Assessment of Appropriate Sanitation Technologies in a Development Context.

Case Study: Tangkae, Timor-Leste

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Supervisor: Associate Professor Carolyn Oldham

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This dissertation is presented in partial fulfilment of the requirements for the degree of Bachelor of Engineering (Environmental).
“If we are to satisfy the acute needs of hundreds of millions of people today, and those of billions tomorrow, we must take a quantum leap by doing things differently and start doing them now”

(Delft Declaration UNDP Symposium 1991)
Abstract

Currently 40% of the global community have inadequate access to hygienic sanitation facilities, contributing to the high incidence of diarrhoeal diseases and preventable mortalities prevalent throughout developing nations. Accordingly, the implementation of appropriate sanitation facilities has the ability to improve the livelihoods of communities worldwide. Such facilities provide broad community benefits such as reducing the burden of disease, increasing school attendance, economic productivity and assisting the empowerment of women.

This dissertation aims to highlight the vitality of these issues and encompasses a broad investigation of the processes associated with the water and sanitation international development sector. The primary aim of this study is to assess the viability of available sanitation technologies which can be applied in a development context. The case study of Tangkae, a small community in Timor-Leste is used to illustrate the procedures necessary to develop appropriate, integrated and sustainable solutions for a community with inadequate sanitation facilities. Through this research it was found that the most viable option for implementation in Tangkae is the Ventilation Improved Pit latrine. Its’ viability owes to the simplicity, economic feasibility and cultural suitability of the technology. The composting and urine diversion sanitation technologies were also considered highly sustainable sanitation solutions, providing environmental, economic and health benefits. However these eco-sanitation options have large educational and resources demands due to the technical operational requirements.

This dissertation also articulates the complexity of international development work, discussing the key concept of capacity building, the Millennium Development Goals and issues arising in relation to stakeholder involvement and information flow. The importance of a holistic and interdisciplinary approach to such programs is demonstrated through exploring the environmental, economic, cultural and technical concerns of implementing water and sanitation projects. Capacity building is a central component of this project, with the objective to empower and build the capacity of the local community and stakeholders to improve their situation. This project demonstrates the procedure required to produce sustainable and holistic outcomes and in doing so proffers an approach that can be utilised as a model for like projects in similar contexts.
Acknowledgments

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- Natalie Young, in-country EWB member;
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Obrigada Barak!!
# Glossary of Terms

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<td>AusAID</td>
<td>Australian Agency for International development</td>
</tr>
<tr>
<td>AVI</td>
<td>Australian Volunteers International</td>
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<tr>
<td>CWSSP</td>
<td>Community Water Supply and Sanitation Program</td>
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<tr>
<td>DNAS</td>
<td>National Directorate for Water and Sanitation</td>
</tr>
<tr>
<td>EWB-AUS</td>
<td>Engineers Without Borders Australia</td>
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<tr>
<td>MDGs</td>
<td>Millennium Development Goals</td>
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<tr>
<td>NDP</td>
<td>National Development Plan</td>
</tr>
<tr>
<td>NGO</td>
<td>Non-Government Organisation</td>
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<tr>
<td>UNTL</td>
<td>National University of Timor-Leste</td>
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<tr>
<td>UN</td>
<td>United Nations</td>
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<tr>
<td>UNCT</td>
<td>United Nations Country Team</td>
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<tr>
<td>UWA</td>
<td>University of Western Australia</td>
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<tr>
<td>VIP</td>
<td>Ventilated Improved Pit</td>
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<td>WHO</td>
<td>World Health Organisation</td>
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Chapter 1: Introduction

A community given access to proper sanitation will have improved living conditions, with increased health and well-being and economic productivity (Elledge 2003). Not only does proper sanitation reduce the burden of disease, but it provides secondary benefits such as increasing child school attendance, increasing the economic productivity of communities, as well as assisting in the empowerment of women (WHO et al. 2004). However despite its importance, inadequate sanitation currently impacts individuals and communities worldwide. Every 15 seconds a child dies from diseases largely due to poor water, sanitation and hygiene, with nearly 40% of the global population having no access to hygienic sanitation (WHO 2000; WHO et al. 2004). Achieving targets towards improved sanitation coverage is a challenge for the global community which must be addressed with urgency.

The primary preventative method to address these issues is through implementation of appropriate sanitation facilities and hygiene promotion. Better hygiene through hand washing and food protection can reduce the impact of diarrhoeal diseases resulting from poor sanitation by 33% (Mooijman 2003). Implementation of latrines, providing safe excreta disposal options reduces diarrhoeal diseases by up to 36% (Mooijman 2003; Cairncross & Kolsky 2003). This dissertation aims to highlight the importance of these issues and examine the viability and details of available sanitation options.

1.1 Purpose and Scope

This dissertation is part of a broader project initiated by Engineers Without Borders Australia (EWB-AUS) in conjunction with The University of Western Australia (UWA). EWB-AUS is a not-for-profit organisation, designed to give young engineers opportunities to be involved in engineering development whilst addressing the principal mission of the organisation, to work with:

“...disadvantaged communities to improve their quality of life through education and the implementation of sustainable engineering projects”

This investigation has been conducted in collaboration with two other UWA final year engineering students, Vaughn Grey and Heidi Michael who have focussed their respective investigations on the topics of water supply and quality in Timor-Leste. Complementing these two projects, this dissertation focuses on the topic of sanitation and the issues surrounding this.

The project team consists of the three UWA final year engineering students (including the author), as well as six final year civil engineering students from the National University of Timor-Leste (UNTL). In addition the project is working closely with a local Timorese water and sanitation NGO, Hamoris Timor.
Oan (HTO), as well as several government agencies and other partners. This collaboration provides a holistic and interdisciplinary approach to the EWB-AUS Timor-Leste Student Program. Involvement with all stakeholders is critical to the project foundation as the underlying purpose; to empower underprivileged communities to improve their infrastructure and resources, relies on the stakeholder partnerships and the capacity building outcomes which they contribute to.

The scope of this dissertation encompasses a broad investigation of the issues and processes associated with the water and sanitation international development sector, as well as a detailed assessment of the sanitation technologies relevant to apply in a developing situation. In doing this the case study of Tangkae, a small community in Timor-Leste is examined to demonstrate the procedures necessary to develop appropriate, integrated and sustainable solutions for a community with inadequate sanitation facilities.

1.2 Project Aims and Objectives

The ultimate aim of this dissertation is to provide an assessment of the options and issues involved with implementing a holistic environmentally, socially and economically sustainable solution for the sanitation problems of the community of Tangkae in Timor-Leste. Capacity building is a central component of this project, with the objective to empower and build the capacity of the local community and stakeholders to improve their situation.

Capacity building specifically aims to empower the stakeholders of the project through education and involvement enabling each group to work towards independently solving development issues in the long term. The key capacity building objectives for the main stakeholders are:

- **UNTL Students:**
  - Provide practical experience in water quality analysis, physical and social site surveys;
  - Raise awareness and increase understanding through discussions relating to water and sanitation issues;
  - Improve English language and computer/internet skills; and
  - Provide increased confidence in each student’s personal communication ability.

- **HTO:**
  - Increase connections with international NGOs and government agencies; and
  - Increase understanding of the environmental factors related to water and sanitation issues, and the importance of a holistic approach.

- **Tangkae Community:**
  - Empower to acknowledge and address water and sanitation problems in the community; and
• Improve their health and lifestyle through improved water and sanitation facilities, increased economic productivity and education.

It is the ultimate aim that these capacity building objectives provide lasting benefits to all stakeholders involved.

1.3 Approach

This project has involved two key stages, firstly an in-country field trip to establish the stakeholder relationships and develop the project scope, and secondly the research and analysis which was undertaken in Australia. Initially, a second field trip to Timor-Leste was planned for June/July 2006, however due to national instabilities arising during this period the trip was postponed. This resulted in a broadening of the project scope to focus more generally on the details of available sanitation technology and the processes involved with applying sanitation options in a developing situation.

Throughout the in-country field trip information was collected by the project team. This focussed on the small community of Tangkae, located south of the capital Dili. This community was chosen as the projects key focus due to the poor water supply, quality and sanitation conditions which contribute to the general community’s poor health and financial situation. The methods used for data collection can be categorised into three groups:

- Verbal - through formal and informal interviews of stakeholders and agencies;
- Physical - through on site water sampling and testing and physical surveys of the community; and
- Research - through analysis of case studies and a review of literature.

The evaluation of sanitation technologies is the initial stage of a long term project. Integral to the success of the project is community acceptance of any outcomes reached and involvement in the process of reaching such outcomes. Likewise the sustainability of these hinges upon the generation of a sense of community ownership of them. All technologies must be assessed for their cultural sensitivity, applicability and appropriateness and this involves community consultation including workshop sessions, interviews and informal discussions with all groups of community members as well as a complete characterisation of the community social and physical demographics.

1.4 Dissertation Synopsis

The following dissertation contains seven chapters, with the first being this introduction which describes the project scope, aims, objectives and approach. Chapter 2 presents the background information of the
project, and discusses the various processes and issues associated with international development work and the sanitation sector.

Chapter 3 then describes the methods and methodology undertaken through the course of the project. This section presents details relating to the project development as well as the processes utilised to evaluate the sanitation technologies.

Chapter 4 then presents the results provided through the three methods of data collection described in Section 1.3. This includes the results from analysis of the project stakeholders, the Tangkae social and physical community surveys as well as the research conducted of available sanitation technologies.

Chapter 5 is the discussion section, which is important because it applies the information collected from research and to the Tangkae case study. This section also discusses the constraints associated with the working environment of the project as well as the broader issues associated with implementing sanitation technologies. This section also uses the method discussed in Chapter 3 to evaluate the sanitation options.

