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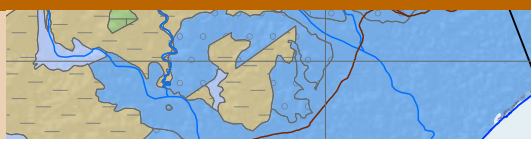
Vulnerability assessment of Timor-Leste's groundwater resources to climate change

Project builds capability for assessing, monitoring and managing groundwater



Luke Wallace, Baskaran Sundaram, Ross S. Brodie, Sarah Marshall, Sam Dawson, John Jaycock, Gerard Stewart and Lindsay Furness

Timor-Leste, a country to the north of Australia, had a population of just over one million people in 2010. Its economy and the livelihood of its people are heavily dependent on groundwater resources that are sensitive to climate change. Groundwater resources are replenished by rainfall in the wet season providing storage for use throughout the year. Increased demand for groundwater caused by population, industry and agricultural growth in Timor-Leste has caused strain on this resource. The current sustainability of groundwater resources in Timor-Leste is largely unknown. In addition, the effects of climate change on both the quantity and quality of groundwater are also uncertain.

Groundwater in a changing climate

In June 2010, Geoscience Australia, in partnership with the Government of Timor-Leste's National Directorate for Water Resource Management (DNGRA) and the Rural Water Supply and Sanitation Program (BESIK) began a two-year project, the Assessment of Climate Change Impacts on Groundwater in Timor-Leste. The project aimed to build Timor-Leste water agencies' capacity for assessing, monitoring and managing groundwater resources in a changing climate.

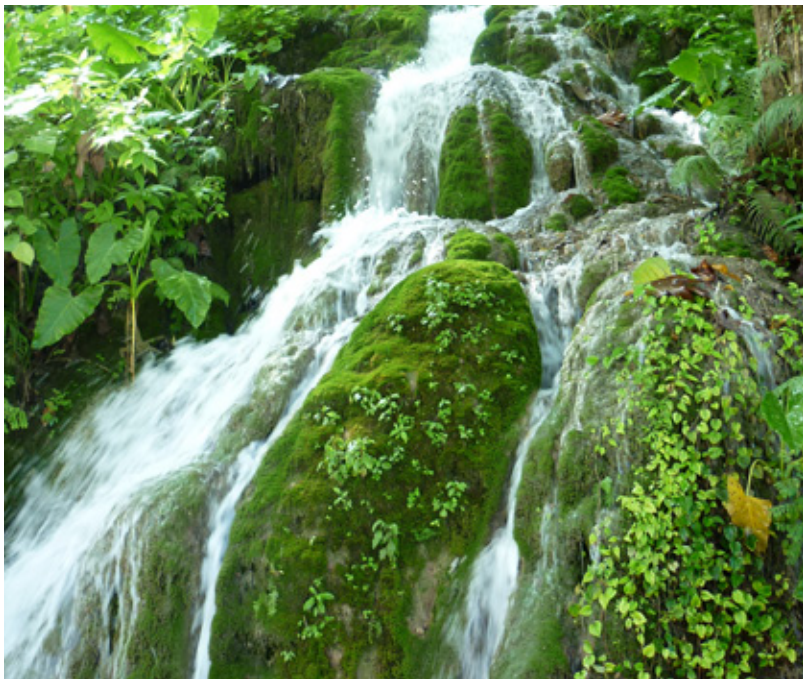


Figure 1. The project provided fundamental datasets and maps to assess the potential impacts of reduced groundwater recharge and availability on people and their livelihoods.

The project was funded by the Pacific Adaption Strategy Assistance Program under the Australian Government's International Climate Change Adaptation Initiative. Phase 1 of the project included a baseline assessment and review of the existing knowledge of groundwater and Phase 2 was a participatory, capacity-building program, based on practical case studies, to develop groundwater monitoring and assessment capabilities in Timor-Leste.

Major products

The project has used a multidisciplinary approach to build groundwater knowledge and monitoring capacity in Timor-Leste during a changing climate. The project has delivered a series of reports, national maps, guidelines and monitoring tools to help water managers and users in Timor-Leste to better understand and manage

groundwater in a changing climate. These products were developed using a participatory and multidisciplinary approach and include the development of the National Hydrogeology Framework, the first National Hydrogeological Map of Timor-Leste to international standards and a National Groundwater Monitoring Field Guide. These products will provide a foundation for all future groundwater management work in Timor-Leste.

National Hydrogeology Framework

A key output was the development of a National Hydrogeological Framework. The framework outlines a method to collect data and categorise, map and monitor groundwater resources and is a useful tool for groundwater managers. The framework is split into two phases, with each phase comprised of four steps.

In Phase 1, the knowledge-based approach, the first step is to define a clear, specific purpose for the project. Then all available existing information and data sets are collected. Thirdly, specialist knowledge for interpreting information and data sets is identified, and the final step is to draft a new map.

Phase 2, the data-based approach, allows detailed, site-specific data to be collected and incorporated to refine the map. The first step is to define the purpose of the groundwater measurement, for example, water level and water quality, followed by selection of suitable case-study field sites to sample. The findings from the new data collected can then be added to the draft map and be used to interpret sites not yet assessed. The final step of the framework is to continue groundwater monitoring over time.

