

TIMOR-LESTE

Adapting to Climate Change



Understanding how fishing and farming activities can be adapted to respond to a change in climate

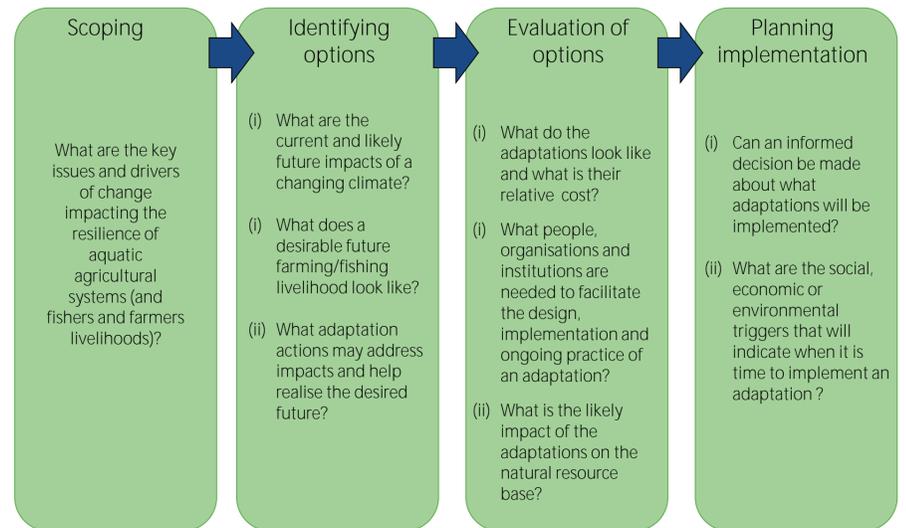
Any changes in future climate are likely to impact the fishing and farming communities in Timor-Leste. An ADB and GEF funded project was set up to identify how communities could reduce any negative impacts from a changing climate, and take advantage of the benefits. A second WorldFish project also contributed scoping and community-level research to this study (see details below*).

A framework was developed by the WorldFish project team to guide community members through a series of activities to:

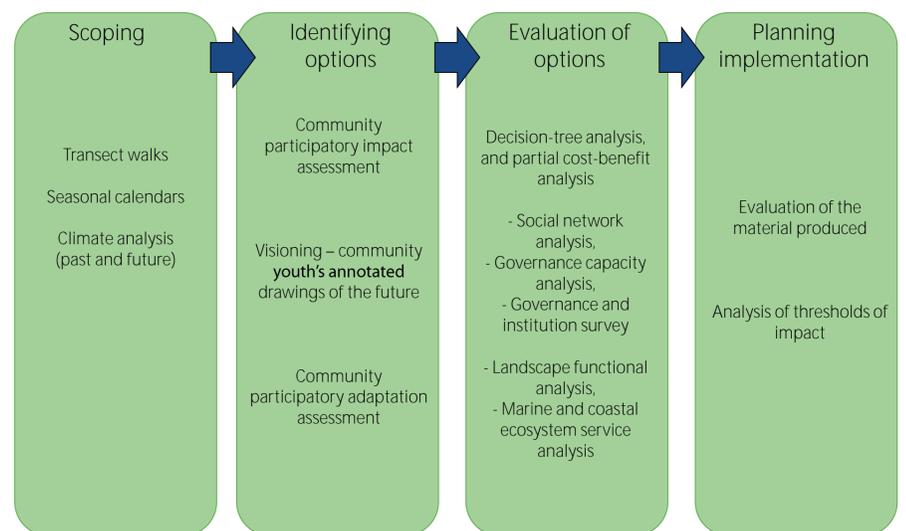
- Scope out the natural resource issues facing fishing and farmers (including climate change)*;
- Understand negative and positive impacts and identify options for adapting*;
- Evaluate some of the options from a social*, economic or environmental perspective, and
- Plan implementation.

The top version of the framework shows four stages. Each stage lists questions that communities may ask when planning their adaption to climate change.

A range of methods and tools were used in participation with members of the fishing and farming communities, and with representatives from local and national government to work through the activities in the framework. These are shown in the bottom version of the framework.



Framework developed to guide community members and leaders through activities to help them identify the likely impacts of a change in climate on fishing and farming activities, identify adaptation actions to respond, and think about how they will implement them.

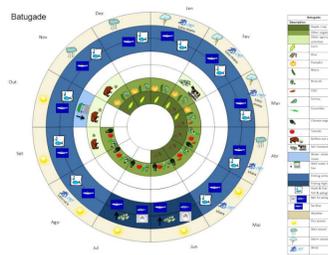


Framework from above, showing the methods and tools used to guide community members and leaders through the activities.

Examples from Atauro and Batugade, Timor-Leste

- Community members and leaders in Atauro and around Batugade participated in some of the above framework to answer questions about the likely impacts of climate change on their fishing and farming livelihoods.
- They also identified possible adaptation actions and provided data to enable some adaptations to be evaluated from a social, economic or environmental perspective.
- The community members and leaders have also participated in activities to consider how best to implement adaptation actions, including identifying people and organizations that may be able to help. They also identified the trigger points that will indicate when it is a good time to start using an adaptation.

What are the current and likely future impacts of a changing climate on fishing and farming activities throughout the year?



Seasonal calendars detail the range of livelihood activities conducted throughout the year (seasonal calendars were produced in the parallel project funded under the Australian Government Coral Triangle Initiative Support Plan*).

What people, organisations and institutions are needed to facilitate the design, implementation and ongoing practice of an adaptation action?



Social networks are drawn with community members

What will the adaptation look like and what is the relative cost?



Decision trees are drawn and estimates of costs and benefits produced to enable partial cost – benefit analysis to be conducted

What adaptation actions may address impacts and help realise the desired future for the community?



Community members participate in an assessment of climate change impacts and adaptations

What do the younger people wish their community to look like in the future?



Younger community members draw their desired vision of natural resources in their community in the future

How will the adaptation actions impact natural resources?



Measures are taken from farmland to determine what agriculture practices will be effective and sustainable

TIMOR-LESTE

Climate Change Impacts and Adaptation Options for Communities



Summary of Results

'Developing Timor-Leste's coastal economy: Assessing potential climate change impacts and adaptation options

This poster summarizes results from the WorldFish Center's research trip to Atauro sub-District in June and August 2012. Four main activities were carried out in order to better understand the impacts of climate change on seasonal livelihood activities and to identify adaptation options to current and future natural resource issues.

