara on the western coastline and snorkelling off the Adara coast.

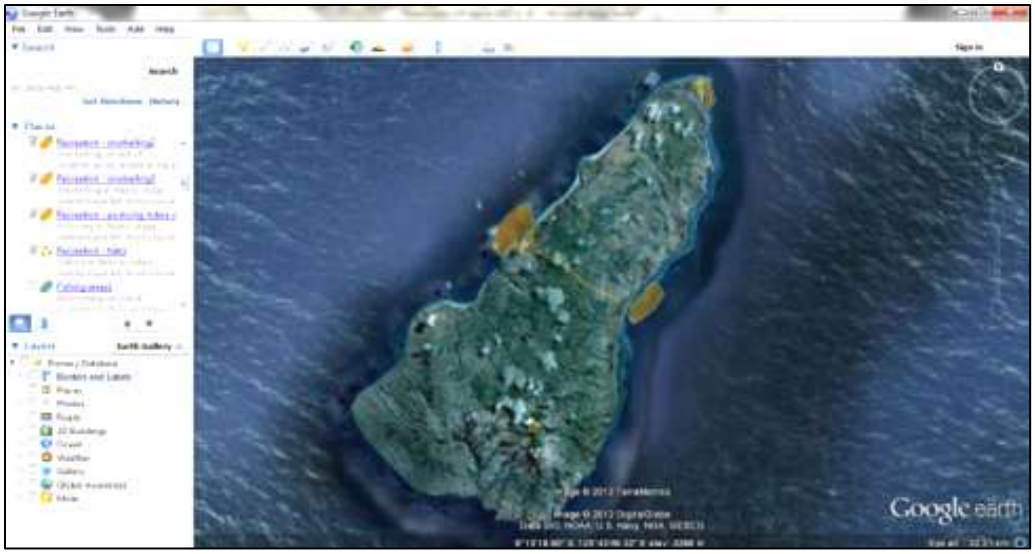

Figure 51 Atauro Island eco-tourism and recreation areas as selected (and ranked, not illustrated) by Barry of Barry's Place eco-lodge.

4.9.5 Natural habitats and utilisation

The main marine and coastal natural habitats (i.e. sea grass beds, mangroves and coral reef) in the region of Beloi village as annotated by Barry of Barry's Place eco-lodge are illustrated in Figure 52. The main community uses of each habitat type were also notated and included in the data set. For instance, the sea grass beds were principally used for spear fishing, net fishing and seaweed farming, whereas the reefs are used more for line fishing and sea cucumber harvesting, as well as snorkelling and recreational fishing (for visitors).

Figure 52 Natural habitats around Beloi village and how utilised by local community as reported by Barry of Barry's Place eco-lodge.

Marcello (of Roman Luan, and having a broad knowledge of the island's habitats) was able to provide mapping and utilisation of natural habitats (mangroves, sea grass beds and coral reefs) of the entire island. These are depicted in Figure 53–57, showing Beloi, Biqueli, Vila and Makili, respectively. Utilisation of each habitat type appears to be very uniform across the island, with sea grass beds generally utilised for spear and net fishing and seaweed farming, coral reefs used for spear, net and line fishing, snorkelling, recreational fishing and sea cucumber harvesting, and mangroves utilised for firewood and crab harvesting.

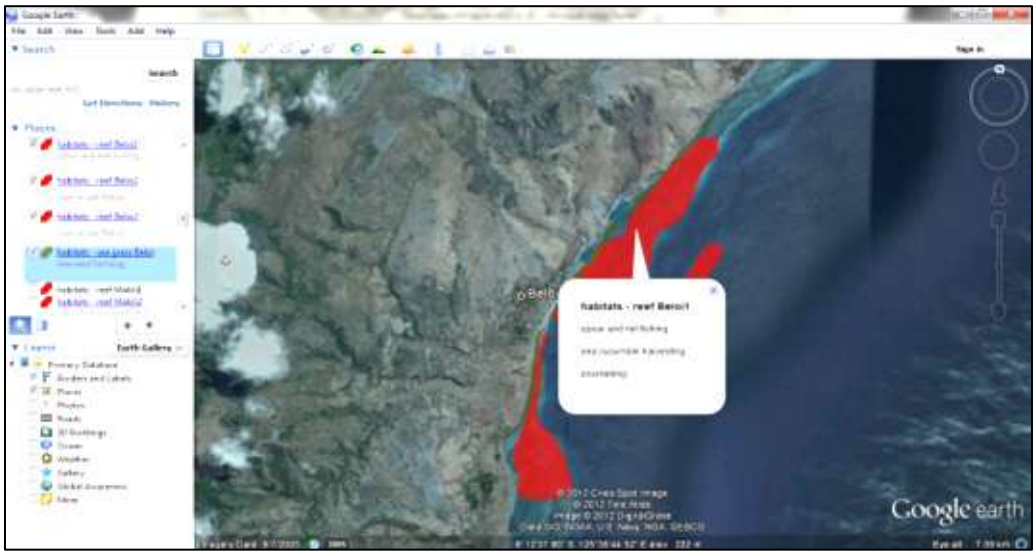

Figure 53 Natural habitats around Beloi village and how utilised by local community as reported by Marcello of Roman Luan.

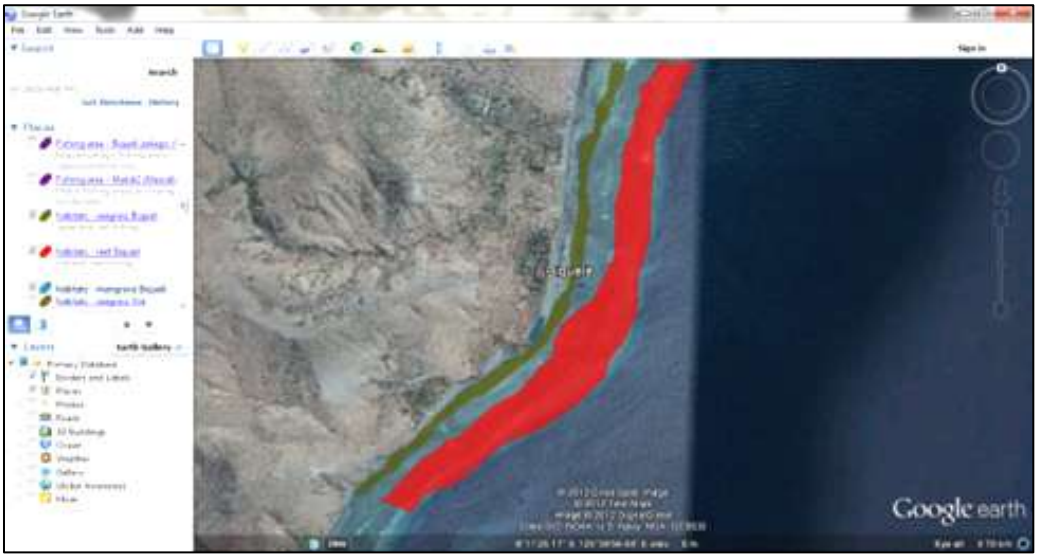

Figure 54 Natural habitats around Biqueli village and how utilised by local community as reported by Marcello of Roman Luan.

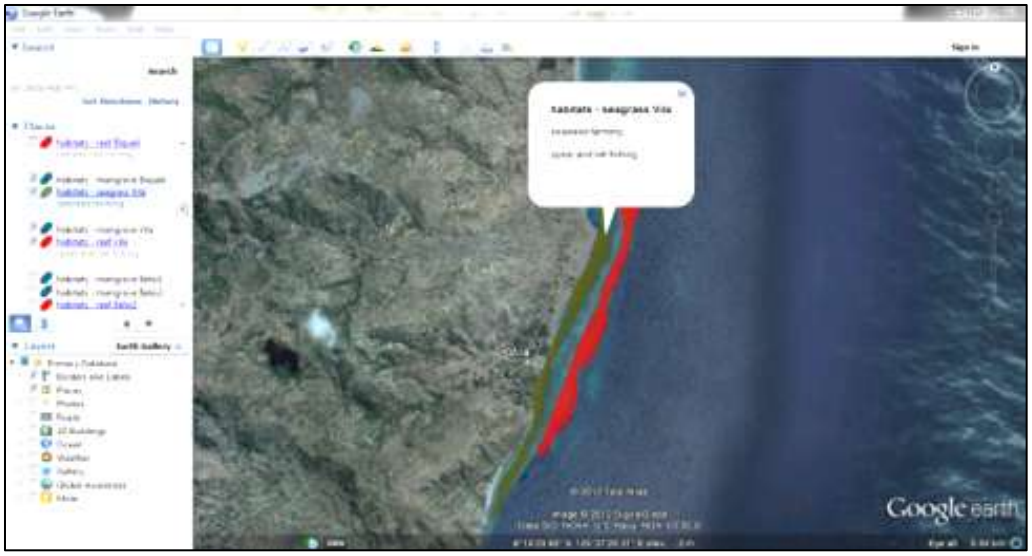

Figure 55 Natural habitats around Vila village and how utilised by local community as reported by Marcello of Roman Luan.

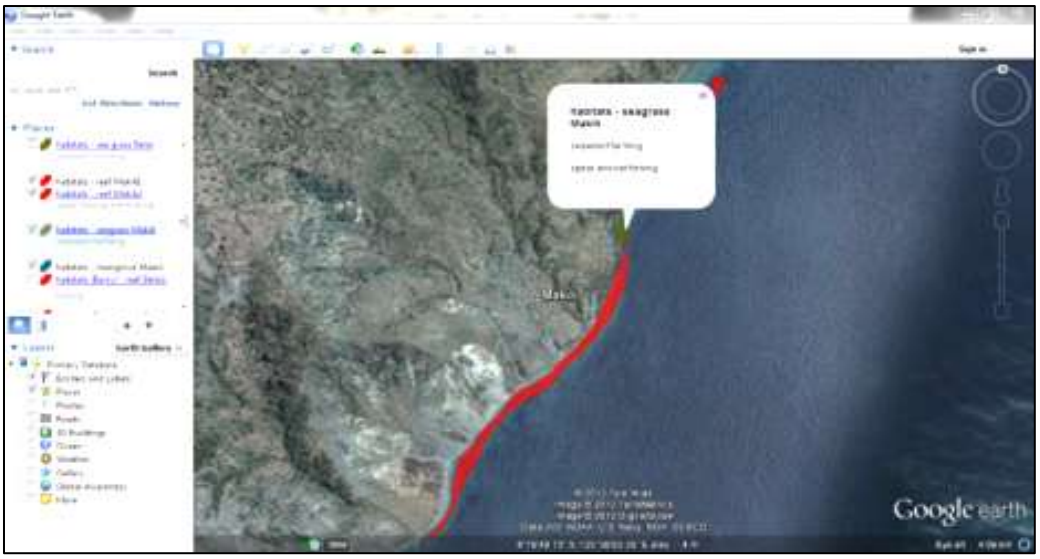

Figure 56 Natural habitats around Makili village and how utilised by local community as reported by Marcello of Roman Luan.

Beloi foreshore structure

The structure of the foreshore in the vicinity of Beloi village, when inspected on-ground, is highly variable, with areas of mangrove, woody native vegetation (generally shrubs <2 m in height), and fallen trees and rocks deliberately placed along between the road and the shore. There are also areas that appear to have very little protection from the sea, with low foreshore height coupled with no natural or constructed features to obstruct sea incursions should they occur.

Figure 57 depicts an overview of the foreshore composition and structure along the Beloi village coastline (extending approximately 1.5–2 km along the coast north and south of the village). Figure 58–62 illustrate a selection of individually mapped features with photographs of each feature.

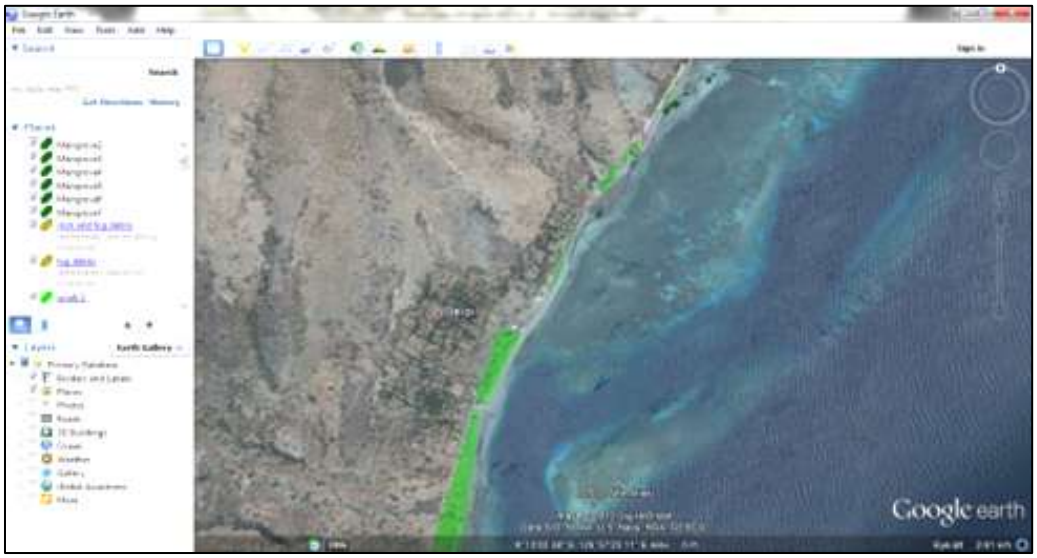

Figure 57 Foreshore features within 1.5–2km of Beloi village, as mapped on-ground.