Chapter 6 is the concluding section which brings the findings and results from this research together. This section also comments on the importance of these results and their application to Tangkae.

Finally, Chapter 7 examines the future work required to complete this project and ultimately provide sustainable sanitation solutions to the community of Tangkae. This is an important closing chapter as it recognises the long term nature of the project and its working environment.
Chapter 2: Literature Review and Background

This chapter presents an analysis of literature which addresses the key topics and concepts surrounding the field of international development in the water and sanitation sector, as well as some important background information on the nation of Timor-Leste. The literature reviewed includes a range of various Australian and East Timorese Government documents as well as reports produced by different sectors of the United Nations (UN). In addition journal articles and online reports produced by international NGOs working in the development field are reviewed. The focus of this investigation relates not only to general international development theories but also case study examples of available sanitation technologies. A list of the materials read and analysed are displayed in the reference list of this report.

2.1 Timor-Leste

Timor-Leste’s physical environment and history have strongly influenced the nations’ current state of development. In particular as discussed further in Section 2.3.1 the events described in the following section have challenged the nation’s ability to achieve important development targets, due to a variety of factors, including a lack of baseline data and human and material resources. It is important for this dissertation that these characteristics and experiences are noted.

2.1.1 Physical Environment

The Democratic Republic of Timor-Leste, shown in Figure 1, is located on the eastern half of the island of Timor, situated approximately 500 kilometres north of Darwin, across the Timor Sea. The nation covers approximately 15 000 square kilometres, including the enclave of Oecussi and the smaller islands of Atauro and Jaco to the north. The topography of the region is dominated by steep mountains ranging between 1000-2000 metres above sea level that tend to the north, with a 20-30 km coastal plain in the north and south (Dwan 2006). Climatic conditions vary minimally throughout Timor-Leste and are generally tropical, semi-arid conditions with an average temperature and humidity of 24°C and 80% respectively (Dwan 2006; US Government 2005). Tropical monsoonal rain is typically experienced from December to May (sometimes extending to July) with varied annual quantities averaging 1000 millimetres. The distinct dry season also varies in length from 3-6 months (Dwan 2006).

Geologically, the island of Timor predominantly consists of limestone and a silt-like clay material which forms slates and schists (Dwan 2006). These sediments are generally aligned in a uniform direction and in response to tectonic force split, producing soft parallel layers. As a result this sediment type is fragile and
porous in nature. The consequence of these characteristics is that minimal sub-surface reservoirs exist within the region and vegetation is not easily supported by the soils (Dwan 2006).

![Figure 1 The thirteen districts of Timor-Leste (Dwan 2006)](image)

The steep topography, intense monsoonal rainfall and impervious geology typical of Timor-Leste also results in rapid runoff which discharges into the sea. As a result water resources across the country are limited as there is a little surface flow in the dry season. Roads regularly wash out due to severe erosion or are blocked by landslides restricting transport routes (PTB 2005). In addition, these conditions contribute to the country’s characteristic infertile, weak soils. Consequently agricultural practices are predominately subsistence farming only, with the only significant agricultural export being coffee beans. The islands’ natural vegetation is light forest with spatial trends according to local geological, elevation and climatic conditions. The use of wood as a primary fuel source as well as slash and burn agriculture contributes to the current rapid deforestation, increased erosion and siltation of river valleys (Dwan 2006).

### 2.1.2 Historical Perspective

The history of Timor-Leste is that of successive invasions and colonialism. For 450 years Timor-Leste remained a Portuguese colony, beginning in the 1700’s when the Portuguese settled in Dili and began to exploit resources such as sandalwood and coffee (Government of Timor-Leste & UNCT 2004; UNMISET 2004). Some centuries later, World War II brought Australian and Dutch troops into Timor-Leste. The position of these troops drew the Japanese army to the country which lead to a violent three year occupation, ending in September 1945 and resulting in the loss of an estimated 60 000 Timorese lives (UNMISET 2004). Following the Japanese defeat Portugal resumed their colonial influence over Timor-Leste and in 1974 allowed Timor-Leste the freedom to form its own political parties.
Shortly after the departure of the Portuguese, in August 1975, Indonesian troops invaded. Over the subsequent 24 year occupation an estimated third of the population perished in the ensuing conflicts, forced resettlements and as a result of malnutrition and insufficient public health services (Government of Timor-Leste & UNCT 2004). This period was characterised by military and political repression and minimal economic development (US Government 2005).

As a result of this prolonged repression an extensive 98.6% of eligible voters turned out to vote when the referendum for independence from Indonesia was held in 1999 (US Government 2005). Seventy-eight percent of the population voted for independence and this triumphant result was followed by a violent rampage led by pro-integration militia. Between 1000 and 2000 people were killed and 70% of essential utilities and private and public buildings was destroyed, including almost 100% of the nations electrical grid and water facilities (US Government 2005). On the 20th May 2002 Timor-Leste celebrated it’s independence after two and a half years of temporary administration by the UN.

2.1.3 The Current Situation

Political Climate

In February 2006, on commencement of this project Timor-Leste was in a state of relative political and national stability. However this significantly changed in March 2006 with the sacking of nearly 600 East Timorese soldiers who had deserted their posts in protest against alleged discrimination (ABC 2006). The sackings lead to riots in Dili throughout April and the subsequent destruction of infrastructure in the city resulted in the displacement of an estimated 150 000 people (Nason 2006).

The continued political turbulence produced allegations of corruption within the government, more specifically directed to the former Prime Minister Mari Alkatiri, concerning the alleged arming of civilians with directives to target political opponents. On May 25 2006 Australian troops arrived in Dili to control the unrest, followed soon after by Portuguese, Malaysian and New Zealand police and military support personnel. On June 25 the senior members of the FRETILIN political party met to discuss the riots and protests against Alkatiri’s leadership. The subsequent decision to keep Alkatiri as Prime Minister caused the resignation of a number of key political figures, including Nobel Peace Prize winner and Defence and Foreign Minister José Ramos Horta, whilst President Kay Rala Xanana Gusmão produced an ultimatum stating he too was prepared to resign. Following this on June 26 2006, Timor-Leste’s first Prime Minister Mari bin Amude Alkatiri stepped down and on July 8 2006 Ramos Horta was named Timor-Leste’s new Prime Minister and a new government was sworn in, in the following week (ABC 2006).
As a result of these events the second field trip planned for June/July 2006 has been postponed. While at the time of writing thousands of displaced people remain in the capital and some civil unrest continues the situation has stabilised to the extent that some military personnel have been withdrawn, replaced by Australian Federal police to help maintain stability leading up to the next elections to be held in May 2007.

**Socioeconomic Situation**

Timor-Leste is currently considered by the UN to be the poorest nation in Asia with an estimated population of 924,642 (UNMISET 2004). Currently approximately 41% of the population fall below the national poverty line of $0.55 per day (Government of Timor-Leste & UNCT 2004). Forty-four percent of this are under the age of 15 years old, compared to 20% in Australia showing the significance of this generation to national development (EarthTrends 2003). In addition, the literacy rate of the remaining population is 43% (2001 estimates) compared to the average of 98% for the Oceania region, indicating the need for educational resources in the country (EarthTrends 2003; Government of Timor-Leste & UNCT 2004).

The nation is still recovering from the destruction which occurred following the 1999 referendum with only 50% of the population having access to an improved water source, and 42% access to piped or pump water (Government of Timor-Leste & UNCT 2004). As can be seen in Table 1, relative to the rest of the developing world, the East Asia-Pacific region and Indonesia, Timor-Leste has extremely poor sanitation and water supply coverage. Malnutrition is also a serious problem, with 43% of children under five years old found to be moderately malnourished, demonstrating the importance that agricultural productivity is increased throughout the country (Government of Timor-Leste & UNCT 2004).

<table>
<thead>
<tr>
<th>Population Indicators</th>
<th>Timor-Leste 2003 (%)</th>
<th>Indonesia (%)</th>
<th>East Asia &amp; Pacific (%)</th>
<th>Rest of Developing World (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access to water (rural)</td>
<td>46</td>
<td>65</td>
<td>66</td>
<td>70</td>
</tr>
<tr>
<td>Access to water (urban)</td>
<td>75</td>
<td>91</td>
<td>93</td>
<td>91</td>
</tr>
<tr>
<td>Access to Sanitation (rural)</td>
<td>21</td>
<td>52</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Access to Sanitation (urban)</td>
<td>63</td>
<td>87</td>
<td>73</td>
<td>72</td>
</tr>
</tbody>
</table>
2.2 **Key International Development Processes**

International development work is an important field in the global community methods utilised by this sector have evolved over time. Development of these processes has seen varying methods of support provided to developing nations by agencies including international NGOs, governmental aid agencies and global agencies such as the World Health Organisation (WHO), the World Bank and the various sectors of the UN.

Traditionally water and sanitation projects of the 1960-70’s did not take holistic approaches, but were largely technology and implementation focussed, such that infrastructure and capital were supplied with limited long term management and community involvement (Alaerts et al. 1991a; Franks 1999). The following decades saw the realisation that this approach was not successful, while the shift towards increasing the knowledge and skills of people, with implementation of technology a bi-product of this (Franks 1999). Currently there is also a trend towards the use and assessment of appropriate technology. Additionally, the acknowledgement of the vitality of stakeholder involvement has contributed to achieving more sustainable project outcomes. This section describes the importance of broad stakeholder participation as well as the concepts of capacity building, monitoring and evaluation and community consultation.