1. Land, water and sea issues facing communities

Objective: To identify what natural resource issues are affecting communities and how they may be impacted by climate change

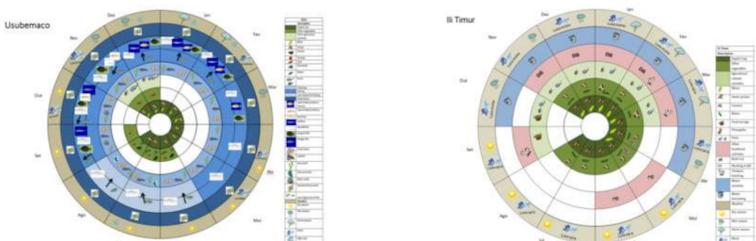
- The top rated natural resource issue was lack of fish and income from fishing
- Second, was lack of access to fresh water
- The third, was low agricultural production



2. Seasonal livelihood activities for coastal and upland communities

Objective: To identify times of the year and activities that could be vulnerable to climate change

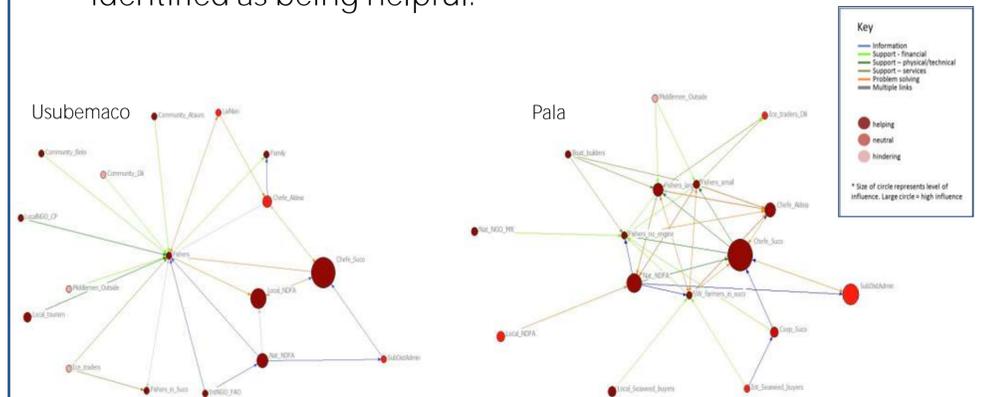
- The calendars show that there are times throughout the year when climate change could greatly impact fishing and agriculture
- Unpredictable rainfall will disrupt planting and harvesting seasons, particularly in the wet season (and increase risk of crop destruction and more pests)
- Calendars made in communities identified a time of year where access to income and food is difficult. In Usubemaco, it is from October to November, and in Ili Timur it is from November to January
- These difficult times of year are more difficult when there is low agricultural yield or reduced catch from fishing. This may be due to climate related events, or not. For example, more stormy weather and intense rainfall may reduce the amount of time fishers are able to spend at sea and reducing income and savings



4. Assessment of existing relationships important for implementing adaptation options

Objective: To analyse fisher relationships and identify who is needed to best implement climate change adaptation options in the future

- The diagrams show the important people and groups (circles) needed for providing information, help with solving problems and providing support to fishers so they can **achieve their goal of "earning enough income from fishing to support their daily lives and improve their family welfare"**
- The size of the circles show how important the groups are. In Usubemaco and Pala, the Chefe suco and the NDFA are very important. In Pala, the National NDFA is a main source of information and problem solving whereas in Usubemaco, the local NDFA is a main source.
- The lines show how the people and groups are linked. Pala has more links between groups than Usubemaco.
- The colour of the circles show who would be helpful for achieving the goal (dark red). Most of the groups were identified as being helpful.



3. Options for addressing climate change impacts on seasonal livelihoods

Objective: To identify different options to address climate change impacts on resources and livelihood activities

- Atauro communities discussed the direct and indirect, negative and positive effects of climate change on fishing
- Negative impacts were potential reduction of time to fish due to more intense rainfall in the rainy season. The community suggested needing to diversify livelihoods and income sources. However, with a longer dry season, there may be more opportunity to fish longer throughout the year
- Adaptation options suggested by community members were to increase fisheries yields, though improving access to deep water fisheries. Examples included improving technology, training on new techniques, and using rampongs.
- Communities are concerned that climate change will increase pressure on the reef which is already heavily fished. Looking at ways to manage reef resources was discussed. There were suggestions to ban poison fishing and catching depleted species, limiting gear use and increasing net sizes.

Summary of Results

'Developing Timor-Leste's coastal economy: Assessing potential climate change impacts and adaptation options

This poster summarizes results from the WorldFish Center's research trip to Balibo sub-District in June and August 2012. Four main activities were carried out in order to better understand the impacts of climate change on seasonal livelihood activities and to identify adaptation options to current and future natural resource issues.

1. Land, water and sea issues facing communities

Objective: To identify what natural resource issues are affecting communities and how they may be impacted by climate change

- The top rated natural resource issue was lack of fish and income from fishing
- Second, was lack of access to fresh water
- The third, was limited access to cash for households
- Fourth was low agricultural production



2. Seasonal livelihood activities for coastal and upland communities

Objective: To identify times of the year and activities that could be vulnerable to climate change

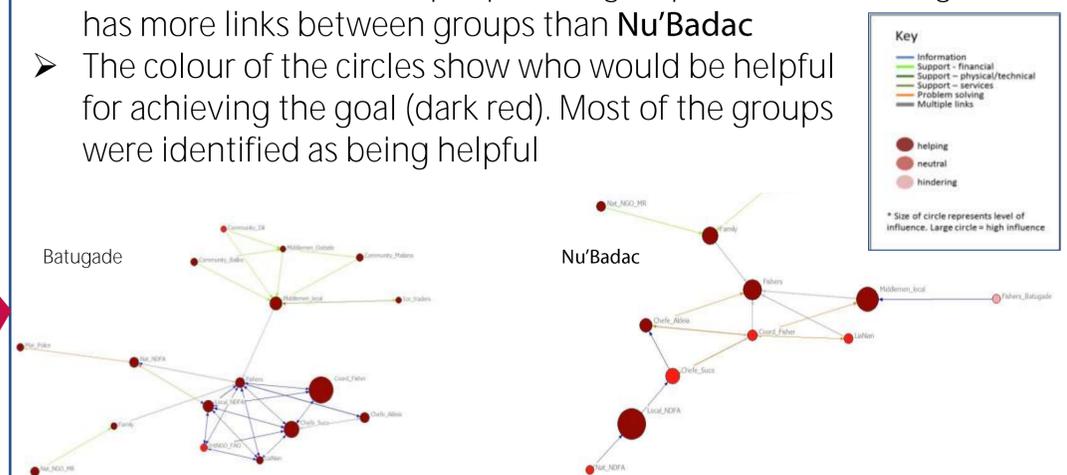
- The calendar shows that there are times throughout the year when climate change could greatly impact fishing and agriculture
- Calendars made in communities identified a time of year where access to income and food is difficult. In Batugade it was identified as February
- These difficult times of year are more difficult when there is low agricultural yield or reduced catch from fishing. This may be due to climate related events, or not. For example, more stormy weather and intense rainfall may reduce the amount of time fishers are able to spend at sea and reducing income and savings
- Unpredictable rainfall may also disrupt planting and harvesting seasons (November for planting and June and September for harvesting)
- A longer dry season could also increase the damage caused by livestock eating crops (e.g. buffalo) as there is less food for them to forage



4. Assessment of existing relationships important for implementing adaptation options

Objective: To analyse fisher relationships and identify who is needed to best implement climate change adaptation options in the future