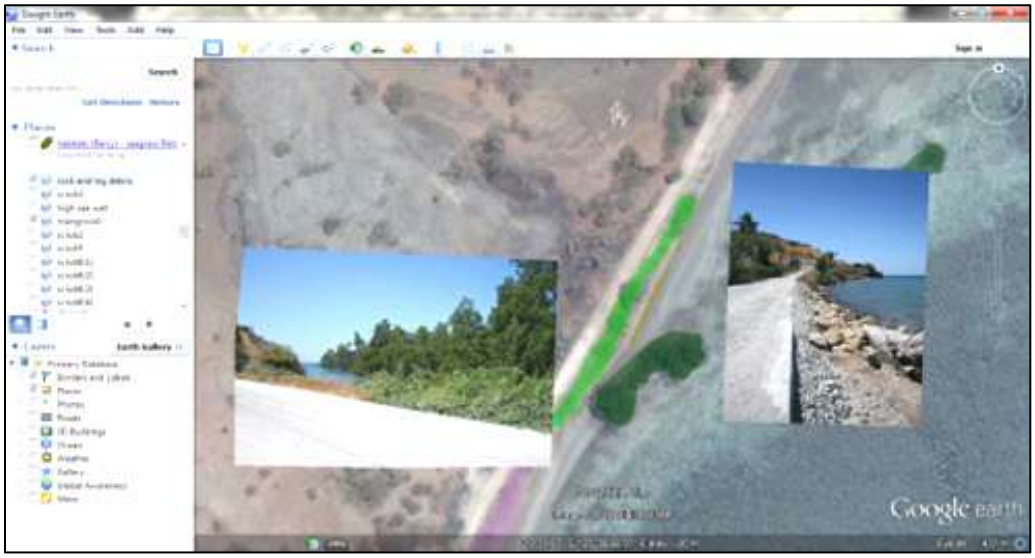

Figure 58 Foreshore 1.5 km north of Beloi village, illustrating mangroves and foreshore protection (rocks and woody debris).

Figure 59 Foreshore 1 km north of Beloi village, illustrating high sea wall and native vegetation growing on foreshore.

Figure 60 Foreshore immediately adjacent to Beloi village, illustrating native vegetation growing on foreshore.

Figure 61 Foreshore south of Beloi village, illustrating native vegetation growing on foreshore.

The data collected in the field (above) will be combined with data from online datasets, data provided with the InVEST software and data held by WorldFish in order to determine a) the current status of ecosystem service provision for Atauro Island, and b) how ecosystem service delivery may change as a result of climate change adaptation actions. The findings will be delivered in final project report in 2013.

5 Planning implementation of adaptation actions

In this section we provide brief details of the remaining activities to be undertaken at the third, and final, workshop in Timor-Leste scheduled for February 2013. These activities relate to the 'Planning Implementation' phase of the framework (see Figure 1–Figure 2 in Section 3). The aim of these final activities is to further progress communities towards their construction of a plan for implementing selected adaptation actions through informed decision-making. The activities consist of an evaluation of the material produced from the multiple participatory action research activities conducted in their communities to date, ranking of adaptation actions they wish to implement, and the identification of thresholds that will trigger implementation.

5.1 Evaluation of the material produced and its credibility, salience and legitimacy for informing decision-making

The community members will be presented with the outputs produced from the multiple participatory action research activities conducted to date (and detailed in Section 4), and asked to evaluate them in terms of their credibility, salience and legitimacy (Cash et al., 2003) in enhancing informed decision making regarding adaptation to climate change. The feedback collected during this activity will be used to consider refinements to the framework prior to its application to the second case study in the project, the Solomon Islands.

5.2 Multi criteria decision-making

Multiple-criteria decision-making (also known as multiple-criteria decision analysis) will be used as the basis for a participatory activity undertaken with community members. Multiple-criteria decision-making explicitly identifies criteria to be used to evaluate different options and aid decision making. Community-level decision-making can involve the negotiation of multiple contested values, and unique optimal solutions typically do not exist. In such circumstances the use of multiple criteria decision-making in participation with community members offers an effective tool for identifying preferences for differentiating between adaptations. The transparency that this approach can bring, particularly to the presence of trade-offs and assumptions, can promote consensus building amongst members with differing points of view, and more informed and better decisions. Whilst this approach does not guarantee that negative impacts and maladaptation will be avoided, the project aims to enhance 'informed decision-making' regarding the selection of climate change adaptation actions.

Net financial returns are regularly the main criteria used for evaluating different options, but in the context of community adaptation to climate change, environmental impacts resulting from an action and the capacity for getting an adaptation action effectively implemented and iteratively managed within existing governance structures, are also important considerations for enhancing

the long-term resilience of communities. The evaluations of adaptation options from an economic, social and environmental perspective (see Sections 4.4–4.9), are aimed to inform this facilitated community discussion.

5.3 Identifying thresholds of action to produce an adaptation pathway

Having facilitated the community members in considering the economic, social and environmental criteria important to them in selecting adaptation actions (Section 5.2 above), each activity will then be considered in terms of the thresholds that would need to be breeched in order for implementation to be triggered. These thresholds may be economic, social or environmental in nature. The aim of this exercise is to identify when community members anticipate the value of an adaptation will out-way the cost (monetary or otherwise) of implementing it, and in doing so, they will develop their own planned pathway for adaptation. Progress along the adaptation path is charted by key thresholds, thereby avoiding issue of uncertainty in climate projections (e.g. high, medium or low emissions scenarios), and importantly focuses decision-making on contextually relevant thresholds. This approach promotes adaptation as a dynamic process that requires ongoing and iterative management. Details of the theoretical underpinning of the threshold approach (as depicted by Reeder and Ranger (undated) is detailed in the Inception report submitted for this project in May 2012 (Park et al., 2012a).

5.4 Planning implementation

Outputs from the multi-criteria decision-making activity (Section 4.2 above) and threshold analysis (Section 5.3) will be collated and presented to the community to provide the basis of an implementation plan for adaptation. However, beyond this third, and final, engagement activity, the communities will likely still require additional activities to support their capacity to adapt, such as obtaining support for funding selected adaptation actions, acquiring knowledge and skills training, or strengthening governance structures to support implementation and on-going activities. This is beyond the scope of this project, however a further extension of the project has been suggested for Timor-Leste to further synthesize the project findings and enhance their integration in to current climate change and natural resource use activities ongoing in the country.

5.5 Dissemination

Discussions with in-country partners in Timor-Leste have identified a number of options for disseminating the findings from this study to community, local authority, sub-national and national level officers concerned with adaptation to climate change. At the community level, we have been asked to produce a series of four-sided leaflets, each containing details of a single activity from the framework as it has been applied in Atauro and Batugade. These will be supplemented with a leaflet that provides an overview of the framework, to provide a comprehensive source of information for communities to access. We offer a proposal for disseminating findings at the sub-national and national levels in Section 5.6 below.

5.5.1 Better understand the range of socio-economic conditions that are likely to influence the capacity of coastal community members to transform their livelihoods

This report documents the interest shown by coast community members in Batugade regarding the possible introduction of aquaculture as an adaptive response to changes in climate. In the vast majority of cases, the adoption of aquaculture would require individuals to undertake changes that are far beyond incremental adaptation of their livelihood activities (e.g. making changes to their harvesting dates or size of fishing nets), and will require more fundamental change to their entire livelihood strategies. More specifically, those fishers wishing to undertake aquaculture would need to switch from obtaining fish from marine capture fisheries, to growing fish in a static, terrestrial-based system. Similarly, existing farmers would need to include animal protein production into their mix of crop specifies. Changes of this magnitude are generally referred to as being transformational in nature (see Park et al., (2011) for definitions of incremental and transformational adaptation).

Whilst previous studies (e.g. NDFA/MAF, 2012) suggest biophysical and economic conditions may be favourable for practicing aquaculture in many areas of Timor-Leste, the capacity of fishers to *actually* undertake this transformational change and maintain it sustainably into the future, is largely unknown. It has been proposed that transformational capacity in an individual can be considered in terms of: (i) how they manage risks and uncertainty; (i) the extent of their skills in planning, learning and reorganizing; (iii) the level of financial and psychological flexibility they will require to undertake a change, and (iv) their willingness to undertake change (Marshall et al., 2012). Recognising a deficit in any of these attributes then offers the opportunity for targeted investments in capacity building that will enhance the success of an adaptation action. It is therefore clear that any further consideration of adaptation options for communities in Timor-Leste, that will require individuals to undertake a transformational change to their livelihoods, such as aquaculture, must include an assessment of the transformational (and incremental) capacity of individuals as part of any initial feasibility studies.

We propose that a survey be conducted in the communities of Batugade and Atauro to consider the capacity of individuals to undertake adaptation options of both an incremental and transformational scale. This will provide information for guiding the Government of Timor-Leste and NGO’s investments efforts to enhance the uptake of specific adaptation actions, and enhance adaptive capacity to respond to climate change more generally.

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Appendix 1 Conference abstract (Park et al., 2012c)

A participatory approach for determining adaptation actions and considerations for their implementation

Sarah Park[1], Kirsten Abernethy[1], Simon Attwood[1], Doug Beare[1], Hugh Govan[1], Jennifer King[1], Beth Timmers[1], David Mills[1],

[1] WorldFish Center, Jalan Batu Maung, 11960 Bayan Lepas Penang, Malaysia

Abstract

Climate change projections suggest that current levels of food security in farming and fishing communities in Timor-Leste are likely to be impacted by future changes in rainfall and temperature. In participation with stakeholders from communities located on Atauro Island and in Batugade, we consider the implications of changes in climate using an adaptations framework to identify stakeholders' thresholds of tolerance. Once thresholds and the most promising adaptation strategies were identified by community members, a multi-disciplinary project team conducted evaluations of the chosen actions from social, economic and environmental perspectives. This was done to help community members decide on their ongoing response to changes in climate as the identified thresholds are progressively breached. Importantly, the approach explicitly considered the development of those factors likely to inhibit and facilitate the implementation of adaptation options. These factors included formal and informal governance organisations and structures, gender relations, financial costs and benefits, and landscape-scale impacts. By undertaking a monitoring and evaluation activity within the project, we are able to report on the community participants' views on the efficacy of the approach to enhancing their capacity to determine appropriate response actions, and plan for their implementation.

Key words: Climate change, decision-making, implementation, aquatic agricultural systems

Appendix 2 Conference abstract (Beare et al., 2012)

Strategies for adaptation to climate change in Timor-Leste: the importance of rainfall thresholds

Doug Beare[1], Sarah Park[1], Kirsten Abernethy[1], Jennifer King[1], Simon Attwood[1].

[1]WorldFish Center, Jalan Batu Maung, 11960 Bayan Lepas, Penang, Malaysia.

Abstract

Timor-Leste is a small developing country located in South-East Asia. Despite its location in the tropics, the climate of Timor-Leste is relatively arid, with around 75% of rainfall (75 mm/year annually at Dili airport) occurring during the wet season (typically October to April). Retention of water in the soil is generally poor and there is limited infrastructure for rainwater storage and distribution. These factors have particular implications for the production of subsistence crops (e.g. maize) around the time of the dry season. We consider past strategies used by subsistence farmers and fishers to address historic annual variation in rainfall using: (a) observed data from 1952 to date and time-series techniques, and (b) knowledge of seasonal calendars and associated livelihood activities produced in participation with members of two communities. Climate change projections suggest an increase in the amount of rainfall received in Timor-Leste during the wet season and an increase in the intensity of rainfall events. Understanding the present connection between rainfall patterns and food production activities enabled further consideration with community members of the implications of any future changes in rainfall on the production of food. We identify a number of thresholds related to changes in rainfall that are likely to impact the ability of farmers and fishers to undertake present livelihood activities. From this we consider those activities that may need to be adapted, and options for changing current food production practices to enhance food security.

Keywords: climate change, rainfall, adaptation.

Appendix 3 Conference abstract (Attwood et al., 2012)

Assessing the environmental and ecosystem service implications of climate change adaptation strategies in Timor-Leste.

Simon Attwood[1], Doug Beare[1], Shwu Jiau Teow[1], Sarah Park[1]

[1] WorldFish Center, Jalan Batu Maung, 11960 Bayan Lepas, Penang, Malaysia

Abstract

Strategies and associated actions adopted by communities to adapt to climate change may result in intended and unintended environmental outcomes. These, in turn, may influence the delivery of ecosystem goods and services upon which these communities depend. Understanding these environmental responses and their implications for ecological function are vital where communities i) share a common resource and ii) are highly dependent upon continued ecosystem service delivery. One means to inform community-level climate change adaptation decision-making is to combine: i) stakeholder participatory methods, ii) remote sensed assessments of natural capital, and iii) on-ground rapid assessments of soil condition and function. This enables: a) the identification and prioritisation of environmental assets and associated services, b) the establishment of baselines of landscape and land use function, and c) an appraisal of how assets, services and landscape function may change in relation to climate change adaptation strategies. We outline the approaches taken in participation with fishing and farming communities in Timor-Leste, presenting here results for landscape/land use condition. In particular, we focus on the tropical home garden and how simple changes to management might improve soil function from the perspectives of soil stability, nutrient cycling and water infiltration.