2.2.1 **Stakeholders and Information flow**

Stakeholders are the individuals or groups who contribute either directly or remotely to a project, through their interest or direct involvement in it. Such groups either affect the programme or are affected by it (OEC 2005) and thus it is important to recognise each stakeholder and their role in a project to achieve the most effective outcomes.

To achieve effective project outcomes the most accurate and detailed information is required. A critical reason for complete stakeholder involvement is that different stakeholders possess important information required to assess, develop and maintain the project. However, acquiring this information can be a challenging task in many situations (UN-Water 2004). Just as there are many different groups of stakeholders there are several information types. UN-Water (2004) identifies three information groups these being, *technical* information (that which is required by professionals), public “*right to know*” information (the legal rights and responsibilities of the public), as well as information in the form of *data* which is used for monitoring purposes. Within the water and sanitation sector all three information types are important. Including all information groups in the project development stage contributes to providing optimal, holistic outcomes. Figure 2 is an example of the information flow paths between stakeholder
groups at this project development stage. Flow maps such of these vary for every stage of project progression as the information required to be collected and distributed changes.

Figure 2 Information flow paths at the project development stage, involving the three types of information and four groups of key stakeholders

Information flow can be difficult in developing countries due to common technological limitations such as reduced access to internet and email services, and other electronic data bases as well as cultural differences and the resulting communication barriers which occur with an international group of stakeholders. For such cases broadcast media and printed materials may be required to reach the most inaccessible stakeholders (UN-Water 2004). Ideas such as drama and songs have also been identified as effective information providers to communities with low literacy rates and high proportion of children.

Creating partnerships to share and distribute this information and resources between agencies and organisations can contribute to achieving holistic project outcomes. The generation of such partnerships also helps new projects to learn from past experiences and reduce duplicative efforts (UN-Water 2004). Within the core stakeholder group exists sub-groups of which some are often under-represented in project processes. It is vital that all subgroups be engaged so that the information and experiences they hold are utilised. In particular women are a common sub-group who often need to be actively engaged, as traditionally they are not involved directly in decision making (PTB 2005). This stakeholder group
generally holds important information for water and sanitation projects as they are generally responsible for household water collection and use and become an important leadership group (Abu-Zeid 1998; Okun & Lauria 1991). In addition as the key care providers to children, women play an important role in distributing information such as hygiene practices so that these important elements are passed down to the future generations.

2.2.2 Capacity Building

Capacity building is a term commonly used in the international development sector explaining the process by which an organisation builds the ability of another organisation, community or individuals to improve their own development situation. More specifically, this improvement can be one which strengthens the ability of the community to build their structures, systems and skills so that they are better able to achieve objectives and engage in consultation, planning and manage their own community projects (Skinner 1997). Capacity building is important for water and sanitation projects in developing countries so that the Millennium Development Goals, which are discussed in Section 2.3, can be achieved (UN-Water 2004). Building the capacity of a nation to address the targets can mean to assemble resources, strengthen institutions and to train individuals so that the appropriate and required skills become accessible (UN-Water 2004).

Capacity building is a critical element for achieving sustainable development, with the main objective to improve the quality of decision making and overall sector efficiency so that the progress towards development continues long term. There are two key approaches to achieving this, either using the concept of ‘learning by doing’ or through direct training (Alaerts et al. 1991b; Strigl 2003). Learning by doing refers to building the stakeholder capacity through encouraging direct involvement so that learning occurs through the process of carrying out an activity. Capacity building as a direct training approach may not always be adequate. Whilst considered by some an essential stage to all development projects Kaplan (2000) has raised some critical arguments relating to the inadequacies of the current capacity building methodology of many organisations. He notes that the capacity building ‘interventions’ most commonly performed are those such as the straight forward provision of resources, training, needs assessment and audits. These are termed by Kaplan (2000) as the ‘visible’, ‘tangible’ elements, and are often accompanied by ‘advice-giving’ as opposed to facilitation of projects. This advice-giving is somewhat restricting to the capacity building objectives, as it may leave the organisation in focus with a plan but without the ability to innovate, reflect on and adapt the plan over time (Kaplan 2000). Kaplan (2000) describes these needed abilities as the ‘invisible’ elements, and it is recognised that in fact it is these elements which should be the critical focus of a capacity building program. These elements are critical for this project to achieve its core capacity building objectives, thus should be incorporated into the project plan.
Another key criticism of typical capacity building practices raised by Kaplan (2000) relates to the uniformity of most capacity building programs. Kaplan (2000) remarks that such uniformity is both inadequate and inappropriate for the primary purpose of capacity building. Instead, Kaplan (2000) suggests that development workers should not only be trained to deliver the package but to also read the individual situation so that the most appropriate response to that situation and time period can be delivered (Kaplan 2000). In saying this, it is also important to note that the benefits of these general programs for large organisations dealing with mass program delivery are significant, given that they are easy to manage, fund and implement. However Kaplan’s (2000) remarks are significant given the available timeframe and individual situation of this project.

To undertake this shift in approach recommended by Kaplan (2000) the capacity builder requires a ‘unique’ ability to engage with the organisation, or community in focus. Kaplan’s (2000) suggestion that the development practitioner must closely observe the situation (without judgement, sensitivity or empathy) and create an atmosphere of trust so that the situation of the organisation in focus may be accurately read, while theoretically possible, preferable to any other, and most certainly would embrace the real ‘people-centred development’ approach (Kaplan 2000) is foreseeably difficult to maintain in practice. As discussed further in Section 5.1 the difficulties faced when working with cultural and economic differences are important controlling factors to the progress and outcome of a project. The complexity of the challenge in changing the approach to capacity building is great. Capacity building calls for long term strategies to provide long term sustainability, and is as important as economic, technical, environmental and health aspects to a development project (Alaerts et al. 1991a).

It is important to acknowledge the time scales involved when applying a capacity building approach. Both capacity building and the traditional approach to development rely upon servicing a demand, however the latter focuses on the short-term scale with immediate technical outputs. Capacity building aims to service a demand, such as knowledge and skills, which in some cases has to first be developed (Alaerts et al. 1991a), and this contributes to the relatively long time scales of this approach. The extent to which capacity building theory is applied in a project can range from small scale details, to broader long term targets such as building a nation’s capacity to achieve the MDGs (Alaerts et al. 1991a). Realistic, achievable goals must also be set and the timescale of a project is dependent on this - sustainability is a long-term goal and thus involves a large scale, holistic approach.

2.2.3 Community Consultation

Community consultation is the process of formally, and informally involving the community to participate in all stages of the project. There are four very important functions of community consultation as
displayed in Table 2. The first is to assess the issues and determine the objective of the project. This is followed by the aim to stimulate demand for the project through creating awareness of the issues through discussions and education campaigns. Motivating communities to embark upon behavioural changes is often driven by social ambition rather than health concerns (NWP et al. 2006). Therefore often a more effective method to generate demand and increase willingness to pay for a project, is through convincing the community that adoption of better sanitation practices will improve a family’s status. Other incentives known to generate demand for sanitation technologies include privacy, safety, convenience and reduced health care costs (NWP et al. 2006).

To begin a capacity building program the existing skills, experience, vision and talent within the community sector must be acknowledged and appreciated (Skinner 1997). This information can only be obtained through effective community consultation and thus the third purpose of consultation is to obtain this information. Finally, the key to successful capacity building is outcomes which empower the community and stakeholders to plan and manage the future (Skinner 1997). Achieving this empowerment requires extensive community participation so that ownership of the project is generated, and in order to achieve this participation community consultation tools are required.

Learning is at the heart of the capacity building process and is the main element of community consultation. Learning has the ability to change the way people view their situation, and this can be used as a tool to create demand for a project (Kirk & Shutte 2004). Generating dialogue between stakeholders is an important tool in achieving the four functions of community consultation displayed in Table 2. Dialogue, which Kirk and Shutte (2004) define as ‘collective thinking’ helps to promote learning because it allows for diversity and creativity and thus can help develop new ideas. In addition dialogue is a key tool in community consultation as it provides a way to increase understanding of issues, and reduce conflict between groups or individuals by clarifying or discussing assumptions and opinions.

<table>
<thead>
<tr>
<th>Purpose of Community Consultation</th>
<th>Consultation Tools</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Assess issues → determine project object</td>
<td>▪ Formal Surveys&lt;br&gt;▪ Informal discussions</td>
</tr>
<tr>
<td>2 Stimulate demand for the project</td>
<td>▪ Provide information about issue&lt;br&gt;▪ Education campaigns</td>
</tr>
<tr>
<td>3 Obtain information</td>
<td>▪ Formal Surveys&lt;br&gt;▪ Informal discussions</td>
</tr>
<tr>
<td>4 Generate ownership through participation in process decision making</td>
<td>▪ Provide information about options&lt;br&gt;▪ Discuss community ideas and expectation</td>
</tr>
</tbody>
</table>

Community consultation should also be structured so that power and leadership should be reflective of the community itself, rather than held by an elite group (Diamond 2004). Therefore it is important that the
approach to consultation stresses the significance of participation by all parties. As discussed in Section 2.2.1 an important group in water and sanitation projects are the women of the community who are the primary users of water and sanitation facilities. In addition the elderly and children must be represented as it is important that facilities are designed to accommodate any special needs they may have (UN-Water 2004). Community sub-groups such as these who are traditionally under-represented must be acknowledged and their involvement and participation actively sort.

Sustainable sanitation solutions require each of these four elements to be achieved. If ‘informed demand’ is stimulated through providing the community with information about appropriate technologies and services, a feeling of ownership of the solutions chosen for adoption will follow (NWP et al. 2006). As a result the community will contribute to obtaining and maintaining them and thus the solution becomes sustainable.