- The diagrams show the important people and groups (circles) needed for providing information, help with solving problems and providing support to fishers so they can achieve their goal of "earning enough income from fishing to support their daily lives and improve their family welfare"
- Aldeia Batugade has a larger number of people that can help them to achieve their goal, than Nu'Badac. Nu'Badac fishers have fewer people providing information, support or helping to solve problems.
- The size of the circles show how important the groups are. In both locations the middlemen are very important for financial support. In Batugade, the Fishing Coordinator and Chefe Suco are important for accessing information. In Nu'Badac, the local NDFA officer is important and is one of the only sources of information
- The lines show how the people and groups are linked. Batugade has more links between groups than Nu'Badac
- The colour of the circles show who would be helpful for achieving the goal (dark red). Most of the groups were identified as being helpful



3. Options for addressing climate change impacts on seasonal livelihoods

Objective: To identify different options to address climate change impacts on resources and livelihood activities

- Balibo communities discussed the direct and indirect, negative and positive effects of climate change on fishing
- Negative impacts were potential reduction of time to fish due to more intense rainfall in the rainy season, especially for small boats. There were concerns that less rain throughout the year would reduce the sardine stocks. The community suggested needing to diversify and improve income and food from non-fishing activities, such as aquaculture
- Adaptation options suggested by community members were to increase fisheries yields, though improving access to deep water fisheries. Examples included improving technology (larger boats and nets) and training on new techniques.
- Also, to try new ways to get more income from fishing. For example, using ice boxes to improve fish quality, creating a fishing co-operative to purchase gear in bulk and borrow credit, and creation of fish market on beach

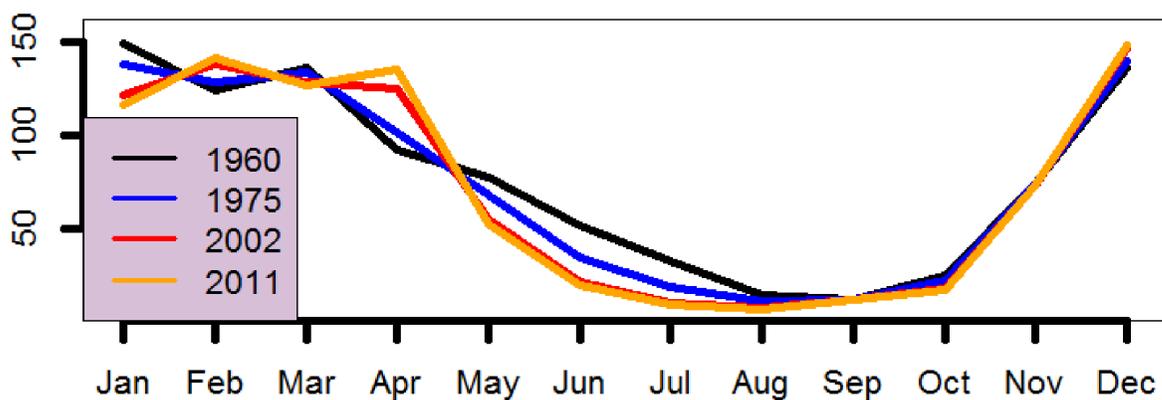
TIMOR LESTE- Atauro sub-district Adapting to Climate Change



Climate Impacts on Livelihood Activities & Adaptations

Rainfall and temperature information was collected for Timor-Leste and analyzed using statistical and data modeling software. This was then compared to observations gathered from fishers and farmers in Timor-Leste and projections of future climate from sources in Australia (ABOM and CSIRO). Using this information, impacts on fishing and farming activities were estimated. Additionally, children from the community came together to imagine the future of the natural resources in the community, drawing their ideas and sharing them with the community. These visions and thoughts on impacts were used by a selection of community decision-makers to identify which adaptations to climate change should be evaluated.

What climate trends have fishers & farmers seen over the past 60 years?



These graphs display monthly rainfall measured in Dili from 1960 to 2011. Each colored line represents an average of the rainfall pattern seen in each year. This graph shows that over the last 50 years, the dry season is starting earlier in the year.

The black line shows how much rain fell in each month of 1960. The lowest point of the line is in August – this shows when the dry season was happening in 1960. The yellow line shows how much rain fell in 2011.

See how the yellow line begins to drop around two months earlier than in 1960. This means the dry season has been starting earlier in the year in more recent times.

How do past trends align with future projections?

The following table shows climate trend analysis and future climate projections. Trend analysis is looking at the patterns of rainfall and temperature as they've changed over the years. Projections of climate change are estimates of how the weather may change in the future.

The left column shows climate trends observed since 1960; the right column shows projections for the future. As the past trends are similar to the projections for the future, we may expect these trends to continue in the future.

Trend analysis	Projections of climate change
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)

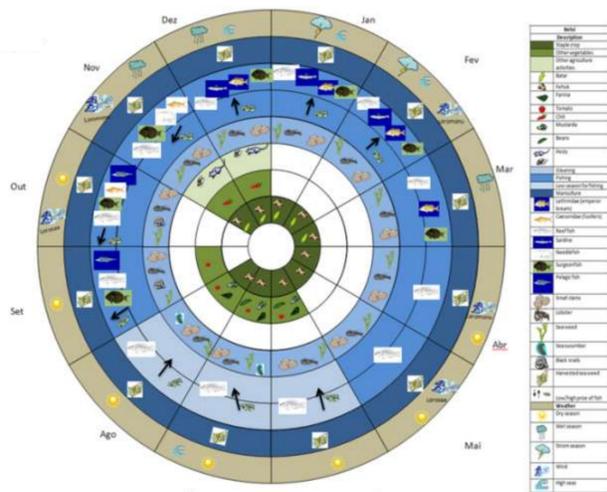
How does the current climate influence fishing & farming activities?

Atauro seasonal calendars

This calendar shows the type of weather, and fishing and farming activities for each month of the year. This helps us to estimate which fishing and farming activities may be affected by future climate changes.

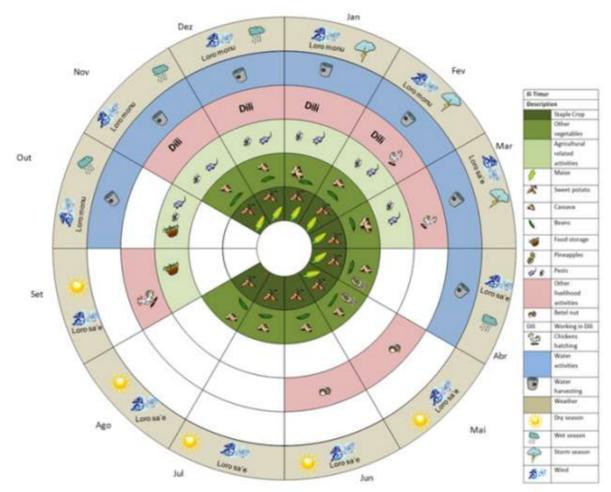
Examples:

- Usubemaco- During the wet season fish prices are high and emperor fish and surgeonfish are caught. If the wet season is shorter, this may limit the number and types of fish that can be caught, reducing fishers' ability to profit from higher prices.
- Ili Timur- Rainwater is collected and maize is farmed during the wet season. If the wet season becomes shorter, this may limit chances to collect water, and shorten the season for farming corn.
- As pests are common during the wet season in both communities, a shorter wet season may mean fewer pests.