Key words: Climate change, ecosystem services, aquatic agricultural systems

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Appendix 5 Workshop 1: Identifying climate change impacts and adaptation options

Workshop DAY 1

Time	Activities	Output produced (needs collecting at the end of the day)
	Registration of participants	
8.30am	Arrangement: Plenary • Welcome all participants • Prayer by community member • "Official Opening "- traditional welcome from most senior dignitary. • Welcome to WorldFish, community partner team and other key participants • Explain (a) aim of the program; (b) scope of program, (c) expected deliverables. • Read consent form and ask participants to provide signatures over morning tea	• Attendees sheet and consent form (doc #1)
10.30 – 12.00	Morning tea	
12.00 – 13.00	Arrangement: Plenary • Presentation of some past research undertaken in the region. Plenary discussion on accuracy. • Presentation of observed rainfall and temperature trends for the closest location. Plenary discussion on how this corresponded to participants' experiences and the link between annual rainfall patterns and livelihood activities. • Presentation on the science of climate change. Plenary discussion, including question and answer session. • Presentation on projections of climate change and some of the implication for current livelihood activities. Plenary discussion, including question and answer session.	
13.00 – 15.00	Lunch	
15.00 – 15.30	Arrangement: Focus groups (Male agriculturalists; Female agriculturalists; Male fishers; Female fishers; Local Authority decision-makers) (activities A and B run concurrently) ACTIVITY A: Community youths asked to draw a picture of their community and the special things in it that make it a nice place to live – and that they would like to keep special as they grow into an adult. Pictures annotated to identify special features and describe why they are special. Aim: To produce a shared vision of the future, and a goal to aim for when considering adaptation.	• Poster containing seasonal calendar complete with yellow stickies showing thresholds (Keep pinned on the wall for Day 2 – may take home at night) • Butchers' paper complete by participants (in Tetum) with impacts details for fisheries and farming. Also, English version (Keep Tetum version pinned on the wall for Day 2) • Photos of output

	ACTIVITY B: Livelihood focus group discussions asked to consider how a continuation of past trends in rainfall and temperature and projected changes may impact current livelihood activities. Existing material detailing livelihood activities (e.g. seasonal calendars) used to prompt this discussion. Aim to get participants to be specific about the activity/fish species/vegetable (not just "it will be difficult to plant crops" – what will make it difficult, why?. WF record what and why on butchers paper. Encourage consideration of env, social, econ impacts. At the end, put calendars (with thresholds stuck on them) on wall for all to look at. The one CP member in each Livelihood group to present back to the whole workshop (there are four groups so CPs know they only have 10 mins each to do this feedback– WF team to get them to pick some interesting impacts, and to keep eye on time). Put children's drawings on the wall – Arrange for children to talk about their paintings of the future briefly.	• Paintings/drawings (Keep pinned on the wall) • Photo of each painting/drawing
15.30 – 16.00	Afternoon tea . Pre-arranged catering	
	Arrangement: Plenary Summary of day's activities. Thank you, reminded of pick up time Prayer	

Workshop DAY 2

Time	Activities	Output produced (needs collecting at the end of the day)
As soon as poss	Registration for new people only – stickers for people to write their name (CP)	
8.30am – 10.00	Arrangement: Plenary of ~ 30 community representatives & additional 10-20 higher-level decision makers = ~40 • Welcome all participants • Prayer by community member • "Official Opening "- traditional welcome from most senior dignitary. • Welcome to WorldFish, community partner team and other key participants • Explain (a) aim of the program; (b) scope of program, (c) expected deliverables. • Read consent form and ask participants to provide signatures over morning tea • Poster providing overview of program • Poster with agenda for the two days (and include 3 days of data collection when we will be around the community, return workshop	• Attendees sheet and consent form for new participants only (doc #1)
10.00 – 10.30	Morning tea	

10.30 – 12.00	Arrangement: Six livelihood focus groups [predominantly farming (M, F); predominantly fishing (M, F); predominantly governance (M, F) Number of groups will depend on number of facilitators available <u>Adaptation session</u> Each Focus Group to consider seasonal calendars and discuss what actions they can take to respond to climate related impacts (i.e. produce a list of adaptation option ideas from the community) One member of each Livelihood group to present back to the whole workshop	• Butchers paper • Photos of output
12.00 – 13.00	Lunch	• Workshop photo
13.00 – 15.00	Arrangement: Plenary Project team members offer ideas on adaptation actions and consideration from social, environmental and economic perspectives Discussion on adaptation actions for fisheries and farming. Activity to prioritise the 3 adaptation actions they would most like us to evaluate from a social, environmental and economic perspective.	• Butchers' paper complete with list of agreed adaptation actions to be evaluated and the specific social, environmental and economic questions that the project team will try to answer from technical evaluations. • Photos of output
15.00 – 15.30	Afternoon tea	
15.30 – 16.00	Arrangement: Plenary Present results of voting Repeat what we have agreed to produce and encourage communities to participate with team members if asked to provide data Discussion on how the community would like the results of the analysis presented back to them Thank you and Prayer	

Appendix 6 Consent form for participants

Interview consent form: Project participants Timor-Leste

We are from The WorldFish Center (Dr Sarah Park, Kirsten Abernethy, Simon Attwood, Doug Beare, Nhuong Tran, Mr Hugh Govan). We would like to invite you to participate in this project. We are interviewing members of your community and conducting a workshop.

Purpose of the project: The purpose of this project is to provide to you with an approach that we consider may be useful to you in planning how you will manage future changes in sea, land and water resources in coastal communities in Timor-Leste. To do this, we would like to conduct interviews and workshops with you. We would like to visit your community three times over the next few months.

The information that we would like to gather on this first visit to your community will about the land, sea and water resources and how you use these. We would like to understand how your lives are changing as a result of changes in resources and other things such as climate. The project will be guided by the issues and challenges facing your communities. In addition to this this initial visit, we would like to use some of the experts that work for The WorldFish Centre to help you assess what options might be useful to you in addressing some of these issues, and think about ways that you can plan for implementing change. This latter task may require that we ask questions about who governs communities, regions and the nation, and how they do this. To undertake this research we also need to understand how you already make decisions to change and solve problems.

Right to refuse or end participation in the study: The government of Timor-Leste has requested your communities to be the focus of this project. However, you can decide to participate in this study, or not. If you agree to participate you have the right to refuse to answer any questions you do not want to answer, or withdraw from the project completely at any time. If you decide not to participate in the project, it will not adversely affect you at all.

Confidentiality: We ensure that your name or any facts that could identify you will not appear in any report. We will return to your community for our last visit to present the results of the project. Any information that we collect from this study will have your name removed and stored securely.

Risks: We do not envisage any risks in the study if you choose to participate, but if any questions we ask make you feel uncomfortable, you do not have to answer them.

Benefits: If you agree to participate, we hope the project will result in information that will be useful to you in planning your own ideas to manage your changing environment. We will be forwarding a copy of our report to the government of Timor-Leste and to the organisations that are funding this project. If you have any further ideas of how this project could be useful to you, please let us know.

Do you have any questions? If at any time during or after this study you would like to ask questions, please do so.

Agree to participate: The project information was read and explained to me clearly. Anything I didn't understand was explained to me and all my questions were answered.

Appendix 7 Summary of impacts for agriculture identified by community members in Atauro in responses to changes in climate

Table 27 Agriculture-focused impacts and adaptations identified in Atauro associated with the past trend for an early start to the dry season. (See Table 9, Section 4.3.3 for a description of the adaptation themes.)

Impact (issue) identified	Adaptation suggested	Adaptation theme
Main crops grown in the wet season fail (beans, corn, pumpkin)	If main crops fail (beans, corn, pumpkin), then fall back on crops that are currently grown to cover the dry conditions – i.e. cassava	**A**
Main crops grown in the wet season fail (beans, corn, pumpkin)	New varieties of 'existing' crops	**A**
Main crops grown in the wet season fail (beans, corn, pumpkin)	Entirely new crop species	**A**
Main crops grown in the wet season fail (beans, corn, pumpkin)	Sell livestock to provide money to buy food (sell male livestock and keep the females if possible).	**B**
Main crops grown in the wet season fail (beans, corn, pumpkin)	Do more fishing.	**E**
Main crops grown in the wet season fail (beans, corn, pumpkin)	Buy fish from fishing communities, process and sell at market for profit. Money used to buy food to make up cropping shortfall.	**E**
Lack of water and crops dying.	Improving soil condition	**A(ii)**
Drying up of spring water → corn, cassava and other farm foods decrease in productivity and do not produce seed for the following season	Plant trees around the spring (need to make fences around the saplings to protect from goats)	**A(i)**
Drying up of spring water → corn, cassava and other farm foods decrease in productivity and do not produce seed for the following season	Build a large dam or install a concrete tank to collect water, and use channels to distribute it around the crops (as done in Vila during the Portuguese time)	**A(i)**
Drying up of spring water → corn, cassava and other farm foods decrease in productivity and do not produce seed for the following season	Stop burning the soil near the spring	**D**

Table 28 Agriculture-focused impacts and adaptations identified in Atauro associated with a projected decrease in rainfall in the dry season. (See Table 9, Section 4.3.3 for a description of the adaptation themes.)

Impact (issue) identified	Adaptation suggested	Adaptation theme
Crops grow in the dry season will fail	Use the waste water from the house on plants	**A(i)**
Crops grow in the dry season will fail	Use compost toilets	**A(i)**
Crops grow in the dry season will fail	Find different ways to grow crops and varieties with a lower water requirement. (Give training to community to diversify the crops they are growing)	**A**
Crops grow in the dry season will fail	Collect rainwater from the river in the wet season (January , February, March), store the water during April, May and June, the pump it into gardens during July, August, September and December. (Local Authority can send proposals to the national government to provide community water tanks, and water tanks on houses and corrugated roofs.)	**A(i)**
Crops grow in the dry season will fail	Conduct research into why the spring water is low in the wells some years.	**A(i)**

Table 29 Agriculture-focused impacts and adaptations identified in Atauro associated with a projected increase in rainfall in the wet season. (See Table 9, Section 4.3.3 for a description of the adaptation themes.)

Impact (issue) identified	Adaptation suggested	Adaptation theme
More water likely to be available for use in home gardens and agriculture	Increase harvesting and storage capacity (presently not fully utilising rainwater supply and storage techniques are ineffectiveness, i.e. evaporation and leakage).	**A(i)**
Able to grow more crops during wet season, (but unable to store food)	Better food storage techniques	**B**
Erosion on sloping land	Reforestation	**D**
Crops will rot or not grow properly because they are sodden. Particularly corn and beans.	No adaptation suggested	
More water may be a positive thing. It can be good for livestock and plants that need water	When there is lots of rain it is a good time to plant trees such as palm, trees that store water (e.g. 'Lamtoro, aimantanduko'), and firewood trees.	**A(i)**
People can capture more water in their tanks (particularly upland communities)	Water harvesting	**A(i)**

Table 30 Agriculture-focused impacts and adaptations identified in Atauro associated with a projected increase in the intensity of rainfall. (See Table 9, Section 4.3.3 for a description of the adaptation themes.)

Impact (issue) identified	Adaptation suggested	Adaptation theme
Intense rainfall causes landslides (destroying fields, gardens, houses, lives) (Example given from 2006 when everything was destroyed in a landslide caused by extreme deluge).	Reforestation	**D**
Intense rainfall causes erosion. The runoff goes into the sea making it muddy and difficult to fish.	No adaptation suggested	
Intense rainfall will causes dengue and malaria	No adaptation suggested	

Table 31 Agriculture-focused impacts and adaptations identified in Atauro associated with projected changes in climate (non-specific projection or historic trend). (See Table 9, Section 4.3.3 for a description of the adaptation themes.)

Impact (issue) identified	Adaptation suggested	Adaptation theme
Changes in the species and numbers of pests that occur, and the need to manage new ones or higher numbers.	Improved pest management	**A(ii) and B**
Climate change will necessitate a need to change farming practices, but communities may not be supported by government in doing this	Formal and informal governance	**C**

Appendix 8 Summary of impact and adaptations for fishing identified by community members in Atauro in responses to changes in climate

Table 32 Fishing-focused impacts and adaptations identified in Atauro associated with the past trend for an early start to the dry season. (See Table 10, Section 4.3.3 for a description of the adaptation themes.)

Impact (issue) identified	Adaptation suggested	Adaptation theme
Increased opportunity to go fishing in Dili or other places further away e.g. Liran island (Indonesia)	Increase fishing	**A(i)**

Table 33 Fishing-focused impacts and adaptations identified in Atauro associated with a projected increase in surface air temperature (and sea-surface temperature). (See Table 10, Section 4.3.3 for a description of the adaptation themes.)

Impact (issue) identified	Adaptation suggested	Adaptation theme
Provides an increased chance to dry fish which can be sold in Atauro and Dili.	Increase fishing	**C**
At low tide the fish, fish eggs, seaweed and coral in the shallow water will get too hot and die	No adaptation suggested	
More runoff from the land into the river and is transported to the coastal waters making the sea dirty and when it is muddy, it is not possible to fish	Do not go diving/spearfishing, and use other methods such as the sock, trap nets in deeper water	**A(ii)**
Waves would be bigger so it would be harder to go fishing.	No adaptation suggested	

Table 34 Fishing-focused impacts and adaptations identified in Atauro associated with a projected increase in rainfall in the wet season. (See Table 10, Section 4.3.3 for a description of the adaptation themes.)