2.2.4 Monitoring and Evaluation

Monitoring and evaluation has been recognised by many agencies and organisations as crucial processes to effective development projects. AusAID emphasises in the Monitoring and Evaluation Capacity Building Study (1997) that although different processes monitoring and evaluation are closely linked and of equal importance. The capacity of monitoring as a tool relates to the accuracy and availability of information, requiring information for the identification and assessment of the problems and successes of a project (Cook 1997). On the other hand the purpose of evaluation is related to the quality and effectiveness of future projects, where evaluation is used as a tool to demonstrate the lessons learned from a current or completed project so that these may be considered in future projects. It is also important in promoting the accountability of a project and this is significant where project funding agencies must be reassured that the funds have been used successfully (Cook 1997). Monitoring and evaluation are interlinked in that monitoring can provide quantitative and qualitative data using selected indicators, which can be used as inputs to the evaluation stage. Evaluation also supports monitoring as a source of lessons that can be applied in the development and refining of the monitoring process (Cook 1997).

It is important that a monitoring and evaluation plan be developed at the beginning of a project with changes made as it progresses so that it is designed suitably for the situation and community (Wan & daCruz 2005). There are many alternatives which can be implemented to provide ongoing monitoring for a project and it is crucial that any option used involves community participation to ensure long term sustainability. It is inevitable that new ideas and approaches will evolve with time within the sanitation and hygiene sector. However for these changes to provide benefits to communities, monitoring on a local scale is critical. This monitoring helps to demonstrate and evaluate the local capacity to generate and use
new information, as well as understand how new ideas actually impact on communities (UN-Water 2004). As a result this information can ensure that new approaches are able to actually benefit these communities.

### 2.2.5 Issues and Lessons Learned

In planning any project it is important to understand and learn from the successes and failures experienced in similar fields of work to optimise its chances for success. Therefore a significant component of this project involves consultation with other NGO’s, government bodies and stakeholders to learn from their experiences. This section describes some important lessons learned by some of these agencies.

The Australian Agency for International Development (AusAID) has a long history of providing assistance to developing countries through a range of different projects. Capacity building objectives have recently come to the focus of AusAID and there are a range of case studies which demonstrate the outcomes from implementing capacity building theories. The Indonesia: Eastern Islands AusAID report (1998) focuses on the lessons learned from capacity building projects undertaken in the region (encompassing the previously Indonesian ruled Timor-Leste). The practice of encouraging the community to pay for services provided is discussed. It recommended that projects are designed to ensure services provided are priced within the capacity of the community. This is important in the situation where governments privatise services, or where there is a reduced capacity to provide subsidies. The community must have the ability and capacity to provide financial support to maintain the project infrastructure and operation if the project is to be successful (AusAID 1998).

Another important issues noted is cultural factors relating to the progress of a project and the pace of development within both the institutional situation and project planning, design and implementation phases (AusAID 1998). The length of a projects development was noted by AusAID (1998) to often experience critical delays because of difficulties inherent in logistics in the East Indonesian region. The importance of considering time factors when formulating project schedules is highlighted, particularly given experience shows that long lead times are often required for the acquisition of equipment or deployment of local staff (AusAID 1998). These issues specific to Timor-Leste are discussed further in Section 5.1.1. Additional concerns relating to culture are raised by Hadi (2000) who concluded that the slow progress of rural sanitation programs within developing countries can be linked to the frequent lack of consideration in the design phase for community social and cultural factors. The frequent lack of project success was also attributed to the inability of communities to visualise the benefits of using safe latrines given that sanitation habits are established over a long time frame (Hadi 2000). Therefore the time and effort required to overcome these cultural constraints must be considered in the project planning stage.
Institutional concerns are also discussed by AusAID (1998) with the conclusion drawn that a project with physical development is much easier to manage than one without or with less. Therefore it was found that the institutional difficulty of a project is inversely proportional to the amount of concrete physical development the project aims to achieve. This is a significant consideration for the success of this project as it contains both physical development and capacity building outcomes. Critical to the capacity building objectives of this project are the comments relating to the time consuming characteristics of participatory planning in the region. It is noted that the effort to promote ‘truly’ participatory planning activities is large and so the time required should not be underestimated (AusAID 1998). It is also noted that at the planning phase rural community consultation should allow time for workshops, field visits and various meetings and evaluation discussions – all being time consuming exercises (AusAID 1998).
2.3 The Millennium Development Goals

In 2000 the world’s UN member states met to discuss and develop what are termed the Millennium Development Goals (MDGs). At this world summit each state signed a declaration to commit to achieving the eight MDGs by the year 2015. By creating these goals the global audience is forced to acknowledge the issues surrounding poverty and developing nations. As summarised in Table 3, the eight goals aim to improve the health and living conditions of all people, targeting principal issues such as gender inequality, HIV/AIDS and other diseases, and environmental sustainability which are key factors in determining the stage of development a community or nation is at.

<table>
<thead>
<tr>
<th>GOAL</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Eradicate extreme hunger and poverty</td>
<td>Reduce by half the proportion of people living on less than a dollar a day and those who suffer from hunger</td>
</tr>
<tr>
<td>2. Achieve Universal Primary Education</td>
<td>Ensure that all children complete a full course of primary schooling</td>
</tr>
<tr>
<td>3. Promote Gender equality and empower women</td>
<td>Eliminate gender disparity in primary and secondary education preferably by 2005, and at all levels by 2015</td>
</tr>
<tr>
<td>4. Reduce child mortality</td>
<td>Reduce by two thirds the mortality rate among children under five</td>
</tr>
<tr>
<td>5. Improve maternal health</td>
<td>Reduce by three quarters the maternal mortality ratio</td>
</tr>
<tr>
<td>6. Combat HIV/AIDS, malaria and other diseases</td>
<td>Halt and begin to reverse the spread of HIV/AIDS, the incidence of malaria and other major diseases.</td>
</tr>
<tr>
<td>7. Ensure Environmental Sustainability</td>
<td>Integrate the principles of sustainable development into country policies and programmes; reverse loss of environmental resources; Reduce by half the proportion of people without sustainable access to safe drinking water and sanitation</td>
</tr>
<tr>
<td>8. Develop a global partnership for development</td>
<td>Develop the open trading and financial system to be rule-based, non-discriminatory, commit to good governance, development and poverty reduction. Enhanced debt relief for heavily indebted poor countries; cancellation of official bilateral debt; and more generous official development assistance for countries committed to poverty reduction Develop decent and productive work for youth Provide access to affordable essential drugs in developing countries Make available the benefits of new technologies—especially information and communications technologies</td>
</tr>
</tbody>
</table>

In 2002 Timor-Leste became the world's newest nation and the 191st UN member-state. With this membership the Government of Timor-Leste formally agreed to the 2000 Millennium Declaration and thus committed to “aim to create an environment, at the national and global levels alike, which is conducive to development and the elimination of poverty” (Government of Timor-Leste & UNCT 2004).
Within the declaration are key values and goals which are directly relevant to this project. The fundamental values essential to international relations are recognised as *Freedom, Equality, Solidarity, Tolerance, Respect for Nature* and *Shared Responsibility*. Solidarity is a critical value to be recognised for this project as it explains that those who suffer or who benefit least deserve help from those who benefit most (UN 2000). In this situation EWB-AUS have initiated and are managing the project outcomes from Australia, a nation where the primary standard of living is much higher than that of Timor-Leste with the aim to provide assistance towards achieving the targets.

The Millennium Declaration commits the General Assembly to address the right of all individuals to development and focus on poverty eradication through aiming to free the human race from want (UN 2000). It also expresses the importance of enhancing quality of living for future generations through protecting the environment, highlighting that effort must be made to abate the environmental impact of human activities, such that global resources sufficient for future needs are preserved (UN 2000). This is highly relevant to this dissertation if the MDGs are to be addressed by this project. The potential environmental impact from sanitation technologies is discussed further in Section 2.4.2.

Critical to this project are the revisions made to the MDGs at the September 2002 World Summit on Sustainable Development, where specific targets on sanitation and hygiene were added (UN-Water 2004). Summarised in Table 4 these additional targets represent the recognition by the global community of the importance of promoting sanitation and hygiene to achieving the other MDGs.

<table>
<thead>
<tr>
<th></th>
<th>Sanitation and Hygiene targets (UN-Water 2004)</th>
</tr>
</thead>
<tbody>
<tr>
<td>i</td>
<td>Halve, by 2015, the proportion of people without access to basic sanitation</td>
</tr>
<tr>
<td>ii</td>
<td>Improve sanitation in public institutions, especially schools</td>
</tr>
<tr>
<td>iii</td>
<td>Promote safe hygiene practices</td>
</tr>
<tr>
<td>iv</td>
<td>Promote affordable and socially and culturally acceptable technologies and practices</td>
</tr>
<tr>
<td>v</td>
<td>Integrate sanitation into water resources management strategies</td>
</tr>
<tr>
<td>vi</td>
<td>Implement plans, national policies and incentives for waste minimisation and improved recycling and use of wastewater</td>
</tr>
<tr>
<td>vii</td>
<td>Develop innovative financing and partnership mechanisms</td>
</tr>
<tr>
<td>viii</td>
<td>Build institutional capacity and develop programmes for waste collection and disposal services for unserved populations; strengthen existing information networks</td>
</tr>
</tbody>
</table>

### 2.3.1 Timor-Leste Development Goals

The most recent literature addressing the MDGs’ progression within Timor-Leste is the Timor-Leste Millennium Development Goals Report (2004). This report is a progress report on the nation’s position in
addressing the goals committed to in the Millennium Declaration, outlining the preliminary targets set by the Government of Timor-Leste. In conjunction with this report, the National Development Plan (NDP) was formulated with the consultation of more than 38,000 of the Timorese population to articulate their vision for the nation’s position by 2020. This survey identified agriculture, education and health as the top three priorities for the people and the country (Government of Timor-Leste & UNCT 2004). These items hold significance for the value of this project as there is potential for all three to be improved by addressing the sanitation situation of Tangkae.