Usubemaco seasonal calendar

* This map was created as part of the 'Assessment of Potential Climate Change Impacts and Adaptation Options for Timor-Leste's Coastal Economy' project.



Ili Timur seasonal calendar

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TIMOR LESTE- Atauro sub-district Adapting to Climate Change

Climate Impacts on Livelihood Activities & Adaptations

What are the likely impacts of projected future changes in climate on fishing and farming?



The communities of Atauro and Butagade each identified possible climate change impacts on fishing and farming activities. All the adaptations were about improving the management of natural resources essential to fishing and farming by:

- Using less of a natural resource, reducing the use of deadwood for fire
- Improving the resilience of a resource, e.g. increasing the amount of nutrients in the soil
- Increasing access to a limited resource so that more sustainable practices can be adopted, e.g. enabling fishing in deeper waters to relieve the pressure on inshore fisheries

The adaptations identified by both communities are about improving the quality and sustainability of their natural resources, essential to their fishing and farming livelihoods.

How do the children of Atauro want their fishing & farming communities to look in the future?



The pictures drawn by the children of Atauro show how they would like their community's natural resources to look in the future.



How can fishers & farmers adapt to these impacts?



To decide which adaptations to evaluate further, local authority community members of Atauro considered:

- What **adaptation themes would help build the youth's vision of their communities?**
- Which adaptation themes had already been chosen by the communities as important for responding to climate change?

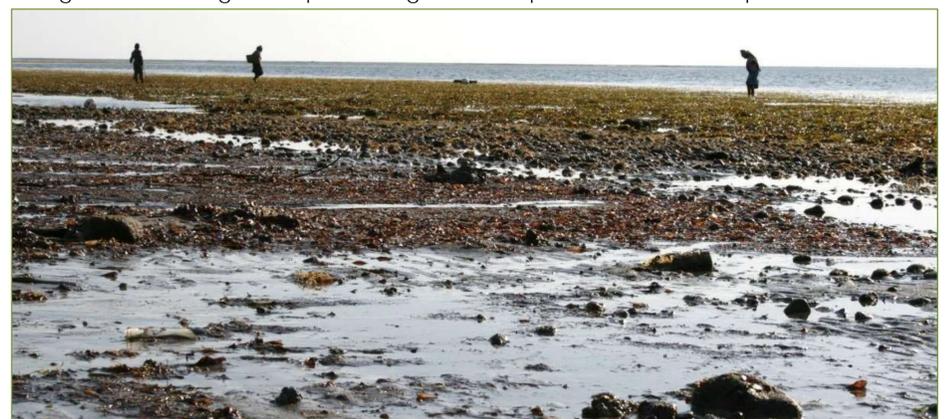
This led to two fishing-related and farming-related adaptations being evaluated from a social, economic or environmental perspective.

Atauro fisheries:

- Special regulation to improve the condition of nearshore coral fisheries
- Enhanced utilization of deep water fisheries (e.g. using echo sounders and fish aggregating devices (FADS)), and including training and knowledge from courses and overseas trips.

Atauro agriculture:

- Better water management through improved collection during the wet season, storage and delivery to crops and animals.
- Enhanced knowledge and training for improved agricultural production techniques.



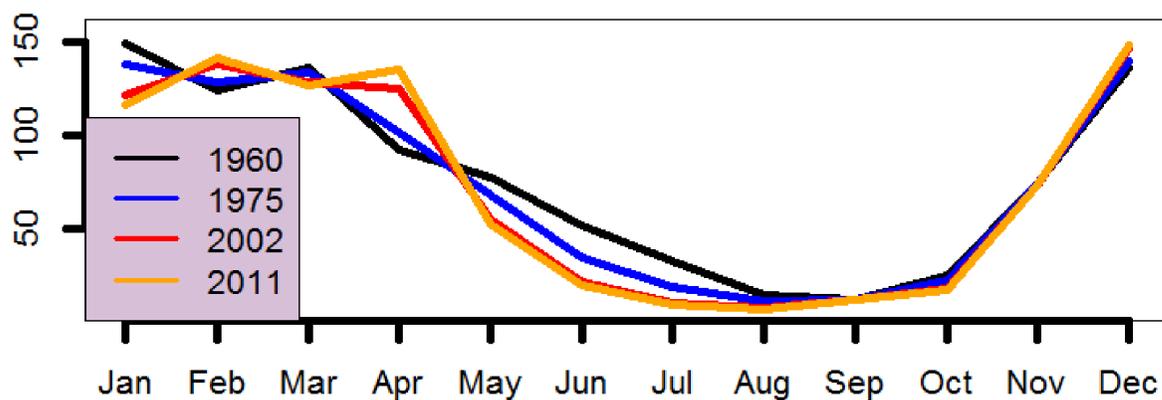
TIMOR LESTE- Batugade sub-district Adapting to Climate Change



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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)

How does the current climate influence fishing & farming activities?

Batugade seasonal calendar

This calendar shows the type of weather, and fishing and farming activities for each month of the year. This helps us to estimate which fishing and farming activities may be affected by future climate changes.

Examples:

- Water related issues happen near the end of the dry season in October. If the dry season expands, then these water problems will also occur for a longer period of time.
- Pumpkin is farmed in November, the traditional start of the wet season. If the wet season starts later in the year then pumpkin farming will likely be delayed.
- As sardines are fished all year round, this activity is less likely to be impacted by changes in weather patterns. But other changes, such as sea temperature and acidity may impact all fish species in the future.



Batugade seasonal calendar

* This map was created as part of the 'Assessment of Potential Climate Change Impacts and Adaptation Options for Timor-Leste's Coastal Economy' project.

TIMOR LESTE- Batugade sub-district Adapting to Climate Change



Climate Impacts on Livelihood Activities & Adaptations

What are the likely impacts of projected future changes in climate on fishing and farming?



The communities of Atauro and Butagade, each identified possible climate change impacts on fishing and farming activities. All the adaptations were about improving the management of natural resources essential to fishing and farming by:

- Using less of a natural resource, reducing the use of deadwood for fire
- Improving the resilience of a resource, e.g. increasing the amount of nutrients in the soil
- Increasing access to a limited resource so that more sustainable practices can be adopted, e.g. enabling fishing in deeper waters to relieve the pressure on inshore fisheries

The adaptations identified by both communities are about improving the quality and sustainability of their natural resources, essential to their fishing and farming livelihoods.

How do the women farmers want their fishing & farming communities to look in the future?

“Visioning” can be a useful tool for building agreement amongst community members, and creating a shared understanding of the goals of undertaking adaptation actions.

Asking younger members of the community to provide their vision of a desirable future recognises the importance of managing natural resources for the next generation to use and enjoy.



The pictures drawn by the women farmers of Lotan show how they would like **their community's nature** resources to look in the future.