Impact (issue) identified	Adaptation suggested	Adaptation theme
Unable to go fishing due to weather	Can fish inside the reef	**A(ii)**
Unable to go fishing due to weather	Can use the time to mend gear	**C**
Unable to go fishing due to weather	East coast fishermen can collect seaweed which can also be dried and sold.	**C**
Unable to go fishing due to weather	Can go to their gardens and help their wives. If money is short, they will not employ people to help them garden their lands.	**F**
Unable to go fishing due to weather	Use their savings or just live a subsistence lifestyle.	**F**
Unable to go fishing due to weather	Engage in other business, such as buying goods in Dili and selling at market in Atauro.	**F**
Decreased seaweed production due to low light levels [added the second day]	No adaptation suggested	

Table 35 Fishing-focused impacts and adaptations identified in Atauro associated with the past trend for a longer dry season. (See Table 10, Section 4.3.3 for a description of the adaptation themes.)

Impact (issue) identified	Adaptation suggested	Adaptation theme
Greater opportunity to fish	Increase fishing	**A**

Table 36 Agriculture-focused impacts and adaptations identified in Atauro associated with a projected increase in sea level. (See Table 11, Section 4.3.3 for a description of the adaptation themes.)

Impact (issue) identified	Adaptation suggested	Adaptation theme
During big storms some peoples' houses will get flooded if they have been built too close to sea	Move houses to another place. (There is not a problem with doing this because the seaside belongs to the fishermen, but it will rely on community collaboration.)	**D**
During big storms some peoples' houses will get flooded if they have been built too close to sea	Rehabilitation of coastal vegetation.	**E**
During big storms some peoples' houses will get flooded if they have been built too close to sea	Educating fishers (But a 2 day education workshop is not likely to work, as they need an ongoing and locally based education program that utilises a network of people across the island. Possibly best to use the NGO (Roman Luan) to do the education. They should form a group that is trained and that can train other people.)	**G**
Reduced space to tie up their boats	No adaptation suggested	

Table 37 Agriculture-focused impacts and adaptations identified in Atauro associated with the past trend for a shorter wet season (and longer dry season). (See Table 11, Section 4.3.3 for a description of the adaptation themes.)

Impact (issue) identified	Adaptation suggested	Adaptation theme
Fishermen heading to fish in Indonesia because of lack of fish in local waters	Encourage more people to fish through a community awareness program.	**A(i)**
Increased opportunity to return to fishing (particularly for West Coast fishers who don't have a relocation strategy to use during the wet season when waves on the west coast are too big to go fishing). But this may reduce the price of fish.	If the fish price is low (because lots of fish on the market from East and West coast being able to fish) – they can sell fish further away, or process fish and sell it in Dili.	**A(i)**
Fishermen heading to fish in Indonesia because of lack of fish in local waters	Improve the skills of fishermen (via training courses and study trips to other countries - they need to see experience from other countries) to be able to fish effectively in fisheries further away.	**A(i)**
Fishermen heading to fish in Indonesia because of lack of fish in local waters	FAD in deep water beyond the coral	**A(i)**
Fishermen heading to fish in Indonesia because of lack of fish in local waters	Special regulation required to stop: - Use of traditionally made potions for poisoning the small fish; - Use of non-organic chemicals and dynamite; - Banging of rocks in water to make noise and drive fish into nets; - Stop use of small nets - Create Marine Protected Area near to shore	**B**

Appendix 9 Summary of impact and adaptations for agriculture identified by community members in Batugade in responses to changes in climate

Table 38 Agriculture-focused impacts and adaptations identified in Batugade associated with the past trend for an earlier dry season. (See Table 13, Section 4.3.4 for a description of the adaptation themes.)

Impact (issue) identified	Adaptation suggested	Adaptation theme
Crops (cassava, maize, rice, peanut, mung bean) will not grow properly because the rainy season will not be long enough if the dry season comes early.	Improve water capture and use (for non-drinking water) through: (i) reforestation of mountain and gardens (to bring rain, provide vegetation for animals to eat, provide shade for people and gardens, and provide leaves for compost), and (ii) collect rainwater from the roofs and use bamboo pipes to distribute. Then you would need to build large water tanks to store water for crops, for animals to drink, for washing in anticipation of long dry season.	**A(i)**
The well will dry up (used for drinking water, washing, water from animals).	Need to dig wells further down (another 1-2 meters).	**A(i)**
There will be less water for irrigation for the rice.	People will need to buy rice.	**B**
Corn - positive, as the corn will dry earlier.	Training to make good decisions about when to plant and what to plant if dry season comes early.	**C**
Veggies (tomatoes, potato, green vegetables, green been eggplant, garlic) will benefit as they can be planted (and harvested) earlier. But this also means that it gets hotter earlier in the year, and these crops may get a low price in the market. Also some of the plants will die as there may not be enough irrigation water.	Training to make good decisions about when to plant and what to plant if dry season comes early. They want to grow more crops to sell for cash sales in Balibo and sell ripe tomatoes and green beans to Dili markets. They also want to sell at Maliane and Atabae markets. A water tank filled in the wet season could help water plants and animals.	**C**

Table 39 Agriculture-focused impacts and adaptations identified in Batugade associated with the past trend for a longer dry season. (See Table 13, Section 4.3.4 for a description of the adaptation themes.)

Impact (issue) identified	Adaptation suggested	Adaptation theme
Low levels of water for drinking (it becomes rationed but they never completely run out, and the water is clean)	Need to dig wells further down (another 1-2 meters).	**A(i)**
Cannot plant crops as there is no water for irrigation. People then become very hungry.	Obtain money to buy dried cassava and things from the market by: (i) young people going to Dili to look for work or on the projects ($3 day); (ii) plant crops that need less water and do well in the dry season (e.g. tomato, chili). Then sell these at the market and buy rice (the problem is that everyone does the same thing); (iii) sell livestock.	**B**
Cannot plant crops as there is no water for irrigation. People then become very hungry.	Eat alternative food, e.g.: (i) If they have stored food, they will eat that (dry maize and cassava); (ii) eat the inside of bark from the palm tree (old people cannot do anything, so they just eat bark.	**B**
Cannot plant crops as there is no water for irrigation. People then become very hungry.	Nu'badak men can go fishing (Lotan men cannot because they don't know how to fish)	**E**

Table 40 Agriculture-focused impacts and adaptations identified in Batugade associated with the projection for a hotter dry season. (See Table 13, Section 4.3.4 for a description of the adaptation themes.)

Impact (issue) identified	Adaptation suggested	Adaptation theme
Drinking water - there will not be enough drinking water, so they will have to walk far and carry it back.	Lack of drinking water - they could collect rainwater off roofs (doesn't happen presently). Need to provide water tanks for animals too.	**A(i)**
Lack of grass for grazing animals - the lack of green grass for animals is a problem because they either die or get very thin.	Need to provide water tanks for animals, and plant trees to feed animals in the late dry season when other food is short. Trees can be planted to feed animals in the late dry season. Rumput Gajan grass can also be grown to feed animals.	**A(i)**
Trees and animals can die (e.g. buffalo, chicken, pig, also wild animals such as deer and boar)	Improve water capture and use (for non-drinking water) through: (i) reforestation of mountain and gardens (to bring rain, provide vegetation for animals to eat, provide shade for people and gardens, and provide leaves for compost), and (ii) collect rainwater from the roofs and use bamboo pipes to distribute. Then you would need to build large water tanks to store water for crops, for animals to drink, for washing in anticipation of long dry season.	**A(i)**
Trees - coconut and papaya die during particularly dry periods.	Trees - these must be replaced when there is sufficient rain.	**A(ii)**
Higher temperatures are not good for fish in aquaculture ponds - it kills them.	Aquaculture ponds will need to be sited next to trees for shade. Shade structures could be built (but training is required for this).	**E**
People get sick because they are too hot	No adaptation suggested	
There will be more wild fires	No adaptation suggested	
Animals will get more pests	No adaptation suggested	

Table 41 Agriculture-focused impacts and adaptations identified in Batugade associated with the projection for less rain in the dry season. (See Table 13, Section 4.3.4 for a description of the adaptation themes.)

Impact (issue) identified	Adaptation suggested	Adaptation theme
If there are no rains at the end of the dry season, this gives the farmers the opportunity to prepare the land for the wet season crops. Preparation of the land includes clearing the garden, cutting the small trees down, drying out the cut foliage, burning it, and building fences. If they don't have time to prepare the land before the rain, they will not be able to plant everything	Prepare land earlier.	

Table 42 Agriculture-focused impacts and adaptations identified in Batugade associated with the projection for more intense rainfall. (See Table 13, Section 4.3.4 for a description of the adaptation themes.)

Impact (issue) identified	Adaptation suggested	Adaptation theme
Water storage - increased rainfall will be captured and available for irrigation in the next dry season.	There is an opportunity to store more rainfall in tanks for drinking water. Tanks on houses was discussed and it was considered that grass roofs could still be used to harvest water. Fresh water can be harvested from the river (it is already), but the community water tank stores of water and the river can be low between August and Osctober - at this time the community needs water. Animals need their own water tanks.	**A(i)**
Crops - some crops can die due to heavy rains.	They need to know how to manage crops better in the wet season so that they don't die of waterlogging. [There is an agri extension training place in Lotan, but many of the women have not attended because (a) some of the women are still at school; (b) lots of women are not interested in working in agriculture. They spoke of a need for training, especially for women to 'excite' them about agriculture and give them knowledge. They need equipment too.	**C**
River - the river will flood and this will have a negative effect on the plantings that are flooded. It also drowns animals and destroys houses and fields (particularly, banks around rice fields which then need to be rebuilt).	Revegetation around the river banks with bamboo and tree species would hold back high water (bamboo will not break) and hold the banks together. Some places already use rocks to shore up the banks of the river.	**D**
Aquaculture pond - these flood when there is really heavy rainfall and fish are lost.	Aquaculture ponds - fish are given by MAP when fish are lost due to heavy rains and flooding. When there is no fish to eat, then people just turn to different vegetables and they sometimes kill a chicken, pig, cow or duck.	**E**
Houses - the roofs of the houses leak when the rainfall is heavy.	No adaptation option given	

Table 43 Agriculture-focused impacts and adaptations identified in Batugade associated with the projection for more rain in the wet season. (See Table 13, Section 4.3.4 for a description of the adaptation themes.)

Impact (issue) identified	Adaptation suggested	Adaptation theme
They will get more of a problem with rice pests (they presently get a green and brown insect, called Nago)	Make a home-made natural pesticide using chili and Ai Nimba	**A(ii)**
Erosion of soil	Prevent erosion by: (i) planting trees; (ii) planting bamboo on the river banks; (iii) Build terraces	**D**
Inundation of gardens - the crops get flooded and rot, and it happens at a time of year that causes rice to not grow well	Prevent inundation of fields (to improve irrigation and prevent water getting dirty) by: (i) making gutters to drain fields; (ii) repairing existing gutters	**D**
Destroys irrigation system because the pipe breaks at the joints, then drinking water gets dirty and people get sick	No adaptation provided	
Cassava, beans, sweet potato, banana, and taro all grow well in the rain so they will benefit	No adaptation provided because this is positive	
Water storage - increased rainfall is positive as water is stored for irrigation (of rice, veg and corn) and for use in aquaculture.	There are already water tanks in Lotan, and this is a good option for harvesting water.	**A(i)**
Maize - if it is too wet, then the corn roots are in the waterlogged soil (same for other veggies grown during the wet season) and this decreases the quality of the corn and it stays immature and does not ripen.	Hilling up used to plant maize and reduce waterlogging of roots.	**A(ii)**
Rice - Positive impact on rise because there will be enough water. But when the rice grains are formed on the crop, the wet weather makes them go mouldy.	Mouldy rice - the Minister of Agriculture has been asked for rice and corn varieties that do not go mouldy. The women want new varieties of rice and corn that can cope with wet weather and the training in how to grow them.	**C**
Maize - if it is too wet, then the corn roots are in the waterlogged soil (same for other veggies grown during the wet season) and this decreases the quality of the corn and it stays immature and does not ripen.	The women want new varieties of rice and corn that can cope with wet weather and the training in how to grow them.	**C**
Cannot plant crops as there is no water for irrigation. People then become very hungry.	Practice storing food from previous harvest, like dry maize and cassava. Storage is up in tree houses, in plastic bottles or in drums.	**B**

Table 44 Agriculture-focused impacts and adaptations identified in Batugade associated with the past trend for a shorter wet season. (See Table 13, Section 4.3.4 for a description of the adaptation themes.)

Impact (issue) identified	Adaptation suggested	Adaptation theme
Less opportunity to capture water.	Need water tanks for plants and for human consumption (they felt the community members could drink straight from the tank and there was no need to boil water)	**A(i)**
Land preparation - the sooner the wet season finishes, the sooner that the land becomes good for planting veggies.	Plant crops earlier.	**A(ii)**
Grass around trees - as the wet season is the time that grass grows around the bottom of trees, the shorter wet season will give less opportunity for the grass to grow, and the task of clearing it will be reduced.	The grass that is usually thrown out at the end of the wet season could be used to make compost. They would like to know how to make compost well and don't have a problem with handling animal manure.	**C**
Erosion and landslides - the number of these will reduce if there is a shorter wet season. This is positive.	No adaptation required.	

Appendix 10 Summary of impact and adaptations for fishing identified by community members in Batugade in responses to changes in climate

Table 45 Fishing-focused impacts and adaptations identified in Batugade associated with the past trend for an earlier start to the dry season. (See Table 14, Section 4.3.4 for a description of the adaptation themes.)