The NDP concentrates on generating opportunities for development for the poor, with the main elements relevant to this project being the focus on improving productivity in agriculture, and the provision of infrastructure (Government of Timor-Leste & UNCT 2004). These are key elements given that the project recommendations include both technological solutions as well as consider the links of eco-sanitation with improved agriculture practices. In addition, the Timor-Leste Government's Poverty Reduction Strategy, which is developed as part of the NDP, identifies the following four main elements as critical aims (Government of Timor-Leste & UNCT 2004):

(i) Promoting opportunities for the poor;
(ii) Improving their access to basic social services;
(iii) Enhancing security, including reducing vulnerability to shocks, and improving food security; and
(iv) Empowering the poor

Of these elements this project will contribute most to (i) and (iv) since in addressing the sanitation problems of Tangkae the community will be provided with greater opportunities of education and health and be empowered to undertake these with a stronger understanding of the issues.

2.3.2 Water and Sanitation Projects and the MDGs

In April 2004 the UN Commission for Sustainable Development met to review the progress of the MDG relating to water, sanitation and human settlements. The commission concluded that achieving the target to halve the number of people living with inadequate sanitation by 2015 is currently out of reach for many countries, stating that “the least progress has been made on sanitation” (Marshall 2004). To address the target the global sanitation coverage needs to increase to 75% by 2015, from 48% (in 1990). However it has been noted that the trends demonstrated from 1990 to 2002 indicate the world will miss the sanitation target by more than half a billion people (WHO & UNICEF 2004).
Highlighting these concerns are the trends identified in the Timor-Leste MDGs Report (2004), which declares that morbidity and mortality related to water borne, hygiene and sanitation diseases in Timor-Leste are estimated to be very high. In addition, the report discusses the findings of the 2001 Vector Borne Disease Control Working Group which identified combined mortality data for watery diarrhoea, dysentery, and lower respiratory infections (all which are linked to sanitation and hygiene) as 30% of the total mortality causes within Timor-Leste (Government of Timor-Leste & UNCT 2004).

A fundamental reason for the limited progress towards promoting sanitation and hygiene are that these sectors are traditionally associated with cultural taboos or stigma (UN-Water 2004). According to Marshall (2004) sanitation is also a less attractive investment option for the private sector. Reasons for this include the long payback periods or return to investment compared to developments such as utility services. In addition the negative association with hygiene and faeces tackles is not attractive to international donors looking to financially support development projects. This negative association often results in sanitation and hygiene ‘disappearing’ when the stages of government policy making, planning and implementation come about (UN-Water 2004).

Concerns have been raised in a number of articles relating to the link between the sanitation targets and other MDGs. As explanation for how other goals rely on the progress of addressing sanitation Marshall (2004) and Hadi (2000) refer to the strong correlation between the presence of human excreta and water quality, noting that the health related targets such as doubling access to clean drinking water are being restricted by the limited progress towards addressing sanitation. This slow progress also has an impact on the child mortality goal and the target to improve primary education, as progress to reduce water borne diseases such as diarrhoea, ascaris\(^1\), guinea and hook worm cannot occur without sanitation improvements being equally successful (Anon. 2004; Marshall 2004). An important point from these discussions is that clean water single-handedly, cannot prevent disease (Anon. 2004; Hadi 2000). This statement emphasises the importance of this projects’ link with the water supply and quality of the Tangkae village demonstrating that an interdisciplinary and holistic approach is vital to achieve successful outcomes. Similarly, McMichael and Butler (2004) see the MDG relating to environmental sustainability in the same light as those views previously expressed pertaining to sanitation, stating that without environmental sustainability the other MDGs will become extremely fragile (McMichael & Butler 2004).

---

\(^1\) Ascaris is a parasitic worm which can infect humans, living in the small intestine, causing abdominal pains, slower growth and weight gain, and in severe cases breathing problems (DPD 2004). The lifecycle involves eggs in faeces, which when ingested hatch in the stomach and then grow and breed in the intestines (DPD 2004). Pigs can be infected with a similar species of Ascaris and this can spread to humans if pig faeces are accidentally ingested (DPD 2004).
Table 5 demonstrates the importance of sanitation and hygiene in relation to water supply and quality through comparisons of the reduction in mortality achieved by the respective interventions. It can be seen that for ‘all studies’ (analysed by Cave and Kolsky (1999)), the maximum reduction in morbidity was achieved through hygiene intervention, and sanitation displaying the highest reductions for the ‘rigorous studies’ category. This shows the importance of implementing hygiene and sanitation and the importance of using an integrated approach. Interestingly, improvement in water quality presents the lowest reduction for both categories and this can be attributed to the high risk of water contamination during collection and storage when the water is treated at the source (Cave & Kolsky 1999). Thus again this shows the importance of interdisciplinary projects, where elements of water quality must be addressed in conjunction with water supply and sanitation.

<table>
<thead>
<tr>
<th>Intervention</th>
<th>All studies</th>
<th>Rigorous studies</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number</td>
<td>Reduction (%)</td>
</tr>
<tr>
<td>Water quality and quantity</td>
<td>22</td>
<td>16</td>
</tr>
<tr>
<td>Water quality</td>
<td>7</td>
<td>17</td>
</tr>
<tr>
<td>Water quantity</td>
<td>7</td>
<td>27</td>
</tr>
<tr>
<td>Sanitation</td>
<td>11</td>
<td>22</td>
</tr>
<tr>
<td>Water and sanitation</td>
<td>7</td>
<td>20</td>
</tr>
<tr>
<td>Hygiene</td>
<td>6</td>
<td>33</td>
</tr>
<tr>
<td>All studies</td>
<td>49</td>
<td>22</td>
</tr>
</tbody>
</table>

### 2.3.3 Achieving Timor-Leste’s Targets

Timor-Leste faces a difficult challenge in achieving the targets set in the NDP. Table 6 displays the sanitation targets for Timor-Leste, coverage in 2001 was estimated to be about 19% of the population with the aim of increasing coverage to 46% by 2015 (Government of Timor-Leste & UNCT 2004).

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Timor-Leste</th>
<th>Global</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2001</td>
<td>2015</td>
</tr>
<tr>
<td>Proportion of people with access to improved sanitation:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>19%</td>
<td>46%</td>
</tr>
<tr>
<td>Urban</td>
<td>44%</td>
<td>63%</td>
</tr>
<tr>
<td>Rural</td>
<td>10%</td>
<td>41%</td>
</tr>
</tbody>
</table>

One major challenge stemming from the historical events described in Section 2.1.2 is the lack of available baseline data in the country, including data relating to demographic trends as well as environmental data such as meteorological characteristics (Government of Timor-Leste & UNCT 2004). This constrains the ability of the government to accurately assess the countries state of development. As it
is necessary to compile this baseline data to assess the development stage, this adds to the complexity of
the tasks required by the Government of Timor-Leste to meet the proposed targets. Also, there exists a
lack of human resources within the public sector and a limit to the technical skills available within the
workforce (Government of Timor-Leste & UNCT 2004). This is because during Indonesian occupation
the majority of public servants were Indonesian nationals, creating steep learning curves for those
Timorese now new to these positions. In particular the water and sanitation sector has human resource
shortages in the areas of resource management, sanitation engineering, quality control and plumbing
technicians (Government of Timor-Leste & UNCT 2004).

In addition to these institutional challenges the Timor-Leste MDGs Report (2004) identifies the three
critical factors to attaining the targets as the combination of high economic growth, low inequality (i.e. in
population wealth distribution) and moderate population growth. However, concern has been raised that
the current high population of 76% is likely to continue and that maintaining the current 6% agricultural
growth rate is an unrealistic aim, due to the fact that this growth has only resulted from the virtual non-
existence of infrastructure after the nation wide destruction of facilities in 1999 (Government of Timor-
Leste & UNCT 2004).

Challenges also identified relate to the lack of government policies caused by the resource constraints and
newness of the nation’s governance. In particular challenges are identified with forming environmental
policies which enforce environmental impact assessment practices, so that natural resources are properly
managed (Government of Timor-Leste & UNCT 2004). The most recent political instability reflects the
difficult task ahead in rebuilding the nation and developing policies to address these issues. This recent
conflict has caused development setbacks through the destruction of infrastructure and unsettling of the
population’s confidence in the nations governance as demonstrated by the mass displacement of people.
2.4 Sanitation

Sanitation relates to water and sewerage systems, and the associated issues of maintenance and public health. For the purposes of this project, the term sanitation is defined as the practices and principles of collection, reuse and disposal of human excreta and domestic wastewater, with the overall objective to protect community health through hygienic disposal (Cave & Kolsky 1999; Elledge 2003). Critical to this definition is the association with terms such as hygiene and cleanliness.

It is well understood that poor sanitation and hygiene practices are associated with high morbidity and mortality rates (Taha et al. 2000; WHO 2000). The presence of parasitic diseases in a community is closely related to a lack of sanitation (Santiso 1997) and 88% of diarrhoeal diseases are attributed to unsafe water supply and inadequate sanitation (IRC & Mc Intyre 2006). Addressing sanitation, and applying good home hygiene has been demonstrated to lower the rate of such diseases by approximately 35% (Waterkeyn & Cairncross 2005; IRC & Mc Intyre 2006). In addition, not only do improved sanitation and hygiene conditions provide increased health benefits, they also provide significant secondary benefits to the overall livelihood of the community (Cairncross & Kolsky 2003). These include:

- Saving time;
- Lowering basic cost of living;
- Reducing stress;
- Better learning capacities of children and increased school attendance;
- Emancipation of women; and
- Greater agricultural productivity, due to greater time availability.