How can fishers & farmers adapt to these impacts?



To decide which adaptations to evaluate further, local authority community members of Batugade considered:

- What **adaptation themes would help build the women's vision of their communities?**
- Which adaptation themes had already been chosen by the communities as important for responding to climate change?

This led to two fishing-related and farming-related adaptations being evaluated from a social, economic or environmental perspective.

Batugade fisheries:

- Increase ability to fish different species using new technologies and skills.
- Improve income and food production from non-fishing activities like aquaculture.

Batugade agriculture:

- Increase production of trees, crops and animals using sustainable agriculture methods
- Improve income and food production from improved management of water collection, storage..



This research was conducted by WorldFish under the project: 'Responding to Climate Change using an Adaptation Pathways and Decision-making approach'. This lies within the ADB/GEF funded initiative: R-CDTA 7753 - Strengthening Coastal and Marine Resources Management in the Coral Triangle of the Pacific (Phase 2). *Scoping material and some contributions at the community level were drawn from: 'Assessment of Potential Climate Change Impacts and Adaptation Options for Timor-Leste's Coastal Economy' funded under the Australian Government Coral Triangle Initiative Support Plan. This poster details activities conducted in the 'Identifying Options' phase of the community participatory research (see the pink box in the small picture on the left, and Poster number 1 in this series). For further details visit: http://www.worldfishcenter.org/resource_centre/WF_3170.pdf

TIMOR LESTE

Adapting to climate change



Using Sustainable Agriculture Practices to adapt to climate change

Community members and leaders in Atauro and around Batugade have participated in a number of activities to answer questions about the likely impacts of climate change on their fishing and farming activities.

They also identified possible adaptation actions and provided information to enable some adaptations to be evaluated from a social, economic or environmental perspective. Here are the agriculture-related adaptations they considered:

Adaptations identified for Atauro:

- 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

Adaptations identified for around Batugade:

- 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



Community members and leaders in Atauro participating in activities to answer questions about the impact of climate change and how to adapt.



Community members and leaders in Batugade participating in activities to answer questions about the impact of climate change and how to adapt.

Which sustainable agriculture practices will help farmers in Atauro respond to the challenges of a changing climate?

- Continue to manage perennial gardens for food and source of natural pest control, crop pollination, etc;
- Reduce bare ground with leaf litter and crop trash (e.g. use banana leaves as ground cover, mulch, or compost);
- Integrate livestock better (e.g. for manure, pest control, weed removal);
- Do not burn off crop trash after harvest;
- Improve capture, storage and distribution of water;
- Use woody debris (e.g. branches and tree stumps) to reduce flow of nutrients and soil away from gardens.



Branches used to block flow of nutrients and soils away from gardens.



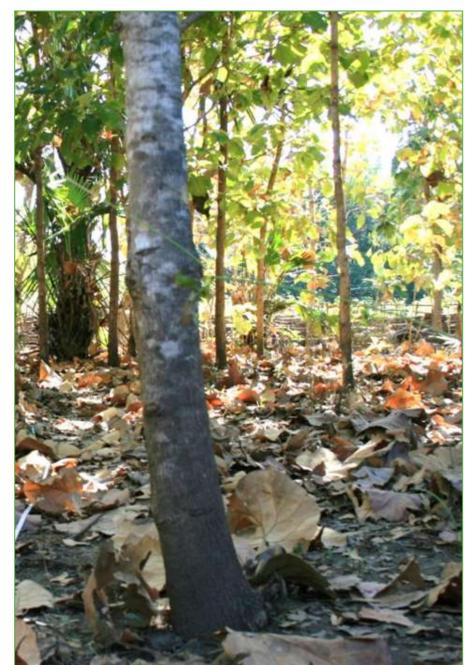
Reduce bare ground nutrient loss caused by burning off ground cover after harvest.

Which sustainable agriculture practices will help farmers in Batugade respond to the challenges of a changing climate?

- Continue to manage perennial gardens for food and source of natural pest control, crop pollination, etc.
- Plant perennial and annual gardens closer together so natural predators, like spiders, move between them and control pests;
- Increase annual garden plant variety (e.g. more plant species, intercrop, add shade trees, reduce bare ground with leaf litter (e.g. collect from plantations), and crop trash compost;
- Improve use of plantations by growing a ground-storey of shade-tolerant perennial crops;
- Use chickens and other animals for manure and pest control;
- During wet season, improve water capture, storage and distribution in annual gardens;
- Do not burn off ground cover after harvest;
- Use more drought-tolerant crops, like maize;
- Avoid over-grazing with livestock in woodland;
- Use fences to manage livestock, avoid over-grazing and increase benefits from manure collection and pest control.
- Use leaf litter from plantations to make mulch and compost.
- Use woody debris (e.g. branches and tree stumps) to reduce the flow of nutrients and soil away from gardens.



Use fences to manage livestock, avoid over-grazing and increase benefits from manure collection and pest control



Use leaf litter from plantations to make mulch and compost.

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Adapting to climate change



Using Sustainable Agriculture Practices to adapt to climate change

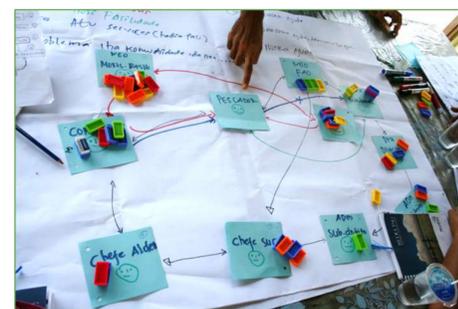
Who is necessary to facilitate the effective planning, implementation and on-going application of sustainable agricultural practices?

Community members and leaders in Atauro and around Batugade participated in an activity to identify social networks in their community. The social networks can be used to identify who is necessary to help farmers plan, implement and maintain sustainable agricultural practices.

The social networks show the important people and groups (shown as circles on the diagram) needed for providing information and support, and help solving problems. A social network was produced by the community members and leaders for farmers whose aim is earning enough income from farming to support their daily lives and improve their family welfare.