Impact (issue) identified	Adaptation suggested	Adaptation theme
Fishing activity can start earlier in the year. Longer fishing season may lead to higher catches for any year. At the end of the rainy season they catch different species of fish (tuna & grouper), i.e. in April and May they catch the biggest fish. If rainy season ended earlier then they would, perhaps, have a longer big fish season.	Extend fishing activities.	**A**
Increased opportunity to go fishing in Dili or other places further away e.g. Liran island (Indonesia). This is a good thing - it is a good opportunity to make money from fishing.	Extend fishing activities.	**A(i)**

Table 46 Fishing-focused impacts and adaptations identified in Batugade associated with the projection of a hotter dry season. (See Table 14, Section 4.3.4 for a description of the adaptation themes.)

Impact (issue) identified	Adaptation suggested	Adaptation theme
Fishermen can spend longer at sea.	Men increase their fishing activities (they go to sea in the early mornings while wives do the gardening).	**A**
Negative impact on home gardens. Tomatoes do poorly in hot weather and more crops get affected by pests.	Three years ago there was a serious pest outbreak, gardens were devastated and people compensated by fishing more.	**F**
Negative impact on home gardens. Tomatoes do poorly in hot weather and more crops get affected by pests.	Irrigation system for household level gardens.	**F**
Negative impact on home gardens. Tomatoes do poorly in hot weather and more crops get affected by pests.	Education from government on what to plant in the dry season.	**F**

Table 47 Fishing-focused impacts and adaptations identified in Batugade associated with the projection for less rainfall in the dry season. (See Table 14, Section 4.3.4 for a description of the adaptation themes.)

Impact (issue) identified	Adaptation suggested	Adaptation theme
Less fish and lower stocks overall. [Circulation in sea is diminished, reducing nutrient supply to surface. When rains come they 'draw' nutrients into surface waters and increase fish production in areas fishers can reach]	Undertake agriculture, but need irrigation system for gardens and education from government on what to plant in the dry season.	**F**

Table 48 Fishing-focused impacts and adaptations identified in Batugade associated with the projection for more intense rainfall. (See Table 14, Section 4.3.4 for a description of the adaptation themes.)

Impact (issue) identified	Adaptation suggested	Adaptation theme
Fishing activity compromised or brought to a standstill (standstills often already happen in January and February and boats with and without engines are affected).	Shortage of cash leads to the sale of livestock.	**F**

Table 49 Fishing-focused impacts and adaptations identified in Batugade associated with the projection for increased sea level. (See Table 14, Section 4.3.4 for a description of the adaptation themes.)

Impact (issue) identified	Adaptation suggested	Adaptation theme
On-shore activities compromised or affected.	Store boats and gear higher up beach.	**D**
The rise in sea level will affect fishing communities that are near the sea and they may need to move inland. If the waves are high, these may break the fishing boats.	Fishers could be trained to be able to do agriculture too.	**F**

Table 50 Fishing-focused impacts and adaptations identified in Batugade associated with the past trend for a shorter wet season. (See Table 14, Section 4.3.4 for a description of the adaptation themes.)

Impact (issue) identified	Adaptation suggested	Adaptation theme
Less sardines, less big fish, less upwelling of nutrients ('fertlises' the upper ocean). In long dry season the bottom waters become colder which makes spear-fishing more difficult.	No adaptation suggested.	

Table 51 Fishing-focused impacts and adaptations identified in Batugade associated with the projection for more rain in the wet season. (See Table 14, Section 4.3.4 for a description of the adaptation themes.)

Impact (issue) identified	Adaptation suggested	Adaptation theme
Fishing activity compromised. This leads to more effort spent on agriculture and horticulture since most fishing families also have gardens. Boats with engines can still go but trips are shorter.	Improve ability to fish by improving infrastructure by building a fish landing for improved marketing.	**A**
Fishing activity compromised. This leads to more effort spent on agriculture and horticulture since most fishing families also have gardens. Boats with engines can still go but trips are shorter.	Improve ability to fish by implementing/improving supporting services such as: (i) creating a fishing co-operative to purchase gear in bulk; (ii) creating a fishing co-operative to borrow credit; (iii) knowing about and using improved fishing techniques, engine repair and maintenance, aquaculture techniques, FAD production/utilization.	**A**
Fishing activity compromised. This leads to more effort spent on agriculture and horticulture since most fishing families also have gardens. Boats with engines can still go but trips are shorter.	Improve ability to fish in wetter weather by changing/improving equipment: (i) replacing small (1m * 3m canoes) with bigger fiberglass boats (2m * 6m) powered by 15hp outboard engines; (ii) having access to bigger mesh gillnets (5 inch) to catch bigger fish; (iii) having access to better clothing for sea (jackets, and also gloves); (iv) having access to ice boxes on boats and also on motorcycles (for delivery) to preserve fish, increase fishing time/preserve quality of fish and increase price; (v) building fish aggregating devices (FAD) (rampoons).	**A(i)**
Fishing activity compromised. This leads to more effort spent on agriculture and horticulture since most fishing families also have gardens. Boats with engines can still go but trips are shorter.	Diversify into other livelihoods, specifically aquaculture and integrated aquaculture and poultry farming.	**F**

Table 52 Fishing-focused impacts and adaptations identified in Batugade not related to any specific change in climate. (See Table 14, Section 4.3.4 for a description of the adaptation themes.)

Impact (issue) identified	Adaptation suggested	Adaptation theme
	Need for protection of coral reef, specifically law enforcement of reef use	**B**
	Need for reforestation of mangrove (mangrove area was present in the past, but no longer exists)	**E**

Appendix 11 Summary of responses to governance and institutional survey conducted at the community level

Table 53 Farmer responses (count and percentage) to the question: Do you know of any rules or regulations that come from the national government that you must follow for using the land, soil, sea and rivers for fishing / farming activities? If so, what are they ?

	Answered 'Yes'	Rules or regulations known about			
		Don't cut trees/ destroy forest	Don't burnt the grass	Protect water sources	Don't destroy plants
Bikeli	5 100%	5 100%	5 100%	4 80%	1 20%
Macadade	7 35%	6 86%	6 86%	2 29%	2 29%
Beloi	3 60%	3 100%	2 67%	3 100%	0 0%
Makili	6 60%	5 83%	5 83%	5 83%	1 17%
Vila	5 100%	5 100%	5 100%	5 100%	0 0%
Balibo	15 100%	15 100%	0 0%	0 0%	0 0%
Batugade	16 100%	16 100%	0 0%	0 0%	0 0%

Table 54 Farmer responses (count and percentage) to the question: Do you know of any rules or regulations that come from Traditional elders (e.g. Lia nain) that you must follow for using the land, soil, sea and rivers for fishing / farming activities? If so, what are they ?

	Answered 'Yes'	Rules or regulations known about						
		Don't cut trees/ destroy forest	Don't burnt the grass	Protect water sources	Don't destroy plants	Don't use another person's land w/o permission	Make the fence/ confine the animals	Tara Bandu
Bikeli	5 100%	5 100%	5 100%	0 0%	0 0%	0 0%	0 0%	0 0%
Macadade	18 90%	12 67%	13 72%	3 17%	0 0%	3 17%	2 11%	3 17%
Beloi	3 60%	2 67%	2 67%	0 0%	1 33%	1 33%	0 0%	2 67%
Makili	6 60%	5 83%	2 33%	0 0%	3 50%	0 0%	0 0%	2 33%
Vila	1 20%	1 100%	1 100%	0 0%	0 0%	0 0%	0 0%	0 0%
Balibo	11 73%	4 36%	0 0%	0 0%	0 0%	0 0%	0 0%	5 45%
Batugade	10 63%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	10 100%

Table 55 Farmer responses (count and percentage) to the question: Have you ever seen a regional extension officer from the national Fisheries/Agriculture Department in your village? If so, how often do you normally see him ?

	Answered 'Yes'	Frequency			
		Every day/ Very often	Every month	Once in 6 months	Once a year
Bikeli	5 100%	0 0%	0 0%	4 80%	1 20%
Macadade	14 70%	0 0%	2 14%	10 71%	2 14%
Beloi	5 100%	0 0%	2 40%	1 20%	2 40%
Makili	8 80%	0 0%	0 0%	4 50%	4 50%
Vila	3 60%	0 0%	0 0%	0 0%	3 100%
Balibo	12 80%	5 42%	7 58%	0 0%	0 0%
Batugade	16 100%	0 0%	16 100%	0 0%	0 0%

Table 56 Farmer responses (count and percentage) to the question: Have you ever seen a NGO person in your village? If so, what NGO were they from? How often do you normally see them ?

	Answered 'Yes'	Frequency			
		Every day/ Very often	Every month	Once in 6 months	Once a year
Bikeli	0 0%	0 0%	0 0%	0 0%	0 0%
Macadade	20 100%	0 0%	1 5%	9 45%	10 50%
Beloi	2 40%	0 0%	0 0%	1 50%	1 50%
Makili	6 60%	0 0%	2 33%	4 67%	0 0%
Vila	3 60%	0 0%	0 0%	0 0%	3 100%
Balibo	12 80%	1 8%	11 92%	1 8%	0 0%
Batugade	0 0%	0 0%	0 0%	0 0%	0 0%

Table 57 Farmer responses (count and percentage) to the question: Who in your community makes decisions on issues related to the land, soil, sea and rivers for fishing / farming activities ?

	Traditional Lawyer	Local Authority	Council Church	Community Leader	Community
Bikeli	5 100%	2 40%	0 0%	3 60%	0 0%
Macadade	20 100%	9 45%	0 0%	11 55%	0 0%
Beloi	5 100%	5 100%	0 0%	0 0%	0 0%
Makili	10 100%	10 100%	0 0%	0 0%	0 0%
Vila	4 80%	4 80%	0 0%	0 0%	0 0%
Balibo	0 0%	12 80%	0 0%	0 0%	15 100%
Batugade	0 0%	5 31%	0 0%	0 0%	16 100%

Table 58 Fisher responses (count and percentage) to the question: Do you know of any rules or regulations that come from the national government that you must follow for using the land, soil, sea and rivers for fishing / farming activities? If so, what are they ?

		Rules or regulations known about			
	Answered 'Yes'	Limitations on practices &/or tools and how to use them	Limit specific species caught	Can use traditional tools	Sea protection
Bikeli	15 100%	15 100%	6 40%	1 7%	0 0%
Beloi	15 100%	15 100%	7 47%	0 0%	0 0%
Makili	4 40%	4 100%	2 50%	0 0%	0 0%
Vila	13 87%	12 92%	6 46%	0 0%	1 8%
Balibo	5 100%	5 100%	0 0%	0 0%	0 0%
Batugade	14 100%	14 100%	0 0%	0 0%	0 0%

Table 59 Fisher responses (count and percentage) to the question: Do you know of any rules or regulations that come from Traditional elders (e.g. Lia nain) that you must follow for using the land, soil, sea and rivers for fishing / farming activities? If so, what are they ?

	Answered 'Yes'	Rules or regulations known about					
		Limitations on practices &/or tools and how to use them	Limit specific species caught	Don't catch fish arbitrarily/ fisheries activities limitations	Hang up items?	Don't undertake activities in the place had hang up	Tara Bandu
Bikeli	13 87%	8 62%	5 38%	0 0%	3 23%	1 8%	0 0%
Beloi	13 87%	2 15%	13 100%	0 0%	1 8%	0 0%	0 0%
Makili	6 60%	5 83%	1 17%	2 33%	0 0%	0 0%	0 0%
Vila	9 60%	4 44%	7 78%	0 0%	0 0%	0 0%	0 0%
Balibo	4 80%	0 0%	0 0%	0 0%	0 0%	0 0%	3 75%
Batugade	8 57%	0 0%	0 0%	0 0%	0 0%	0 0%	8 100%

Table 60 Fisher responses (count and percentage) to the question: Have you ever seen a regional extension officer from the national Fisheries/Agriculture Department in your village? If so, how often do you normally see him ?

	Answered 'Yes'	Frequency			
		Every month	Once in 6 months	Once a year	Never
Bikeli	12 80%	3 25%	3 25%	6 50%	3 25%
Beloi	13 87%	0 0%	4 31%	9 69%	2 15%
Makili	8 80%	0 0%	4 50%	4 50%	2 25%
Vila	11 73%	0 0%	4 36%	7 64%	4 36%
Balibo	4 80%	3 75%	0 0%	1 25%	0 0%
Batugade	1 7%	1 100%	0 0%	0 0%	0 0%

Table 61 Fisher responses (count and percentage) to the question: Have you ever seen a NGO person in your village? If so, what NGO were they from? How often do you normally see them?

	Answered 'Yes'	Frequency			
		Every month	Once in 6 months	Once a year	Never
Bikeli	14 93%	2 14%	5 36%	8 57%	0 0%
Beloi	11 73%	0 0%	4 36%	7 64%	4 36%
Makili	10 100%	0 0%	7 70%	3 30%	0 0%
Vila	9 60%	0 0%	0 0%	9 100%	6 67%
Balibo	2 40%	0 0%	2 100%	0 0%	0 0%
Batugade	2 14%	0 0%	2 100%	0 0%	0 0%

Table 62 Fisher responses (count and percentage) to the question: Who in your community makes decisions on issues related to the land, soil, sea and rivers for fishing / farming activities?