Achievement in reducing the morbidity and mortality rates depends on cutting the transmission routes of diseases, primarily through the safe disposal of disease spreading faecal waste (Hadi 2000). However implementation of infrastructure such as latrines and wash houses are not the only method of providing barriers to the infection-disease cycle. Health education campaigns relating directly to personal hygiene are also crucial to reducing disease (Taha et al. 2000). Typically these education programs aim to encourage the communities to adopt practices such as hand washing (after defecation, handling children’s faeces, and before food preparation and consumption), as well as the use of latrines for proper faeces disposal and drinking water disinfection (UN-Water 2004; IRC & Mc Intyre 2006).

For successful implementation of both education and infrastructure programs it is important that the community in focus identifies a need. Hadi (2000) determines the unmet need of a safe latrine to be present when there is an “expressed intention to buy or build a latrine” by households who do not
currently have one. In addition to the need for initial desire to be expressed it is important to recognise that a critical factor in success of sanitation and hygiene programs relates to direct behaviour changes made by the community. In order to change behaviour culturally sensitive and appropriate health education is required which demonstrates that the improved health of the community depends on the adoption of the new practices (UN-Water 2004). Community participation and involvement in all stages of a project is crucial to help participants recognise the importance and need for proper sanitation coverage (Hadi 2000). Raising awareness of why sanitation and hygiene are important will increase community enthusiasm to change harmful behaviours (UN-Water 2004).

**2.4.1 Hygiene Education Programs**

Studies have shown that the simple practice of hand washing with soap can reduce the risk of diarrhoeal diseases by 42-47% (Mooijman 2003). Therefore, the implementation of hygiene education programs in conjunction with sanitation technologies is critical to ensure a sustainable solution to community health problems. Hygiene education programs are designed to demonstrate the link between sanitation, hygiene, health and economic prosperity so as to promote the importance of good hygiene practice to a community (UN-Water 2004). The AusAID Community Water Supply and Sanitation (CWSSP) program in Timor-Leste, have identified five key hygiene related behaviours which should be emphasised in hygiene education programs (Dwan 2006). These are to:

1. Cover water containers to keep water clean;
2. Build latrines;
3. Practice hand washing;
4. Keep animals in pens; and
5. Clean up around the community - especially mosquito breeding sites.

Hygiene promotion should target a small number of risk practices, and specific audiences (Curtis 2005). It has been shown to be most effective when targeting youth as younger populations not only benefit from the information but act as information providers to their families and communities (UN-Water 2004). As a result hygiene education campaigns are often used to target schools and can be combined into school curricula. In order to be most effective the motives for behaviour change, such as social status or consumer demand should be identified as tools to help drive change (Cairncross & Kolsky 2003; Curtis 2005). In addition hygiene education should be designed so that it provides a positive message, i.e. not message of ill-health, death and doctors (Curtis 2005; Mooijman 2003). Often campaigns use music, radio or drama to demonstrate the message and this is most effective in holding a young audience’s attention.
In addition to the five key hygiene behaviours there are five fallacies relating to hygiene promotion which should be considered. These are that:

1. Behaviour change is easy
2. Knowledge change = behaviour change
3. Experts know how to change behaviour
4. A whole variety of hygiene practices should be encouraged
5. Hygiene promotion is a cheap add-on to water programmes (Curtis 2005)

Acknowledging and understanding the issues associated with these five points is critical to directing the approach undertaken for hygiene education. The difficulty associated with generating behaviour change can be attributed to many factors such as change being too time consuming or expensive (Curtis 2005). In addition getting communities to change traditional practices takes large amount of time, resources and skills and often requires generational change. Fallacy 3 relates to the importance that the educational approach is designed around the specific needs, wants and situation of the community (Curtis 2005). Therefore it is important that thorough studies are undertaken to understand the community’s attitudes and traditional beliefs to defecation, anal cleansing, water quality and cleanliness (Dwan 2006). The key message these fallacies raise is that hygiene promotion requires careful planning, a large amount of resources and skills and should be able to stand alone as a solution to reducing morbidity and mortality within a community.

2.4.2 The Environmental Effects of Sanitation

Inadequate community sanitation and waste disposal facilities have the potential to negatively impact the surrounding environment in several ways. Wastes left in the open environment can contaminate surface water resources, which can endanger downstream users as well as the aquatic ecosystem, while groundwater resources can be contaminated from latrines that are improperly lined or sited (UN-Water 2004). The pollution of drinking water resources by faeces can reverse the purpose of implementing sanitation facilities through increasing a community’s chance of ingesting pathogens. Figure 3 shows the six ways in which contamination of water resources can occur due to pathogen transfer from latrines. These are explained in Table 7. In addition contamination from waste disposal can be harmful to waterway ecosystems due to increased nutrient loads from excreta and urine encouraging algae growth and eutrophication.
The assessment of the risk of water source contamination is based on the length of time it takes for the pathogens to travel to the water point. Pathogen travel time of less than 25 days is categorised as a ‘significant health risk’, with a time greater than 25 days to be a ‘low risk’ and more than 50 days categorised as a ‘very low risk’ (Sugden 2006). An increased distance from water sources increases the travel time of pathogens through the subsurface environment which acts as a filter for larger microorganisms, while mechanisms such as adsorption cause pathogen retention. In addition a longer travel time reduces the chance of pathogen survival as the chance that natural pathogen die-off will occur increases with time (Cave & Kolsky 1999).

Table 7 Pathways of water source contamination from latrines

<table>
<thead>
<tr>
<th>Pathway</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Amount of liquid in the pit</td>
<td>Increased liquid volume in pit increases leaching potential.</td>
</tr>
<tr>
<td>2. Nature of the unsaturated zone</td>
<td>Small sediment grain size in saturated zone increases pathogen adsorption thus slows or inhibits transport to water sources – clays are better adsorbers than sandy or organic soils.</td>
</tr>
<tr>
<td>3. Distance between base of pit and water table</td>
<td>The greater the distance between the pit base and groundwater table the lower the risk of pathogen transfer.</td>
</tr>
<tr>
<td>4. Nature of the saturated zone</td>
<td>The greater the aquifer’s permeability the higher the risk of water source contamination.</td>
</tr>
<tr>
<td>5. Horizontal distance between latrine and water point</td>
<td>The greater the distance between the latrine and water source the lower the risk of contamination.</td>
</tr>
<tr>
<td>6. Direction and velocity of the groundwater flow</td>
<td>The greater the hydraulic gradient towards the water point, the higher the risk of water source contamination.</td>
</tr>
</tbody>
</table>
Due to the potentially damaging effects of water source contamination it is critical that an environmental impact assessment is undertaken before any waste disposal solutions are implemented and that chosen technologies protect the environment. Appendix A5 shows an example of an environmental checklist based on a CWSSP form. This demonstrates how environmental risks can be assessed, through the preliminary use of a checklist. For implementation of sanitation technology this checklist should extend to determining the depth to groundwater table, soil characteristics, steepness of slope and other environmental characteristics known to influence the impact sanitation technologies have on the environment. Applying environmental assessments provides part of a criterion to help determine the appropriateness of technologies and solutions.

The commonly used guideline for distance from the drinking water abstraction point and pit height above the groundwater table are 15-30m and 0.5-1m respectively (Cave & Kolsky 1999; DNAS 2005a; Morgan 2000). The relevance of these guidelines depends strictly on soil type, water table depth, potential for flooding and other site specific environmental factors which should be determined and recognised prior to implementation (Morgan 2000). Where these guidelines cannot be met the sanitation technology should be carefully chosen to minimise contamination risks.

Technologies which minimise environmental impact include those which utilise and have low wastewater volumes, encourage recycling and reuse of waste products such as eco-sanitation systems and have minimal impact on the landscape (i.e. require limited clearing of natural vegetation, and excavation) (UN-Water 2004). Options such as above ground systems, which are discussed further in Section 4.3 or latrines which have been elevated can reduce the risk of leaching and the resultant pathogen contamination (DNAS 2005a; Schönnig & Stenström 2004). The potential for groundwater contamination is not solely dependent on the depth of the pit the waste treatment method is also a key factor. Latrines which utilise the principals of composting for treatment (discussed in Section 2.5.4) can convert the raw excreta into a soil like humus with relatively low pathogen content. Compared to traditional pit latrines these have a lower risk of contaminating water sources with pathogenic micro-organisms (Morgan 2000).

If the groundwater table is very high, but it is not cost effective to provide technologies such as above ground systems, then a more cost effective solution may be to combine simple latrine technology with water supply treatment. This raises concerns about the non-health related environmental impacts being neglected. However if levels of indicator bacteria such as E. Coli do not exceed natural stream levels of the order $10^3$-$10^4$ E. Coli/100mL this should not be a environmental concern (Cave & Kolsky 1999). In addition, for the situation where sustainable sanitation technologies are not implemented in order to eliminate the environmental risk of groundwater contamination this effectively foregoes the opportunity to
provide large health benefits through the provision of appropriate sanitation to a community (Cave & Kolsky 1999).