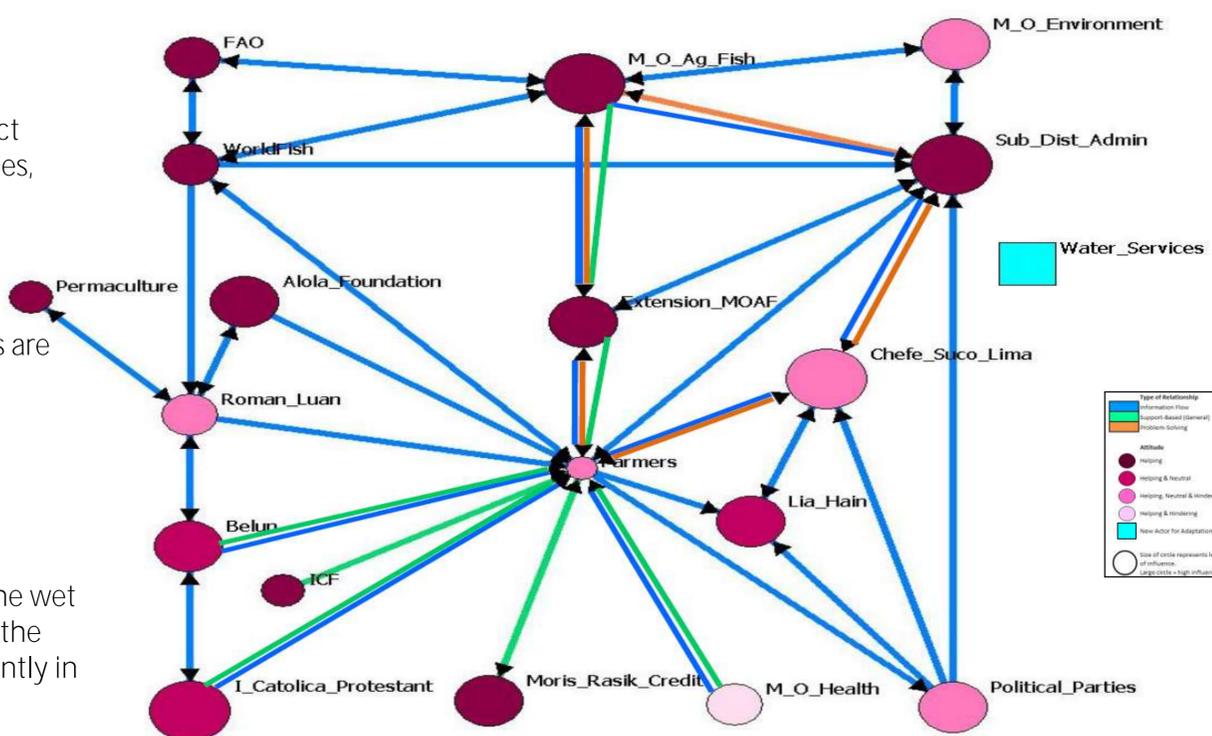
Community members and leaders in Atauro participating in drawing a social network for farmers



Community members and leaders in Batugade participating in drawing a social network for farmers

Atauro:

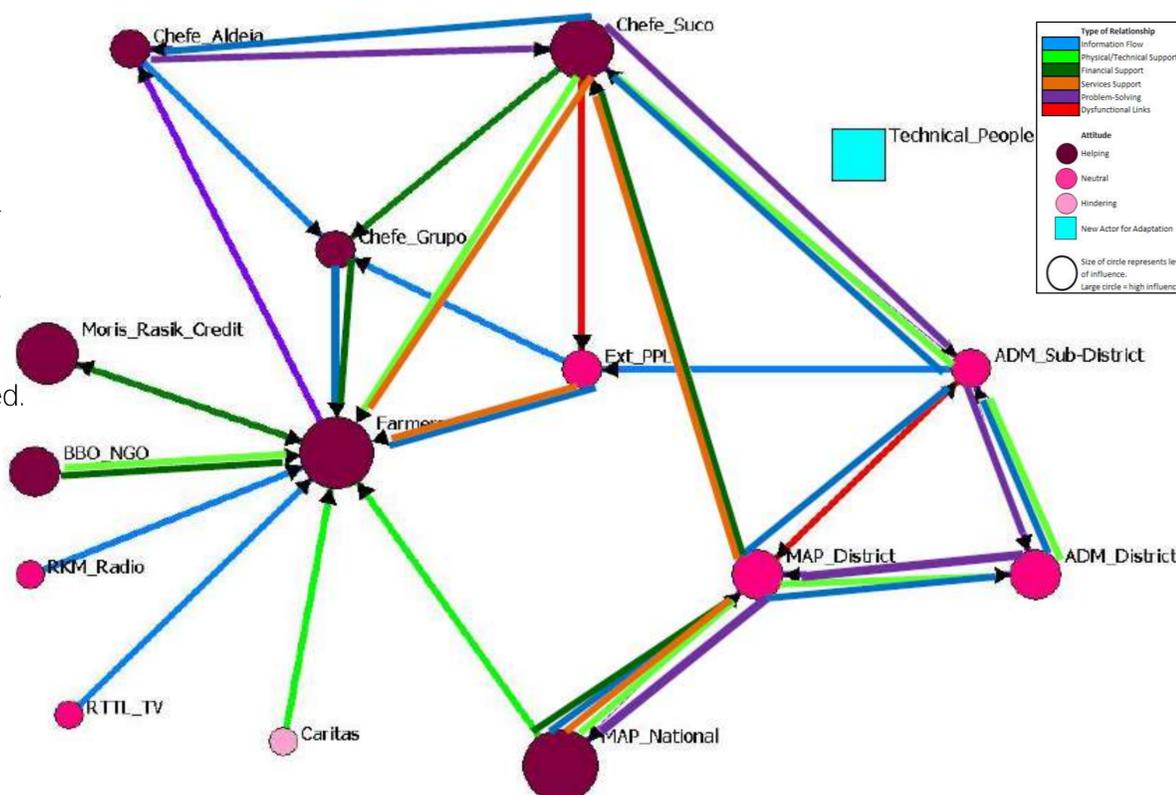
- Key people influencing farming in Atauro are: the Sub-District Administrator, Suco Chief, Ministry of Agriculture and Fisheries, and Catholic and Protestant Churches.
- The Sub-District Administrator and Suco Chiefs receive information from farmers and pass it to higher levels of governance, playing an important role in ensuring programs are implemented to address community needs
- The Ministry of Agriculture and Fisheries provides useful programs, training and equipment, such as seeds and hand tractors.
- If farmers want to improve their collection of water during the wet season, its storage and transportation to crops and animals, the national water services will be important. They are not presently in the farmers' social network, so this link needs to be made.



Social network produced for farming in Atauro. The size of the circles show how important each person or group is. The different coloured lines show how the people and groups are linked and what flows between them.

Batugade:

- Key people influencing farming in Batugade are: the Ministry of Agriculture at the national level and other farmers.
- The national level of the Ministry of Agriculture has control over making things happen for farmers, but decisions about how to undertake agriculture can be influenced by farmers themselves.
- If farmers want to improve the productivity of their agriculture, technical help from outside the farming social network is needed.



Social network produced for farming in Batugade. The size of the circles show how important each person or group is. The different coloured lines show how the people and groups are linked and what flows between them.

TIMOR LESTE

Adapting to climate change

Adapting fishing activities to respond to a changing climate

What are the impacts of a continuation of past trends in climate and projections of future climate on fishing communities in Timor-Leste?



Workshop held in Atauro with community members. Impacts of a changing climate on fishing and farming was considered, along with possible ways to adapt.

In workshops held in Atauro and Batugade, community members identified 13 possible impacts that may result if many of the past trends in climate continue into the future, as projections suggest. The impacts include:

- increasingly earlier start date to the dry season
- increase in surface air temperature (and sea-surface temperature);
- increase in rainfall in the wet season;
- trend for a longer dry season;
- increase in sea level;
- shorter wet season.



Workshop held in Batugade with community members. Impacts of a changing climate on fishing and farming was considered, along with possible ways to adapt.