National hydrogeology map

The 'Hydrogeological Map of Timor-Leste' is the first map which allows aquifer types to be consistently identified across the country. Three main aquifer types were identified:

- Sedimentary porous rock aquifers with intergranular porosity associated with river valleys and coastal low lands
- Fissured aquifers of karst formations within limestone rocks
- Rocks with localised flow comprised of fractured rocks and clay sediments (figure 2).

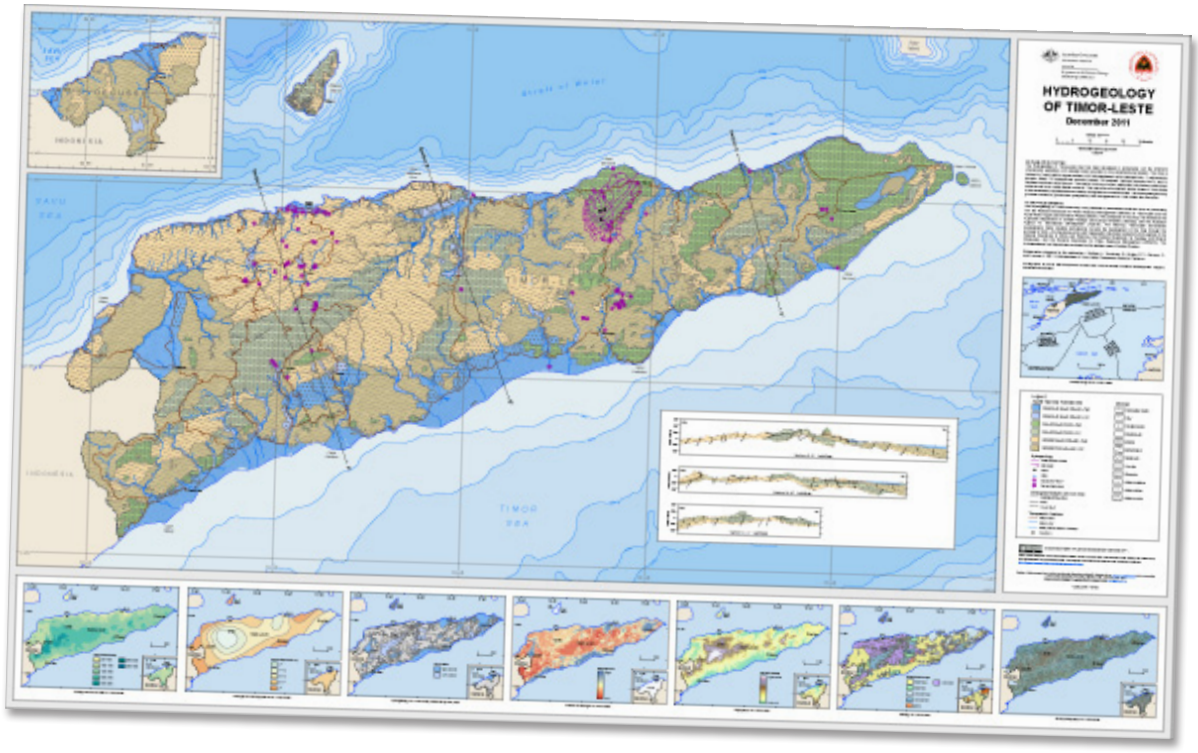


Figure 2. Draft version of the Hydrogeological Map of Timor-Leste which displays the type, potential aquifer yield, and lithology of aquifers across Timor-Leste.

The hydrogeology map also displays the type, potential aquifer yield and lithology of aquifers across Timor-Leste. The combination of aquifer type with potential yield is valuable for prospectivity, indicating where usable groundwater resources are likely to occur. This map can be used to:

- Assess the impacts of climate change on groundwater
- Manage extraction under increasingly variable conditions
- Assist in the design of monitoring programs for groundwater quality and quantity
- Provide a basis to calculate use and sustainable yields for current and future needs.

Fieldwork

Studies were undertaken in Dili, Baucau and Aileu districts as they included Timor-Leste's three major aquifer types: intergranular (sedimentary), fissured (karst) and fractured (localised) respectively. These sites were also chosen because of their greater potential vulnerability associated with the high population densities and/or low water availability. Data was collected during fieldwork in partnership with DNGRA and Charles Darwin University (CDU) with the support of the Timor-Leste Government Directorates, and BESIK (figure 3)

Fieldwork at each of the case-study sites involved:

1) ground truthing of the aquifer characteristics
2) ground-based electromagnetic geophysical (TEM) surveys by CSIRO to delineate aquifer architecture and groundwater salinity
3) direct measurement of groundwater levels and water quality. Data from these case study sites were used to add detail to the National Hydrogeology Map.

Figure 3. Groundwater monitoring during fieldwork in selected sites.