### 2.5 Latrines

Latrines act as direct, physical barriers between people and the harmful pathogens associated with faeces as they collect and control excreta to a designated, confined area (NWP et al. 2006). As a result, the implementation of safe and hygienic latrine technology as widely accepted as dramatically reducing the risk of direct faecal contact which reduces the occurrence of disease. Vast amounts of literature exist relating to specifications and design of latrines. However implementing the right technology for a project relates to having effective alternatives and making the correct choices for the individual situation (UN-Water 2004). The choice involves assessment of many project specific factors relating to the environmental, economic and social costs and benefits of the scenario.

In general the function of latrines can be broken up into three stages, these being:

i) Collection;

ii) Transportation; and

iii) Treatment.

The aim of the first stage is to contain the excreta in a sanitised way, such that human contact with faeces is minimised, and so therefore is the risk of contracting faecal related disease. The collection facility contains faecal waste awaiting transportation (NWP et al. 2006). At this stage there are many variations to the facility which are discussed in greater detail in the following sections. Some collection options may also be combined with treatment or pre-treatment options. Appropriate collection facilities are those which make good use of the specific conditions, and thus can function over a long period of time (NWP et al. 2006).

The second phase, transportation is crucial when the waste cannot be treated, disposed of or used on site. This encompasses infrastructure such as sewers or standard transportation means using vehicles such as trucks or tankers (NWP et al. 2006). For this project, it is assumed for logistical reasons that transportation is unnecessary. Sewers are not considered a viable option for the community of Tangkae as there is little available water, and the local terrain would not provided easy footings for such large scale infrastructure. In addition the scale of this project does not extend to such transportation means.

The final stage of latrine function is the treatment stage. The aim of this stage is to reduce the levels of harmful pathogens in excreta to prevent infection of people and the natural environment (NWP et al. 2006).
Treatment options vary greatly including primary treatment which occurs directly in the latrine, or secondary treatment where material is collected and treated in a controlled manner to reduce pathogen levels (Schönning & Stenström 2004). The most effective treatment is one which is designed specifically for the required characteristics and potential use of the treated end product (NWP et al. 2006). A common method of primary treatment is where ash is added to the waste after each use of the latrine, secondary treatment is described in more detail in Section 2.5.4. It can include initiating decomposition to produces high temperatures which help to reduce pathogens to acceptable limits.

2.5.1 Choosing Appropriate Technology

Nineteen percent of the East Timorese population has access to improved sanitation and therefore there is an urgent need for implementation of sanitation technologies (GovtTimor-Leste & UNCT 2004). However it is critical that implementation observes appropriate steps so that the solutions are sustainable based on simple technologies which can be carried out by the communities and maintained and operated over the long term. There are several key factors which determine whether technology is appropriate for the specific situation summarised in Table 8.

<table>
<thead>
<tr>
<th>Factors</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social</td>
<td>Culturally acceptability</td>
</tr>
<tr>
<td>Technical</td>
<td>Suits local building materials and technical abilities</td>
</tr>
<tr>
<td></td>
<td>Appropriate for available space</td>
</tr>
<tr>
<td>Economic</td>
<td>Suits local economic condition</td>
</tr>
<tr>
<td></td>
<td>- Capital costs within available budget</td>
</tr>
<tr>
<td></td>
<td>- Maintenance and operational costs within available budget</td>
</tr>
<tr>
<td>Environmental</td>
<td>Water usage reflects water availability</td>
</tr>
<tr>
<td></td>
<td>Effects on groundwater quality and surrounding ecosystems</td>
</tr>
</tbody>
</table>

It is important that a technology option suits local building materials and practices and local economic conditions. In addition technologies must be based on cultural preferences, accounting for traditional practices and behaviours (NWP et al. 2006; Robinson 2002). The technology chosen is also dependent on environmental characteristics such as the availability of water which may determine whether dry or flush latrines are appropriate (Wan & daCruz 2005). Technology which fits into these categories will be more successful as communities are likely to have a greater feeling of ownership towards them (Robinson 2002).

2.5.2 The Adoption of Latrines

Although it is clear that the health benefits associated with improved sanitation and waste disposal facilities are great, implementation of such systems will only reach optimal effectiveness when the
solutions are embraced by the community. The adoption of a particular latrine design is reliant on the economics and technical advantages of the option. However it has also been found that the adoption of particular technologies by the community is more widely influenced by cultural factors, local materials and ownership of the technology (Robinson 2002). Defecation and faeces have long been universally associated with cultural taboos, pollution and danger (Jenkins 1999), and these attitudes can restrict the prospect of project success. The feasibility of a sanitation system not only depends on the physical parameters of water availability, soil and groundwater levels, but also the cultural and socioeconomic conditions of the community (IRC 1997).

An example of how attitudes can affect project success is described by Jenkins (1999) where the community of Benin, in rural West Africa, considered latrines a luxury rather than a necessity. This was attributed to past practices, given that extensive bush land and fields have provided a free defecation site for many years. Also, Robinson (2002) found that in some cases it is culturally inappropriate to defecate in a roofed building (Robinson 2002). It is important for this project that fundamental cultural attitudes such as these are identified specific to the community of Tangkae. This is required so that the most culturally appropriate technology can be selected, thus assuring project sustainability.

Jenkins (1999) also suggests that in some cases, the social relevance and meaning of latrines may be greater than their perceived functional value that is the social status of owning a latrine is viewed as more important than the health benefits it provides. This is an important consideration when conducting any community consultation and when aiming to implement latrines in a community. The cultural meaning of latrines must be thoroughly understood and this may be achieved through an understanding of the changes in social structure which may occur given the introduction of sanitation technology (Jenkins 1999). Consequently, the culture of consumer behaviour may be able to be used so sanitation adoption is successful.

Also important for the case study of Tangkae are the factors influencing an individual's decision to adopt a latrine. Jenkins (1999) found that the quality and quantity of past latrine exposures influences the choice because certain beliefs and attitudes towards latrines are molded by these past experiences. Given that the community of Tangkae already has three pit latrines, the way in which these are perceived will likely influence the final design choice made by the community. This may have positive and negative effects. If the previous experience assures adoption of additional latrines this is positive. However experience may skew the design choice to one of similar characteristics which is familiar, even if it is not optimal for environmental, economic and social reasons. Several aspects which can be used as indicators of a community’s past exposure and experiences relating to latrines include:

- Whether they have heard of a latrine;
• Used a latrine only once or twice, or for an extended period;
• The age at first use;
• Whether use occurred inside or outside the community setting; and
• The attractiveness of the latrine encountered (smell and sight of faeces, construction quality or condition, novelty features, etc.)

Significantly, the age of first exposure to latrines has been shown to influence the attitudes of an individual, where early age exposure promotes positive attitudes towards latrine adoption (Jenkins 1999). These indicators are also important in aiding interpretation of cultural and social significance of latrines which influence the adoption of a system. These can be used as a tool to assess the awareness of individuals in the community. This is important as successful implementation cannot occur if individuals are not aware of how a latrine is constructed, operated and maintained (Jenkins 1999).

Significantly, Jenkins (1999) also found that the most common barriers influencing non-adopters (in Benin) were misunderstandings, high cost and fear of disrupting social relationships. Misunderstandings can be functional or technical – as well as a result of the cultural attitudes previously discussed. Functional misunderstandings generally relate to concepts such as pit depth, (number of users and capacity) or materials required for construction, cost and issues such as odour severity (Jenkins 1999). In the case of the Ventilation Improved Pit latrine, which is discussed in more detail in Section 4.3.3, although accepted worldwide, there are some countries such as Mozambique, where materials needed to construct such a design are expensive, and difficult to obtain and thus cost becomes a factor to adoption (Robinson 2002). Technical misunderstandings may occur where a technology’s unfamiliarity results in the incorrect assumption that the option is too difficult to operate and maintain. This can inadvertently limit a community’s development, restricting the use of improved, new technologies.

It is also important that the issues of operation and maintenance are addressed in the planning phase (IRC 1997). This is relevant to the issue of latrine adoption because these are factors which must be considered when design choices are made. It is important that inappropriate assumptions relating to technical functioning and user response are not made (IRC 1997). Nevertheless, these are all issues which can be overcome through community consultation and education programs, which were discussed in Section 2.2.3.

### 2.5.3 Water Borne and Dry Sanitation

Water borne sanitation describes latrines which require water for flushing wastes into the collection facilities. Generally these flush systems require a supply of 45 litres of water per person per day (Anon. 1990). However, even with systems such as the pour-flush options (Section 4.3.1) which require minimal
volumes, they are difficult to maintain in areas with low water supply. As discussed in Section 2.1.1 Timor-Leste experiences a long dry season of 3-6 months. For a system to be considered a feasible option it must be suitable to the climatic constraints of water availability as well as culturally appropriate. Water borne sanitation may be considered the most appropriate option if the cultural practice involves anal washing, (as opposed to wiping) which requires the disposal of water to be managed by the latrine design. Therefore it is imperative that this cultural practice is understood when determining the best option for implementation.

There are many variations in dry sanitation options including bucket latrines, composting and pit systems. Given the long dry season experienced in Timor-Leste and the current water supply constraints on the village of Tangkae, these dry options are considered in more detail in this dissertation and the Pit Pour-Flush design is the only water borne system considered.

2.5.4 Composting and Ecological Sanitation

Composting is an aerobic process, which employs bacteria and other micro-organisms to decompose organic material (NWP et al. 2006; Guardabassi et al. 2003). It is a very important process within all terrestrial ecosystems and is one which can be utilised to effectively treat human excreta, through stabilising the faecal matter. The basic method to promote the decomposition involves the combination of high carbon, and high nitrogen materials, to which air is then added using various methods such as blowers and air diffusers or by periodic turning of the waste in windrow systems (NWP et al. 2006; Guardabassi et al. 2003). In the case of a composting latrine the high nitrogen product is sourced from the human faeces, and the high carbon or organic material can be sourced from a bulking agent such as wood chips, rice husks or other previously composted material (Guardabassi et al. 2003).