	Traditional Lawyer	Local Authority	Council Church	Community Leader	Ourselves/ Our family	Fisheries
Bikeli	14 93%	14 93%	1 7%	1 7%	2 13%	0 0%
Beloi	13 87%	1 7%	0 0%	12 80%	0 0%	0 0%
Makili	10 100%	0 0%	0 0%	10 100%	0 0%	0 0%
Vila	15 100%	0 0%	0 0%	15 100%	0 0%	0 0%
Balibo	0 0%	2 40%	0 0%	0 0%	1 20%	5 100%
Batugade	0 0%	3 21%	0 0%	0 0%	0 0%	14 100%

Appendix 12 Review of CORE and PROFOR

Collaborative Governance Assessment

CORE is designed as a process to build dialogue among local actors to enable collaborative actions aimed at transforming multi-stakeholder competition and conflict over natural resources. It provides a framework for understanding stakeholder interactions and organizing for social and institutional change, distinguished by its emphasis on whole systems, an open search for solutions, and explicit treatment of power. Ratner and Smith (2012) describe the participatory process.

Ratner and Smith (2012) present an analytical framework on governance assessment in aquatic agricultural systems, and Ratner (2012) provides more detail on how to apply that framework in the context of participatory program planning and implementation as part of the CORE approach. Emphasis is placed on using the approach to catalyze collective action to address shared challenges of natural resources management.

The framework focuses on three dimensions of governance—stakeholder representation, distribution of authority, and mechanisms of accountability. Under each of these dimensions the characteristics of different governance arrangements are assessed using key questions to help orient analysis. The assessment includes both formal and informal mechanisms emphasising how decision-making works in practice, which may differ significantly from how it is meant to work in principle.

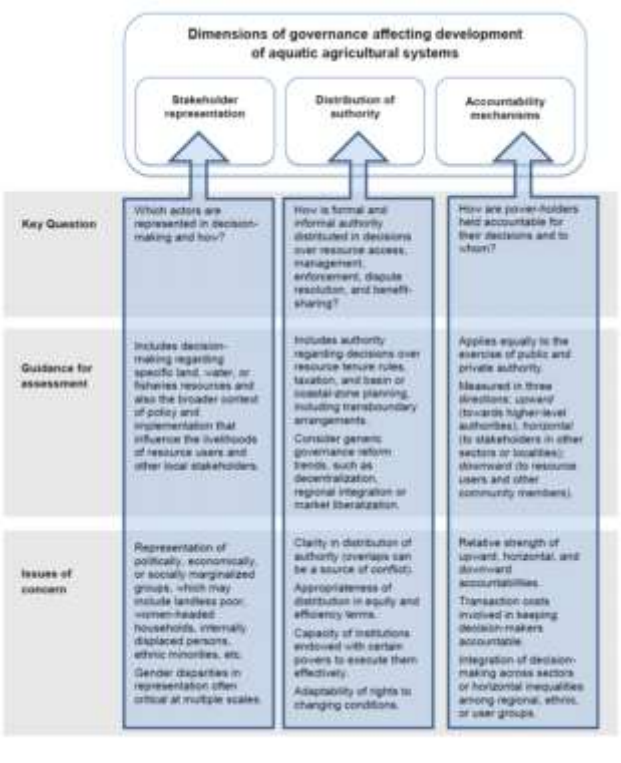

Figure 62 Key questions and considerations in analyzing the governance context for development of aquatic agricultural systems (Source: Ratner and Smith. 2012).

PROFOR forest governance assessment tool

The PROFOR framework (PROFOR 2011 Kishore and Rosenbaum 2012) emerges from major forest governance assessment approaches spurred on by the challenges presented by REDD+ and centres around a matrix based question driven tool. It draws on the World Bank's Framework for Forest Governance Reform; the World Resources Institute's Governance of Forests Initiative and the proposed draft UN-REDD/Chatham House Framework for Monitoring REDD+ Governance. It also builds on existing national forest governance-related monitoring systems.

The tool aims to provide a diagnostic assessment that identifies areas of governance needing reform. It can also identify priorities, encourage discussion of specific steps to be taken, and aims to help build consensus for reform. The tool includes core parameters that are shared by many processes and initiatives, not just in the forest sector, and may facilitate discussion across them.

The PROFOR framework adopts three generally accepted pillars of governance a. policy, institutional and legal frameworks, b. planning and decision-making processes and c. implementation, enforcement and compliance. These pillars frame questions that are inspired by experiences documented in the governance literature and are guided by principles of good governance (accountability, effectiveness, efficiency, equity, participation, transparency).

Table 63 Framework for assessing and monitoring forest governance including components of each of the three pillars (PROFOR-FAO 2011).

Policy, regulatory, institutional and legal frameworks	Planning and decision-making processes	Implementation, enforcement and compliance
•1.1 Resource-related policies and laws •1.2 Legal framework to support and land tenure, ownership and use rights •1.3 Concordance of broader development policies with resource policies •1.4 Institutional frameworks •1.5 Financial incentives, economic instruments and benefit sharing	•2.1 Stakeholder participation •2.2 Transparency and accountability •2.3 Stakeholder capacity and action	•3.1 Administration of natural resources •3.2 Resource management law enforcement •3.3 Administration of land/sea tenure and property rights •3.4 Cooperation and coordination •3.5 Measures to address corruption

Appendix 13 Affiliations of staff interviewed for governance capacity analysis.

Table 64 Key Informants (KI).

Code	Affiliation
[KI1]	Sub district administrator
[KI2]	NGO staff
[KI3]	Sub-district development officer
[KI4]	Sub-district fisheries officer
[KI5]	DNPA Aquaculture
[KI6]	Advisor FAO RFLP office
[KI7]	Advisor Agriculturist Rural Development Programme
[KI8]	DNPA - policy and budgets
[KI11]	Directorate National Environment International affairs
[KI12]	Acting Director DNPA
[KI13]	Staff FAO Field officer

Table 65 Informal interviews.

Code	Affiliation
[KI9]	Resort owner and operator
[KI14]	NGO staff working on MPAS
[KI15]	National consultant
[KI16]	Fisheries officer
[KI17]	National project staff
[KI18]	International MPA expert working in Timor
[KI19]	Indonesia MPA expert working in Timor

Appendix 14 Assessing Landscape Functional Analysis (LFA)

Transect location. In each land use type (garden type) we randomly selected a location from which to start a transect. Each transect began at a 'patch' edge and followed the slope of the site in order to follow the likely flow of resources (e.g. Figure 63). The transect was not of a fixed length, but incorporated a representative sample of the landscape elements (patch and inter-patch types) present along the transect and aimed to include replicates of each landscape element type where possible. Two transects were undertaken in each land-use/garden type with the exception of the Batugade native vegetation, where three transects were taken in order to account for inter-site heterogeneity.

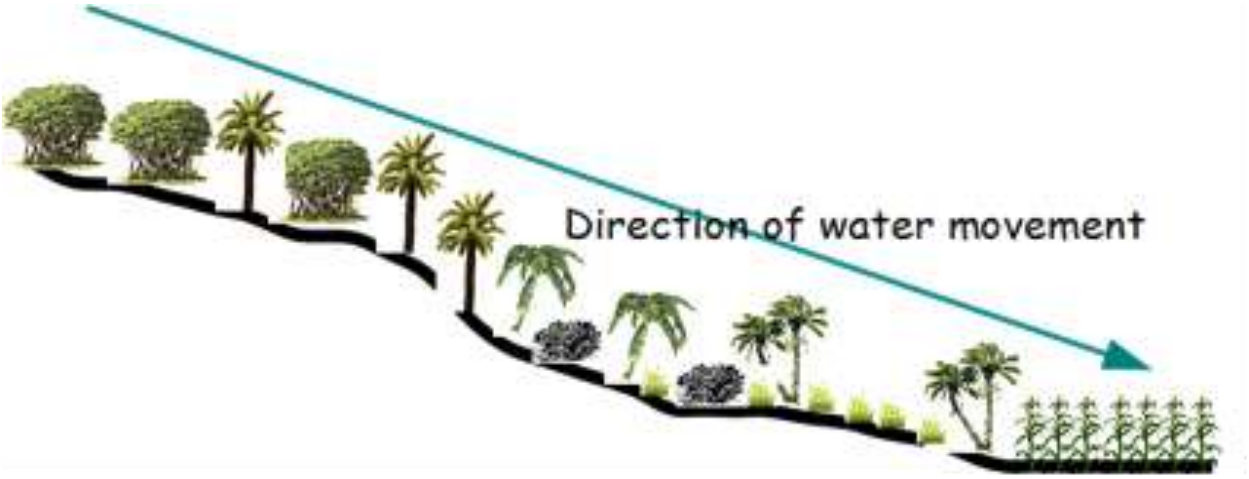

Figure 63 Hypothetical transect for LFA following direction of resource flow.

Landscape arrangement/organisation. We then walked each transect in order to record the location, and map and measure the length and width of patches (landscape elements where resources are captured, e.g. clumps of grasses, fallen logs) and areas between patches (called interpatch areas, landscape elements where resources are often lost. i.e. bare soil). The following measurements were taken:

- Starting point and finishing point (in metres, accurate to 5 cm) of each patch and interpatch along the transect (see Figure 67 and Figure 68);
- A description of each patch/interpatch (landscape element) type (e.g. 'tall perennial grass', 'palm tree grove', leaf litter/crop trash);
- The width of each patch. Interpatch (i.e. bare soil) is not required to be measured for LFA.

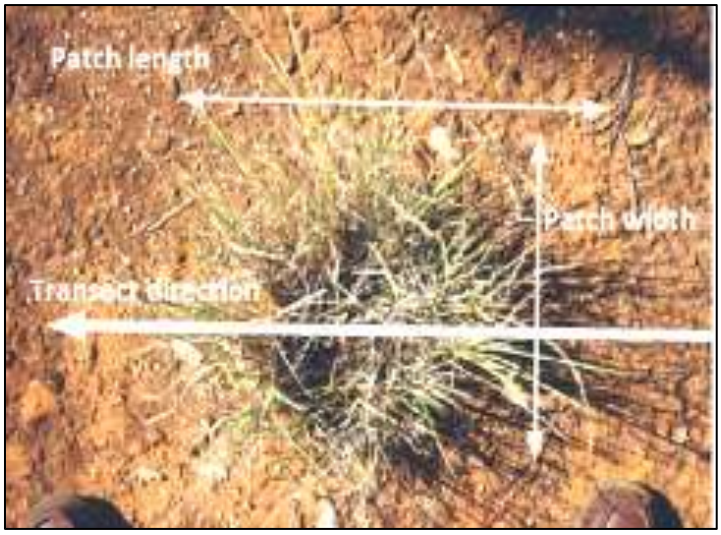

Figure 64 Hypothetical transect for LFA showing how landscape elements (patches and interpatches) are spatially arrayed

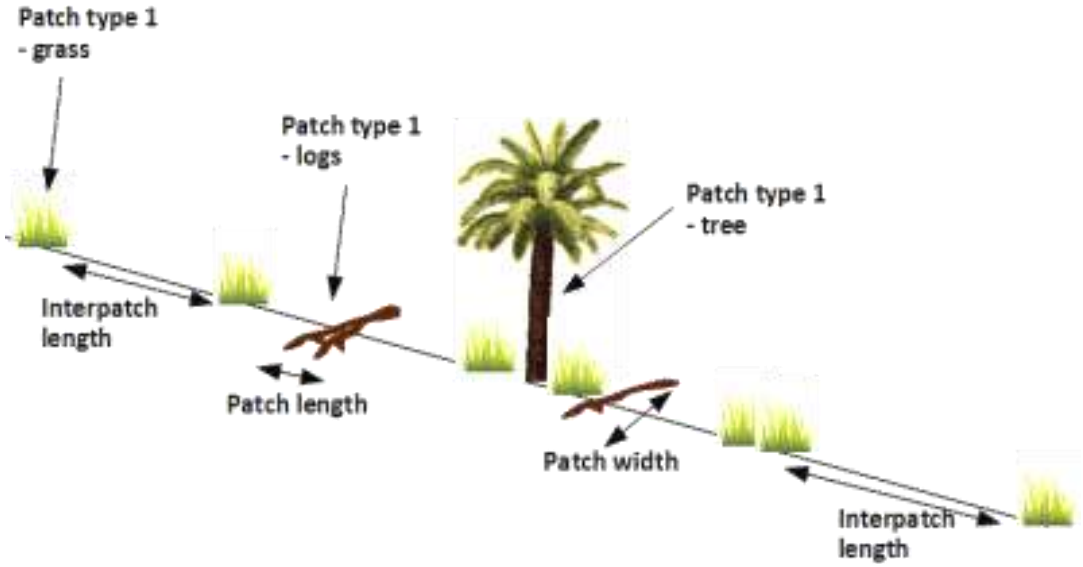

Figure 65 Hypothetical transect for LFA showing how landscape elements (patches and interpatches) are measured for length and (for patches) width.

From these measurements three scores can be calculated: i) the average patch length per 10 metres of transect, ii) the average total patch width per 10 metres of transect and iii) the average interpatch length per 10 metres of transect. The more patch types and the larger the overall patch size on the slope, the better the slope will be at holding valuable resources such as water and nutrients.

Landscape function assessment. For each patch (e.g. grass, woody debris) and interpatch (i.e. bare soil) type identified in stage 2 of the LFA process, we undertook measurements of soil and vegetation structure. Where possible we took five replicates of each measurement of each patch and interpatch type (i.e. five measurements for grass, five readings for logs). The

measurements for soil surface condition and the important environmental processes and functions they contribute to are shown in Table 66 below.

These measurements are then entered into the LFA table tool which calculates the scores for each function at each site. For further details of the LFA process, methods and spreadsheets, please see: http://www.csiro.au/Organisation-Structure/Divisions/Ecosystem-Sciences/EcosystemFunctionAnalysis.aspx#a1

Table 66 Measurements for soil surface condition and important environmental process and functions they contribute (From: Tongway and Hindley, 2004).