The children in Atauro drew pictures of what they wanted their communities fishing and farming natural resources to look like in the future. Note that the large fish is a feature of this picture.

How can fishing communities adapt to a change in future climate?



Fisherman in Atauro repairing a boat.

Communities in Atauro and Batugade identified adaptations to respond to a changing climate. The following adaptations were later identified for economic and social evaluation:

Atauro:

- **Special regulation to enhance the condition of nearshore (coral) fisheries**
- **Enhanced utilisation of deep water fisheries** (e.g. through the use of echo sounders and fish aggregating devices (FADS), including training and knowledge via courses and overseas trips)

Batugade:

- **Increase ability to fish different species using new technologies and skills**
- **Improve income and food production from non-fishing activities, such as aquaculture**



Fisherman in Batugade preparing for a fishing trip.

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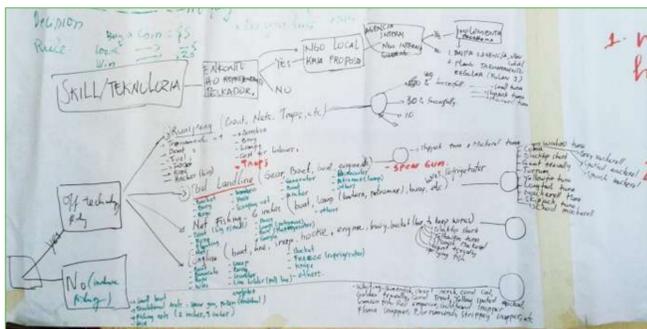
Adapting to climate change



Using fishing activities to adapt to climate change

What are the key decisions and design steps needed to enhance the practice of deep water fisheries?

Fishers in Atauro helped to evaluate if enhancing the ability of fishers to use deep water fisheries was a useful response to climate change impacts. First, the fishers determined the key decisions and design steps needed to fish in the deeper waters.



This decision-tree for offshore fishing adaptation was developed by local authority level community members during a focus group discussion. It shows the different decisions and possible options involved in adapting present-day fishing activities to enable greater utilisation of deep water species.

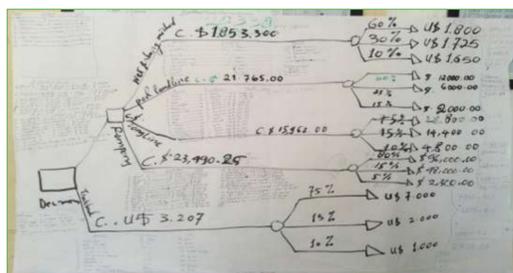
Fishers need to decide if they will:

- Explore the rumpong (fish aggregating devices) fishing method;
- Use the pool landline fishing method;
- Use the modern net fishing method;
- Use the longline fishing method;
- Continue the traditional fishing method.

For each option, the fishers provided details of the possible costs of using the different fishing methods and the fish species that they might catch. From this the economic cost and benefits were estimated.



This one kind of modern fishnet



Costs and benefits calculated for different ways to fish offshore. This was produced by fisherman in Biqueli village, Atauro

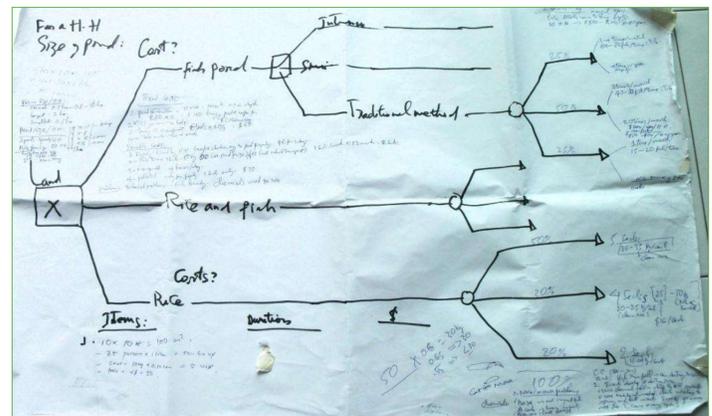
This table lists the cost and benefits of each fishing method (further financial analysis is required before investments are made):

Method	Cost per year	Cost or benefit per dollar invested
Longline	\$17,178	benefit of \$0.41
Traditional fishing methods	\$4,250	benefit of \$0.33
Modern net fishing	\$4,423	loss of \$0.13
Pool landline fishing methods	\$12,802	loss of \$0.30
Rumpong	\$23,880	

This first attempt at estimating costs and benefits shows traditional fishing methods are the cheapest, costing \$4,250 per year. For each dollar invested in traditional fishing methods, there is a return of \$0.33. The longline method provides a benefit of \$0.41 for each dollar invested, costing \$17,178 per year. This is four times more than the start-up costs for the traditional method. The rumpong method costs \$23,880 per year. Due to the risks and uncertainties, the cost or benefit per dollar for this method could not be estimated.

What are the key decisions and design steps that need to be taken in order to develop aquaculture?

Adapting to climate change by developing aquaculture was evaluated together with fish farmers in Leohito village, Balibo. This suco was chosen, as there are already some aquaculture ponds established in Leohito. First, the fish farmers determined the key decisions and design steps needed to develop an aquaculture pond.



The decision tree for aquaculture development adaptation was developed by fish farmers during a focus group discussion in Leohito village, Balibo sub-district, Timor-Leste. It shows the different decisions and possible options involved in converting suitable land into aquaculture ponds.

Some land that could be used for aquaculture is already being used to grow rice, or could be used to grow rice in the future. Because of this, potential aquaculturalists need to firstly decide if they want to:

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

If they decide to develop aquaculture, they must determine if it will be:

- intensive aquaculture.
- semi-intensive aquaculture.
- the traditional aquaculture method.

For each combination of options, the fishers provided details of the possible start-up costs and the fish species likely to be used. From this, the economic cost and benefits were estimated.



Aquaculture ponds in Leohito village, Balibo

This table shows the cost and benefits for growing rice and fish (further financial analysis is required before investments are made):

Method	Cost per year	Cost or benefit per dollar invested
Fish pond (100m ²)	\$195	benefit of \$0.28
Rice field (100m ²)	\$90	loss of \$0.27

In these first estimates aquaculture appears to be the best financial option if there is land available, but more robust estimates of costs and benefits would help understand if aquaculture is a cost-effective adaptation to a changing climate.

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Adapting to climate change



Adapting fishing activities to respond to a change in climate

Who is necessary to facilitate the effective planning, implementation and on-going use of adaptations to fishing practice?



Community members and leaders in Atauro drawing a social network for fishers - to consider who will help them adapt to climate change

Community members and leaders in Atauro and around Batugade participated in an activity to identify social networks operating in their community. The social networks can be used to identify who is necessary to help farmers plan, implement and maintain fishing adaptations to respond to climate change.

The social networks show the important people and groups (shown as circles on the diagram) needed for providing information and support, and helping solve problems. A social network was produced by the community members and leaders for fishers whose aim is to earn enough income from fishing to support their daily lives and improve their family welfare.