National Groundwater Monitoring Guide

The groundwater monitoring guide was developed to ensure that Timor-Leste's groundwater resources can continue to be monitored long after the project's completion. It provides basic information such as what groundwater is, different types of bore drilling and monitoring methods, how to measure groundwater levels and how to sample and test the quality of groundwater.

Developing groundwater monitoring skills

Groundwater management is essential for ongoing sustainable groundwater use and was a critical component of this project. Monitoring of groundwater requires a full understanding of Timor-Leste's climate, aquifer types and the threats to groundwater systems. Training and workshops were provided in Timor-Leste on the use of monitoring tools and analysis of information on groundwater.

Training

During 2011 the project conducted three lectures and hands-on practical sessions covering Groundwater Fundamentals, Geographic Information Systems (GIS) Mapping, and Groundwater Sampling and Monitoring Methods. Training was attended by staff from the DNGRA and

other Timor-Leste agencies. Groundwater Fundamentals focused on the basics of groundwater, aquifers, mapping, sampling and the hydrogeology of Timor-Leste. In GIS Mapping attendees installed free GIS software and were instructed in GIS basics and used these skills to reproduce the national hydrogeology map (figure 2). The Groundwater Sampling and Monitoring Methods covered the basics of sampling and monitoring. The attendees were also given training in the field on various groundwater sampling and analysis methods.

Workshops

Three workshops were also conducted in Dili during the project. The main purpose of the workshops was to engage with the Government Directorates of Timor-Leste, including the DGNRA, to ensure that their suggestions were implemented effectively throughout the project. Attendees from Timor-Leste included representatives from DNGRA, BESIK, Agriculture and Land-use Geographic Information System (ALGIS), National Directorate for Water Supply and Sanitation (DNSAS), Seeds of Life and Timor-Leste directorates for geology and the environment. Australian representatives from AusAID (Australia's agency for international development), the Department of Climate Change and Energy Efficiency, Geoscience Australia and CDU also attended. The outputs of the project were presented and received by the Australian Ambassador, Miles Armitage, and the Secretary of State for Electricity, Water and Urbanisation, Timor-Leste, Senor Januario da Costa Pereira, respectively.

Figure 4. Training in GIS mapping for staff from the DNGRA and other Timor-Leste government agencies. Attendees were instructed in GIS mapping and used these skills to reproduce the National Hydrogeology Map.

Groundwater vulnerability to climate change

Climate change is likely to impact on groundwater resources in Timor-Leste by reducing groundwater recharge and availability and increasing groundwater use as surface water becomes scarce. Groundwater quality in coastal freshwater aquifers may also be affected through seawater intrusion as a result of higher sea levels. In this project, Geoscience Australia investigated the bio-physical vulnerability of groundwater systems to climate change while Charles Darwin University used this data to analyse the socio-economic vulnerability of the Timorese people and their livelihoods with respect to changes in water resources.

The potential impacts on people and their livelihoods, caused by reduced groundwater recharge and availability, are dependent on sensitivity to change (a combination of aquifer types and population densities in particular areas). The vulnerability of a community depends on the potential impact of climate change and the capacity of that community or system to adapt to those impacts. A high adaptive capacity, that is a system's ability to respond to change, can minimise the vulnerability of a community or nation to challenges such as climate change.

Areas of higher vulnerability

The results of the combined bio-physical and socio-economic vulnerability analysis identified Dili, Liquica, Oecussi and Baucau as areas of high potential impact from climate change. High population growth and density increases the potential impacts in Dili and Baucau. Liquica's localised, low yielding aquifers and poor rainfall and the extremely low yield of Oecussi's fractured rock aquifers mean that reduced groundwater availability could have a high potential impact in both of these regions.

Key adaptation options to assist communities in adapting to climate change identified by the project team were:

- Documentation and monitoring of groundwater resources to improve understanding of water availability
- Managed aquifer recharge (storing water underground and re-use)
- Integrated surface and groundwater management
- Integrated water harvesting and irrigation maintenance to build local resilience and adaptive capacity
- Agricultural diversification to build resilience and adaptive capacity
- Improving governance (policy and regulation)

The main outputs of the project will provide a fundamental knowledge base and practical tools to assess climate change impacts on groundwater. The close partnership developed by the project team and the Timor-Leste Government agencies as well as comprehensive training of Timorese staff has ensured that these outputs and the tools developed will continue to be used.

Summary and future research

Some major gaps remain in our knowledge of:

- Timor-Leste's groundwater resource characteristics (such as the size, location, dynamics and sustainability of extraction)
- interactions and connectivity between groundwater and surface waters
- potential threats to groundwater resources (such as salt water intrusion and other contaminants).

There is scope for more detailed studies on aquifers across Timor-Leste to provide additional data for the Hydrogeology Map and more detailed and localised maps of specific areas. A number of research, capacity building and communication activities remain to be carried out to ensure effective management of groundwater resources and source protection in Timor-Leste.

The main outputs of this project have the potential to be applied in other countries or regions. The Hydrogeological Framework presented here provides a means through which countries can build data sets and maps on groundwater resources and assess the threats and vulnerabilities they face, such as climate change

For more information

email ausgeomail@ga.gov.au