LFA measure	Ecosystem function/processes most relevant to	LFA measures that contribute to (i.e. stability, nutrients, infiltration)
Rainsplash protection: Assess the projected percentage cover of perennial vegetation to a height of 0.5 m. plus rocks > 2 cm and woody material > 1 cm in diameter or other long-lived, immoveable objects. These objects intercept and break up raindrops, making them less erosive and less liable to form soil physical crusts	Soil stability and protection from impacts that could lead to erosion	Soil stability
Basal cover of native grasses and percentage canopy cover of trees and shrubs	Nutrient cycling (e.g. movement, decay) and infiltration in soil	Infiltration, nutrient cycling
Percentage cover of fallen leaves and twigs, origin of leaves, etc. (e.g. washed there by water flow), and extent of decomposition	Movement and decay of leaves and other organic material, nutrient cycling	Soil stability, infiltration, nutrient cycling
Percentage cover of mosses and lichens (cryptogams)	Stability of soil, resistance of soil to erosion and nutrient content of soil	Soil stability, nutrient cycling
Surface soil break-up—assessment of extent of soil surface break up and therefore extent to which soil surface vulnerable to erosion	Wind and water erosion of soil surface	Soil stability, infiltration
Assessment of type and severity of soil erosion	What is causing soil erosion and how severe it is	Soil stability
Nature and amount of alluvium build up from erosion and water movement	Upslope stability of soil	Soil stability
Soil surface roughness—assessment of capacity of soil to capture and retain mobile resources such as water, propagules, topsoil and organic matter.	Water infiltration, water flow rate and direction, plant seed movement	Infiltration, nutrient cycling
Soil surface resistance to disturbance— assess the ease with which the soil can be mechanically disturbed to yield material suitable for erosion by wind or water.	How vulnerable soil is to being disturbed (e.g. by farm machinery, water flow, animal movement)	Soil stability, infiltration
'Slake test' (putting a piece of dry soil in water to see how long it takes to break down)	Soil stability when wet	Soil stability, infiltration
Soil texture—assessed using a pedologist's moist bolus test	Rate of water filtering into soil	Infiltration

Appendix 15 Data requirements for InVEST

Table 60 Data requirements for InVEST

Ecosystem service to be measured	Data required	Purpose of data	Question to be answered
Coastal vulnerability	Land polygon (required)	Seascape/landscape interface shape and contours (part of fetch calculation)	What is vulnerability of coastline presently to storm surges, high tides, erosion, etc. How might this change in relation to proposed adaptation scenarios.
	Land polyline (required)	Seascape/landscape interface shape and contours (part of fetch calculation)	
	Land area filter (required)	Filters out land masses of a specified minimum spatial area from further fetch calculation	
	Analysis area (required)	Spatial boundaries of area of interest (and hence analysis)	
	Cell size (required)	Sets spatial resolution of fetch analysis (finest resolution available is 250 m x 250 m	
	Fetch distance threshold (required)	Threshold used to determine between sheltered and exposed shorelines	
	Wind-wave exposure (required)	Wind and wave data that represent storm conditions for area of analysis	
	Average water depth in area of interest (required)	Determine wave exposure	
	Relief ranking of shoreline (required)		
	Natural habitat	Biophysical and vegetation profile of area of analysis/interest (restricted to set of habitat types specified by InVEST)	
	Human population	Population distribution along coastline in area of analysis/interest	
	Natural habitat rank and distance	Relative protective rank of each native habitat type and the distance of the natural habitat	
	Geomorphology - shoreline type	Specified set of shoreline types that are ranked for their protective qualities	
	Presence of structures in area of analysis/interest	Assesses influence of other structures on coastline vulnerability	
	Continental shelf boundary	Surge potential estimate	
	Sea level rise	Delineate areas that are subject to sea level rise (this appears not to be referring to long-term CC projected sea level rise)	
	Land polygon (required)	Seascape/landscape interface shape and contours (part of fetch calculation)	
	Land polyline (required)	Seascape/landscape interface shape and contours (part of fetch calculation)	
	Land area filter (required)	Filters out land masses of a specified minimum spatial area from further fetch calculation	
	Analysis area (required)	Spatial boundaries of area of interest (and hence analysis)	
	Cell size (required)	Sets spatial resolution of fetch analysis (finest resolution available is 250 m x 250 m	
	Fetch distance threshold (required)	Threshold used to determine between sheltered and exposed shorelines	
	Wind-wave exposure (required)	Wind and wave data that represent storm conditions for area of analysis	
	Average water depth in area of interest (required)	Determine wave exposure	

	Relief ranking of shoreline (required)		
	Natural habitat	Biophysical and vegetation profile of area of analysis/interest (restricted to set of habitat types specified by InVEST)	
	Human population	Population distribution along coastline in area of analysis/interest	
	Natural habitat rank and distance	Relative protective rank of each native habitat type and the distance of the natural habitat	
	Geomorphology - shoreline type	Specified set of shoreline types that are ranked for their protective qualities	
	Presence of structures in area of analysis/interest	Assesses influence of other structures on coastline vulnerability	
Coastal protection	Land point (required)	Shapefile of point close to shore	Wave and sea bed erosion based on presence and distribution of natural habitats currently and how may change in relation to adaptation scenarios
	Land polygon (required)	geographic shape of coast/land interface	
	Cross shore transect/profile (required)	Determine physical attributes of shoreline profile	
	Smoothing percentage of shore profile (required)	Determine physical attributes of shoreline profile	
	Sediment size	Part of profile determination	
	Tide elevation	Part of profile determination	
	Bathymetric grid	Part of profile determination	
	Natural habitats	Part of profile determination	
	Wind and wave data	To represent oceanic conditions	
	Wave Watch III search distance	Distance from area of analysis/interest to nearest Wave Watch III point	
	Land point (required)	Shapefile of point close to shore	
	Land polygon (required)	geographic shape of coast/land interface	
	Cross shore transect/profile (required)	Determine physical attributes of shoreline profile	
Marine fish aquaculture (not applicable for Atauro)	Farm location(s) (required)		Assess how production and value of farmed fin fish changes in relation to farm operations and conditions
	Fish growth parameters (required)	Fish productivity over time	
	Daily water temperature at each farm point (from upper water column) (required)	Farm conditions	
	Farm operations (required) - data required are: weight of fish (kg) at outplanting; target weight of fish for harvesting; number of fish in each farm; start day for growth (from outplanting); length of fallowing period (if any)	Farm operations	
	valuation parameters (required if undertaking valuation component): market price per kg of processed fish; fraction of market price that accounts for costs of production; daily market discount rate.	valuation of fish farm activities	
Fisheries and recreation	polygon of area of analysis/interest (required). To be gridded on a user-defined resolution, or user defined management polygons	set analysis boundaries	Density of recreational activity; density of commercial fishing; importance of each activity to people (each activity can be weighted to reflect relative importance)
	Polygons, lines or points of each activity in specified area (required)	spatially define activities	
	relative importance scores of each location of each activity (e.g. one fishing ground may be more valuable or important than another). The relative value of income from different fleets or different fishing grounds can be inputted into the analysis	determine relative importance of activities and locations of activities	

	Distance of activities from hubs - an activity that is otherwise important but is far from a community hub can be down-weighted accordingly	importance of activities in relation to distribution	
	Distance decay rate - as above, but with a set decay in importance with increasing distance from hubs	importance of activities in relation to distribution	
Habitat risk assessment	Identify and map main habitat types (required)	to identify natural assets and location/extent/distribution	The risk of exposure of natural habitats to human threats and disturbance, and the consequences of that exposure
	Identify and map main threats ('stressors') impacting on habitat types (required)	to identify , map and determine source of main threats	
	spatial and temporal overlap of threat (required)	likelihood of threat and habitat coinciding	
	Severity of threat, quantitative (required)	likely impact of threat should it coincide with habitat	
	polygon of area of interest/analysis (required)	set boundaries of analysis	
	grid of seascape	to map intensity of threats and habitat risk	

Appendix 16 Decision tree and partial cost benefit analysis estimates

Table 61 Decision tree for offshore fishing adaptation developed by local authority during focus group discussion held in Vila 14 October 2012.

Decision options	Items for implementation	Potential benefits/harvest (fish can be caught)	Uncertainty/risk factors
Off-shore net fishing method	Nets 6 inches Boats (big and small) Rope Buoys Lamps (petronax) Boxes (refrigerator) Engines	Cobia, Black shark Giant travelly, Turrum Yellow fin tuna, Longtail tuna Mackerel tuna Skipjack tuna Wahoo tuna School mackerel Grey mackerel Spotted mackerel Spanish mackerel	
Off-shore pool landline fishing method	Boat, Bucket, Buoy Rope, Bamboo, Hook Scoping net, Generator Anchor, Spear gun Binoculars, Lamp (petronax) Others	Skipjack tuna Mackerel tuna	
Off-shore longline fishing method	Boat, line, binoculars, rope, wire, Hook, engine, buoy, bucket, Sounder, Line holder (pull line), Refrigerator, knife, and others	Blacktop shark Yellow fin tuna Spanish mackerel Giant trevally Flying fish	
Off-shore Rumpong fishing method	Boats, nets, traps, Trained labour Fuel, rope, anchor (big) Bamboo, buoy	Small tuna Skipjack tuna Mackerel tuna	
Traditional fishing method	Small boat, traditional tools (spear gun, poison, explosive) Fishing nets (2 inches and 3 inches) Hoe	Whiting, queen fish, pearl perch, coral cod, golden trevally, coral trout, yellow spotted rock cod, flame snapper, barramundi, strippey snapper, etc	

Makili village (suco) group discussion (9 participants, 100% male) on 18 October 2012

Table 62 Partial costing and benefit of modern net fishing method estimated by a group of fishermen in Makili village, Atauro. Further financial analysis is required before investments are made.

No.	Items	Duration of use (years)	Cost ($US)	Annualized cost and benefit ($US)
	Partial costs			
1	Boat (1)	7	2,000	285.71
2	Motor 15 p/k (1)	10	1,800	180
3	Fuel 20 litters/ fishing day	1		3,360
4	Net rope 6 millimeter (4)	5	56	11.2
5	Anchor (1)			
6	Buoys (5)	4	40	10
7	Net 2 inches (4)	3	240	80
8	Knife (1)	5	10	2
9	Petronax lamp	1	25	25
10	Spear gun	10	15	1.5
11	Culcas (1 box)	1	150	150
A	Partial Total cost			4,105.41
B	Partial benefits			5,200
	In a very successful year	65%	7,000	
	In a normal year	30%	2,000	
	In an unsuccessful year	5%	1,000	
	Partial net benefit (B-A)			1,094.59
	Gross benefit-cost ratio (B/A)			1.15
	Net benefit-cost ratio (B-A)/B			0.27

Table 63 Partial costing and benefit of the pool landline fishing method estimated by a group of fishermen in Makili village, Atauro. Further financial analysis is required before investments are made.

No.	Items	Duration of use (years)	Cost ($US)	Annualized cost and benefit ($US)
1	Bucket (6)	1	5	5
2	Buoy (1)	1	10	10
3	Rope (1)	1	10	10
4	Hook (1)	1	15	15
5	Lamp (1)	2	15	7.5
A	Total partial cost			47.5
B	Partial benefit (aggregation of chance* possible income)			12
	In a very successful year	25%	25	
	In a normal year	20%	15	
	In an unsuccessful year	55%	5	
	Partial net benefit (B-A)			-35.5
	Gross benefit-cost ratio (B/A)			0.25
	Net benefit-cost ratio (B-A)/B			-0.75

Table 64 Partial costing and benefit of the Longline fishing method estimated by a group of fishermen in Makili village, Atauro. Further financial analysis is required before investments are made.

No.	Items	Duration of use (years)	Cost ($US)	Annualized cost and benefit ($US)
1	Boat (1)	5	1363	272.6
2	Hook (9-12)	2	5	2.5
3	Rope (16 millimeter; 2 rolls)	3	120	40
4	Knife (6)	1	12	12
5	Line holder (pull-line; 6-20 rolls)	3	15	5
A	Total partial cost			332.1
B	Partial benefit (chance and possible income)			20.75
	In a very successful year	75%	25	
	In a normal year	15%	10	
	In an unsuccessful year	10%	5	
	Partial net benefit (B-A)			-311.35
	Gross benefit-cost ratio (B/A)			0.06
	Net benefit-cost ratio (B-A)/B			-0.94

Table 65 Partial costing and benefit of the Rumpong fishing method estimated by fishermen in Makili village, Atauro. Further financial analysis is required before investments are made.

No.	Items	Duration of use (years)	Cost ($US)	Annualized cost and benefit ($US)
1	Bamboo (20)	1	200	200
2	Rope 6 millimeter (2 rolls)	1	24	24
3	Anchor rope (10 millimeter; 2 rolls)	1	140	140
4	Cement (4)	1	20	20
5	Wire (14 m)	1	30	30
6	Buoy (1)	2	150	75
7	Petronax (4)	1	80	80
8	Coconut leaves (40)	1	20	20
9	Kili-kili (3)	1	60	60
10	Bidong/barrel (2)	1	100	100
11	Roda/Pneu (2)	1	10	10
12	Lampu simel (2)	1	30	10
13	Lampra tasi (2)	2	200	100
14	Boat (1)	5	1363	272.6
A	Total partial cost			1,141.6
B	Partial benefit (chance and possible income)			570
	In a very successful year	30%	1000	
	In a normal year	20%	600	
	In an unsuccessful year	50%	300	
	Partial net benefit (B-A)			-571.60
	Gross benefit-cost ratio (B/A)			0.50
	Net benefit-cost ratio (B-A)/B			-0.50

Table 66 Partial costing and benefit of the traditional fishing method estimated by fishermen in Makili village, Atauro. Further financial analysis is required before investments are made.