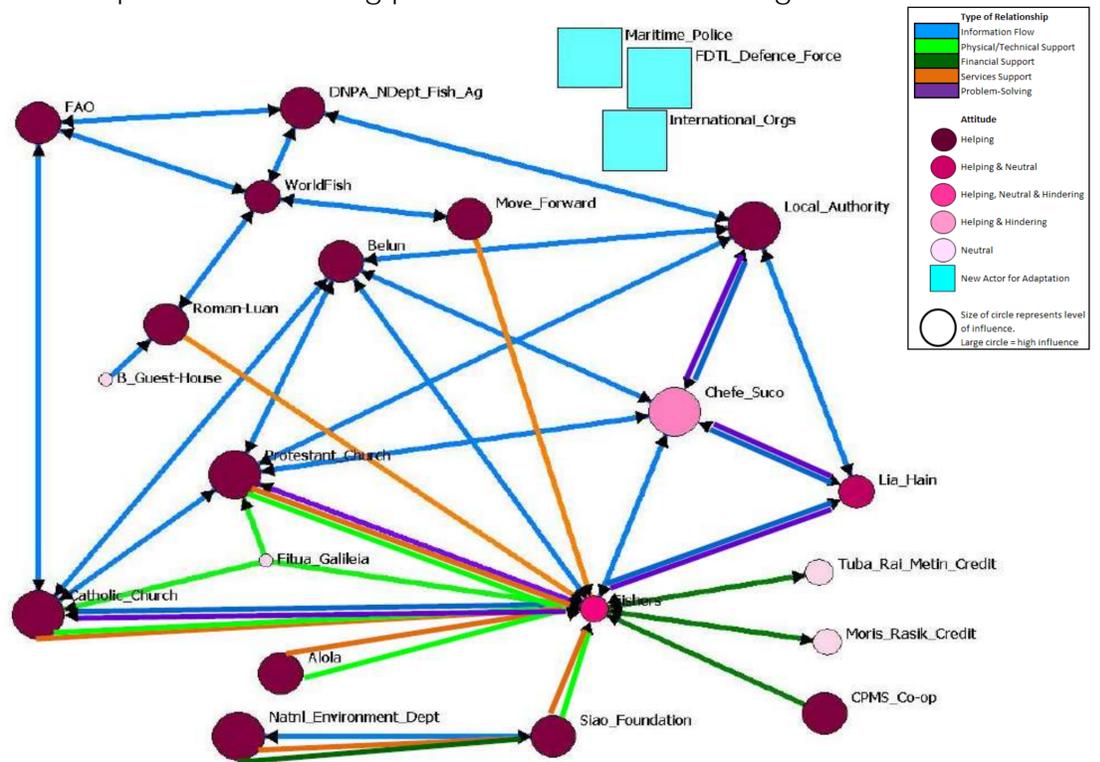


Community members and leaders in Batugade drawing a social network for fishers - to consider who will help them adapt to climate change

Who is necessary to facilitate the effective adaptation of fishing practices to climate change?

Atauro:

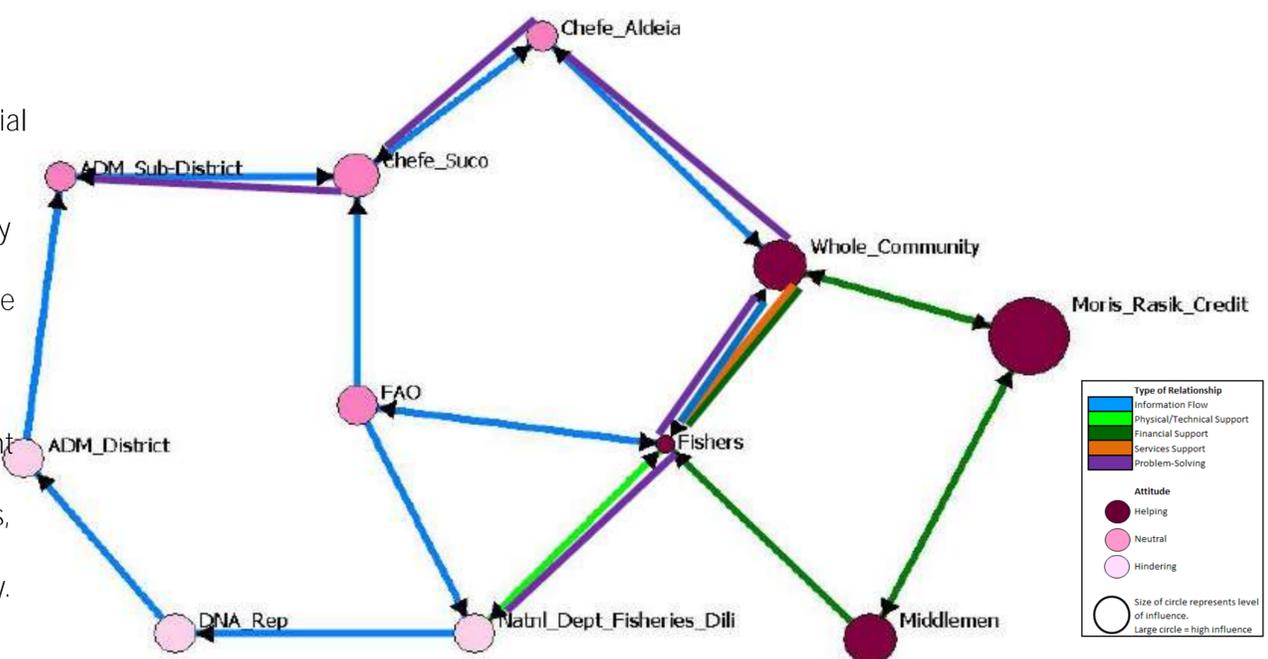
- The National Environment Department, Suco Chiefs, Local Authority, Catholic Church, and Protestant Church are key actors within the Atauro fishing network. They help fishers to achieve their goals.
- The Local Authority group includes District Administrator, Sub-District Administrator, and National Sectors (education, health, police, rural development, fisheries and agriculture). They are a source of information for the community on agriculture and fisheries. They generally do not distribute money directly, but help in skills training.
- The Catholic and Protestant Churches are important for socializing information.
- International** organisations, the Maritime Police and the Defence Force may need to be integrated into the fishing network if either special regulation was used to improve the condition of nearshore (coral) fisheries, or steps were taken to enhance the utilisation of deep water fisheries.



A social network was produced for fishing practices in Atauro (produced by community members and leaders). The lines show the present flows of information, services (such as financial, physical and support services), and pathways for seeking help to solve problems.

Batugade:

- Moris Rasik are important in the fishing community social network in Batugade as they provide credit to women.
- Middlemen are also important in the fishing community social network, as is the support provided by the community in general. Both help the sale of fish, and the community helps to unload the catch when the haul is large.
- If the fishers wish to increase their ability to fish different species using new technologies and skills, and improve income and food production from non-fishing activities, such as aquaculture, they will need the support and cooperation of middlemen and the broader community.



A social network was produced for fishing in Batugade (similar to above).