No.	Items	Duration of use (years)	Cost ($US)	Annualized cost and benefit ($US)
1	Boat (1)	7	1800	257.14
2	Fuel 30 litter/ fishing day ($42/day)	1		5,040
3	Rope (1)	5		
4	Anchor (1)			
5	Motor p/k (1)	10	2800	280
6	Fish trap	4 months	50	
7	Spear gun (1)	10	10	1
8	Oklu (1)	2	5	2.5
9	Lampra tasi (1)	5	100	20
A	Total partial cost			5,600.64
B	Partial benefit (chance and possible income)			6,350
	In a very successful year	60%	8000	
	In a normal year	25%	5000	
	In an unsuccessful year	15%	2000	
	Partial net benefit (B-A)			749.36
	Gross benefit-cost ratio (B/A)			1.13
	Net benefit-cost ratio (B-A)/B			0.134

Biqueli village (suco) focus group discussion (13 participants, 3 women, 10 men)

Table 67 Partial costing and benefit of the net fishing method estimated by fishermen in Biqueli village, Atauro. Further financial analysis is required before investments are made.

No.	Items	Duration of use (years)	Cost ($US)	Annualized cost and benefit ($US)
1	Boat/Ro (1)	3	1000	333.33
2	Motor (1)	10	2000	200
3	Fuel/mina at $30/fishing day (assuming 4 months fishing/year)	1		3,600
4	Tali anchor (1)	2	30	15
5	Anchor (1)	2	20	10
6	Lampra tasi (1)	4	240	80
7	Oklu (1)	4	45	11.25
8	Kilat (1)	4	25	6.25
9	Tudik (1)	1	14	14
10	Kever (1)	1	20	20
11	Petronax lamp (1)	6 months	25	25
12	Redi 4 inches	5	9	1.8
13	Palampu	5	6	1.2
14	Buoy	1	54	54
15	Tali redi	5	150	30
16	Kasas redi	4 months	20	20
17	Daun suku	5	9	1.8
A	Total partial cost			4,423.63
B	Partial benefit			3,862
	In a very successful year	60%	4,800	
	In a normal year	30%	2,725	
	In an unsuccessful year	10%	1,650	
	Partial net benefit (B-A)			-561.63
	Gross benefit-cost ratio (B/A)			0.87
	Net benefit-cost ratio (B-A)/B			-0.13

Table 68 Partial costing and benefit of the pool landline fishing method estimated by fishermen in Biqueli village, Atauro. Further financial analysis is required before investments are made.

No.	Items	Duration of use (years)	Cost ($US)	Annualized cost and benefit ($US)
1	Boat (1)	10	15,000	1,500
2	Motor (1)	4 months	10,000	10,000
3	Hook	1	500	500
4	Generator	2	500	250
5	Bamboo (big)	6 months	40	40
6	Bamboo (small)	6 months	50	50
7	Bolde	3 months	20	20
8	Raga	3 months	20	20
9	Fiu	1	50	50
10	Lampu	1	20	20
11	Tudik	1	5	5
12	Catana	1	10	10
13	Lubas	1	10	10
14	Kulsas	1	5	5
15	Petronax lamp	1	200	200
16	Anchor	2	20	10
17	Minoculu	2	200	100
18	Mina cihoon	2	25	12.5
A	Total partial cost			12,802
B	Partial benefit (chance and income)			9,000
	In a very successful year	60%	12,000	
	In a normal year	25%	6,000	
	In an unsuccessful year	15%	2,000	
	Partial net benefit (B-A)			-3,802
	Gross benefit-cost ratio (B/A)			0.70
	Net benefit-cost ratio (B-A)/B			-0.30

Table 69 Partial costing and benefit of the longline fishing method estimated by fishermen in Biqueli village, Atauro. Further financial analysis is required before investments are made.

No.	Items	Duration of use (years)	Cost ($US)	Annualized cost and benefit ($US)
1	Small boat (1)	6 months	500	500
2	Big boat (1)	2	1,500	750
3	Engine, outside motor	1	2,000	2,000
4	Engine, inside motor	1	4,000	4,000
5	Fuel 25 liter/ 4 hours; ($US31.25)			3,750
6	Oil 2litter/4hours ($6)			720
7	Oil gigi 2 litter/ 4 hours ($8)			960
8	Anchor (2)	1	100	100
9	Ropes (8 millimeter; 6 millimeter)	1	70	70
10	Sounder (2)	3	5,000	1,666
11	Hooke (1-13)	1	247	247
12	Pull line (300-1000)	1	1,050	1,050
13	Ikam falsu (20)	1	1,200	1,200
14	Kapliasu (20)	1	100	100
15	Petronax (2)	6 months	50	50
16	Lampra	1	3	3
17	Knife	1	2	2
18	Luvas (kaos Fagan)	1	10	10
A	Total partial cost			17,178
B	Partial benefit (chance and income)			
	In a very successful year	75%	28,800	24,240
	In a normal year	15%	14,400	
	In an unsuccessful year	10%	4,800	
	Partial net benefit (B-A)			7,062
	Gross benefit-cost ratio (B/A)			1.41
	Net benefit-cost ratio (B-A)/B			0.41

Table 70 Partial costing and benefit of the Rumpong fishing method estimated by fishermen in Biqueli village, Atauro. Further financial analysis is required before investments are made.

No.	Items	Duration of use (years)	Cost ($US)	Annualized cost and benefit ($US)
1	Boat (2)	2	3,000	1,500
2	Engine (2)	2	4,000	2,000
3	Fuel 25 litter/day ($31.25)			3,750
4	Oil 2l/day ($6)			720
5	Oil GiGi 2l ($8)			960
6	Nets	8 months	8,000	8,000
7	Petronax (8)	6 months	200	200
8	Lamp (2)	1	200	200
9	Bacfery (2 boxes)	2 weeks	50	400
10	Bamboo (100)	6 months	1,000	1,000
11	Ropes (4 milli & 20 milli – 20 rolls)	6 months	350	350
12	Buoy (4)	6 months	600	600
13	Semen 24 sacks	6 months	240	240
14	Anchor (8)	6 months	200	200
15	C karakola (4)	6 months	400	400
16	Pneu (8)	6 months	200	200
17	Coconut leaves (40)		8	8
18	Lampu kode (2)	6 months	50	50
19	Kooke (1-13) 1 box		247	247
20	Pullline (tali kail)	1	1,050	1,050
21	Kaia sutra	1	500	500
22	Ikam falsu (20)	1	1,200	1,200
23	Kapdiasu (20)	1	100	100
24	Argola (10)	1	5	5
A	Total partial cost			23,880
B	Partial benefit (chance and income)			7,360 (84,115)
	In a very successful year	5% (80%)	96,000	
	In a normal year	15% (15%)	48,000	
	In an unsuccessful year	80% (5%)	2,300	
	Partial net benefit (B-A)			-16,520 (60,235)
	Gross benefit-cost ratio (B/A)			0.31 (3.52)
	Net benefit-cost ratio (B-A)/B			-0.69 (2.52)

Table 71 Partial costing and benefit of the traditional fishing method estimated by fishermen in Biqueli village, Atauro. Further financial analysis is required before investments are made.

No.	Items	Duration of use (years)	Cost ($US)	Annualized cost and benefit ($US)
1	Boat/Ro (1)	6	2,000	333.33
2	Kose	6	6	1
3	Motor 15 p/k	10	2,000	200
4	Mina 20 litter /fishing day ($30)			3,600
5	Tali ankoro rolu (1)	3	20	6.67
6	Anchor	2	15	7.5
7	Palampu	2	45	22.5
8	Sumbu (nets)	2	7	3.5
9	Kilat big (2) and small (1)	2	30	15
10	Arame 6 meters	4	6	1.5
11	Oklu	2	45	22.5
12	Lampra tasi (3)	7	240	34.28
13	Kail tali (3)	11	12	1.09
14	Kail usin (12)	15	12	0.8
A	Total partial cost			4,249.67
B	Partial benefit (chance and income)			5,650
	In a very successful year	75%	7,000	
	In a normal year	15%	2,000	
	In an unsuccessful year	10%	1,000	
	Partial net benefit (B-A)			1,400.33
	Gross benefit-cost ratio (B/A)			1.33
	Net benefit-cost ratio (B-A)/B			0.33

Lotan village (Aldeia) focus group discussion (6 participants, 100% male)

Table 72 Partial cost and benefit of the rice production option estimated by a group of farmers in Lotan village, Balibo subdistrict, Timor-Leste. Further financial analysis is required before investments are made.

No.	Items	Duration of use (years)	Cost ($US)	Annualized cost and benefit ($US)
	Costs			
1	Cafe, sugar and cigarette, and food for self-help group for land preparation and rice harvest		85	45
3	Labor cost for planting rice		25	25
	Seed supported by government		5	5
	Private seed 1 sack		25	25
A	Partial total cost		140	140
B	Potential benefits			516
		30	45 sacks of rice if in a very successful year	720
		55	30 sacks of rice in a normal year	480
		15	15 sacks of rice in an unsuccessful year	240
	Partial net benefit (B-A)			376
	Gross benefit-cost ratio (B/A)			3.69
	Net benefit-cost ratio			2.69

Table 73 Partial cost and benefit of the corn production option estimated by a group of farmers in Lotan village, Balibo subdistrict, Timor-Leste. Further financial analysis is required before investments are made.

No.	Items	Duration of use (years)	Cost ($US)	Annualized cost and benefit ($US)
1	Land preparation		40	40
2	Weed and grass clearance		2.5	2.5
3	Labor for planting		10	10
4	Labor for harvest		10	10
A	Partial total cost		62.5	62.5
B	Benefits			
	In a very successful year	15%	100 big corn groups	
	In an average/normal year	75%	50 big corn groups	
	In an unsuccessful year	10%	2 big corn groups	

Table 74 Partial cost and benefit of the long bean production option estimated by a group of farmers in Lotan village, Balibo subdistrict, Timor-Leste. Further financial analysis is required before investments are made.

No.	Items	Duration of use (years)	Cost ($US)	Annualized cost and benefit ($US)
1	Land preparation		10	
2	Weed and grass clearance		2.5	
3	Chemicals and insecticides		31.50	

Table 75 Partial cost and benefit of the vegetable production option estimated by a group of farmers in Lotan village, Balibo subdistrict, Timor-Leste. Further financial analysis is required before investments are made.

No.	Items	Duration of use (years)	Cost ($US)	Annualized cost and benefit ($US)
1	Chemicals and insecticides (rentonik, supper flora, akodan, manure)		28	

Leohito fish farmer group discussion, Balibo sub-district, Timor-Leste (12 participants, 2 women, 10 men)

Table 76 Partial costing and benefit of the pond fish culture option estimated by a group of 11 fish farmers in Leohito village, Balibo subdistrict, Timor-Leste. Further financial analysis is required before investments are made.

No.	Items	Duration of use (years)	Cost ($US)	Annualized cost and benefit ($US)
1	Fixed costs			
	Pond construction (10 x 10 x1 = 100m2)	5	160	32
	Labor in exchange (self-help group) 17 persons x $5/labor day		105	105
	Tools and equipment	3	6	2
2	Variable costs			
	Fingerlings breed by household; chicken eggs to feed fingerlings		6	6
	Rice bran 1 sack 50kg		20	20
	Pond management 1 person, 4 hours/day			
	Pelleted feed for fingerlings 1 sack	30		30
A	Total partial cost			195
B	Partial benefits			250
	In a very successful year	25%	Fish consumption for family 3-4 times/month with 60-70; Fish fingerlings sold to NGOs and other farmers 4 times/year with an income of $600/household/year	
	In an average year	50%	Fish consumed by family 2 times/month with 40-50 fishes/time; Fish fingerlings sold 2 times/ year with an income of $200 /household/year	
	In an unsuccessful year	25%	Fish consumed by family 1 time/month with 15-20 fishes/time; No income earned from fish fingerling sales.	
	Net benefit (B-A)			55
	Gross benefit-cost ratio (B/A)			1.28
	Net benefit-cost ratio			0.28

Table 77 Partial costing and benefit of the rice culture option estimated by a group of 11 fish farmers in Leohito village, Balibo subdistrict, Timor-Leste. Further financial analysis is required before investments are made.

No.	Items	Duration of use (years)	Cost ($US)	Annualized cost and benefit ($US)
2	Variable costs			
	Food and drink for 25 persons (self-help group) for land preparation		60	60
	Seed 10 kg		5	5
	Tools and others	2	50	25
A	Total partial cost		115	90
B	Partial benefits			65.6
	In a very successful year	50%	Rice harvested 5 sacks at 50kg/sack (30-35 kg of clean rice /sack); $16/sack	80
	In an average year	30%	Rice harvested 4 sacks at 50 kg/sack (20-25 kg of clean rice/sack); $16/sack	64
	In an unsuccessful year	20%	Rice harvested 2 sacks (15-20kg of clean rice/sack)	32
	Partial net benefit (B-A)			-24
	Gross benefit-cost ratio (B/A)			0.73
	Net benefit-cost ratio			-0.27