An important result of the micro-organism activity is the generation of heat which occurs in the composting process. This is significant as it enables disinfection of the waste to take place through the destruction of harmful pathogens. The composting process consists of three phases: the mesophilic phase, thermophilic phase and the maturation phase. During the first phase the mesophilic bacteria use the organic matter and produce a large increase in temperature, often reaching 55°C in several days and up to 80°C if the system is not correctly controlled (Guardabassi et al. 2003). A rapid change in physical and chemical characteristics of the composting waste occurs due to this change in temperature. The second phase is termed the thermophilic phase as at this stage thermophilic organisms such as various fungi and endospore forming bacteria grow (Guardabassi et al. 2003). In addition, at this stage the thermophilic bacteria initiate the degradation of proteins and carbohydrates, whilst the fungus contribute to the degradation of complex cellulose and lignin (Guardabassi et al. 2003). During the third phase heat
production reduces, as at this period there is a reduction in available nutrients to feed the microbial activity. During this stabilisation period pathogen levels are continually reduced, and the decomposition of cellulose and lignin continues. Importantly, humic and fulvic acids also form which are considered valuable properties in fertiliser (Guardabassi et al. 2003).

The benefit of the composting process is that the decomposed faecal waste provides a nutrient source which can be applied in agricultural practices with minimal risks of pathogen transfer. As can be seen in Table 9 urine has a much greater nutrient load than faeces and thus provides the most beneficial product for increasing crop productivity (Smet & Sugden 2006). As is discussed further in Section 4.3.6, options such as the urine diverting latrines work to optimise the agricultural benefits. In addition, although faeces have a lower nutrient load they contain high levels of organic matter which aids moisture retention, and thus can be applied as a soil conditioner to improve soil structure (Smet & Sugden 2006).

<table>
<thead>
<tr>
<th>Fertiliser</th>
<th>500L of Urine</th>
<th>500L of Faeces</th>
<th>Total</th>
<th>Fertiliser needs of 250kg of cereal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen</td>
<td>5.6 kg</td>
<td>0.09 kg</td>
<td>5.7 kg</td>
<td>5.6 kg</td>
</tr>
<tr>
<td>Phosphorous</td>
<td>0.4 kg</td>
<td>0.19 kg</td>
<td>0.6 kg</td>
<td>0.7 kg</td>
</tr>
<tr>
<td>Potassium</td>
<td>1.0 kg</td>
<td>0.17 kg</td>
<td>1.2 kg</td>
<td>1.2 kg</td>
</tr>
</tbody>
</table>

Due to the valuable end product of faecal composting, it is regarded as a fully sustainable practice. As is demonstrated in Figure 4, it is possible to close the nutrient circle if nutrients are obtained for crops using human waste compost as a fertiliser. The process of composting can be considered sustainable because it reduces the need for non-renewable resources and energy through conventional waste treatment, and lowers the risk to humans through preventing unsafe disposal of organic wastes (Guardabassi et al. 2003). In addition, it is an economical process as it presents a convenient low cost waste disposal solution which contributes to the productivity of agriculture. Ecological sanitation is the term which describes the closing of the nutrient cycle and involves treating human excreta as a resource rather than a waste product (Schönning 2001; Smet & Sugden 2006). This waste once sanitised is used in such a way that the nutrients are recycled to provide nutrition for humans and this contributes to better health and food production and reduces pollution (Schönning 2001; Smet & Sugden 2006; World Bank 2005).
Several different options for faecal waste disposal apply the principals of ecological sanitation in the form of latrines. This can be as simple as planting a tree on a disused pit, through to composting excreta and reusing products to apply to agriculture (World Bank 2005). Each of these operates by storing and treating the faecal waste in preparation for use in agriculture. Treatment generally occurs by optimising the decomposition process through control of physical parameters such as moisture and temperature, encouraging the formation of fertile humus by the addition of wood ash and soil (Smet & Sugden 2006). The different options include various urine diverting mechanisms, above or below ground vaults or the simplest pit option such as the Arborloo latrine. These are discussed further in Chapter 4.

In addition to the primary agricultural benefits of eco-sanitation latrines these systems are dry systems which greatly reduces the risk of groundwater contamination through leaching (Smet & Sugden 2006). This is enhanced due to the addition of carbon substrate such as wood ash, leaves or soil as these absorb any moisture, making eco-sanitation a particularly good option where groundwater sources are used for community water supply. In addition these dry systems reduce water consumption and thus are ideal in water limited regions.

The role of an eco-sanitation technology depends on various project specific factors. These include geographic and physical constraints, economic issues as well as social and cultural factors. Eco-sanitation may be inappropriate for communities where soil fertility is already adequate, or agricultural practices do not demand nutrients (World Bank 2005). It is important to understand that although nutritional and environmental benefits are considered extremely important, the primary role of an eco-sanitation latrine is to improve the sanitation facilities, and thereby improve hygiene and community health. Given that sanitation systems aim to improve community health through reduction of pathogen transfer, health concerns are raised for eco-sanitation technologies due to the necessary handling of decomposed waste. In well maintained systems risk of pathogen transfer is very low due to the effective disinfection through heat generation (Smet & Sugden 2006). However these systems are health risks where the latrine is not
Literature Review and Background

properly managed or users do not properly understand the operation requirements. This is considered the principal weakness of ecological sanitation (Smet & Sugden 2006).

In addition, many cultures hold strong beliefs linking the use of human faeces in food production and disease, and this has the potential to limit the acceptance of eco-sanitation technologies (Smet & Sugden 2006). It has been documented by the World Bank Water and Sanitation Program that African families unfamiliar with excreta reuse held strong negative sentiments and cultural resistance towards its application to agriculture, and many implemented eco-sanitation latrines were being used only as a sanitation facilities rather than for agricultural benefits (World Bank 2005). Given that these systems require some form of secondary handling it is important to recognise the likelihood that a reluctance to operate and be involved in this process may be expressed by the user (Smet & Sugden 2006). Importantly, it has also been noted that users did not find management of these facilities easy. However, various eco-sanitation facilities have been successful throughout Africa. The benefits expressed towards eco-sanitation included the permanency of systems, the potential for agricultural productivity and improved hygiene (World Bank 2005).

These potential limitations demonstrate the importance of good education and training in conjunction with the implementation of eco-sanitation. A process of education suggested by the World Bank Water and Sanitation Program (2005) indicates there should be greater user education and support during the first year of implementation. This should involve regular inspection of composting piles so the user can be identify and observe the changes and errors in use, (such as too much moisture, addition of inorganic materials etc.). The most important information the user must understand relates to the addition of organic matter and soil to the substrate to promote the decomposition (World Bank 2005). Thus sufficient resources must be made available for these follow up operational requirements.

2.5.5 Removal of Pathogens through Composting

Pathogens are organisms such as a bacterium or viruses which can cause disease when in contact with an individual and are commonly found in human wastes (Cave & Kolsky 1999). The presence of these organisms in excreta is usually the direct result of infection in individuals within the community. This is understood to mirror the hygiene situation in a society (Schönnen & Stenström 2004). In communities where diarrhoea is prevalent, such as Tangkai, large amounts of pathogens are excreted making transmission more common (Vinneras et al. 2003). Ascaris, or parasitic worms are also easily transmitted through faecal contact as the eggs are found in faeces and when accidentally ingested hatch and infect the individual (DPD 2004).
There are three main transmission routes for diseases such as these (as can be seen in Figure 5) (Vinneras et al. 2003):

1. From direct contact with faeces contaminated surfaces and materials. In this case the pathogens may be transmitted via hands and through food and fluids;
2. Transmission through contact with soil that has been fertilised with faeces; and
3. By consumption of vegetables fertilised with faecal wastes.

![Figure 5](image)

**Figure 5 The transmission routes for enteric pathogens (Schönning & Stenström 2004)**

Using excreta, human faeces and urine can provide beneficial nutrients to plants and agricultural land (Schönning & Stenström 2004). However, to be able to use faecal waste as a soil conditioner or fertiliser the harmful pathogens must be destroyed and this process is called disinfection. Through proper treatment of faecal wastes it is anticipated that the occurrence of intestinal diseases in general would decrease (Vinneras et al. 2003).

There are several methods of disinfection which are useful in developing countries. One method is the application of wood ash to the waste to raise the pH of material and thus destroy faecal pathogens (Vinneras et al. 2003). Carlander and Westrell (1999) found from a study in Vietnam that there was a reduction in viable ascaris over six weeks of between 50-100% with the addition of ash to faecal waste. Composting is another method which can be used to disinfect faecal matter. Adequate disinfection will only take place if sufficient temperatures are generated by the composting process.

There are four critical parameters which control whether optimal composting conditions exist. These conditions are temperature, aeration, moisture and the carbon-nitrogen ratio. Temperature is the most important factor because it controls the rate of waste degradation and effectiveness of disinfection. Temperatures must be maintained between 45 and 55°C for optimal degradation rates, and above 55°C for maximum pathogen reduction (Guardabassi et al. 2003). Importantly Guardabassi et al. (2003) found that
above 60°C microbial diversity is greatly reduced which is positive for disinfection purposes however can have negative consequences to the degradation process. Therefore a balance between health safety and the stability of decomposition is vital for an optimal process.

The temperature can be controlled by rotating the compost pile and providing aeration. Aeration is the second important controlling factor which provides oxygen to the aerobic organisms, and can be supplied by agitation or forced aeration (Guardabassi et al. 2003). If anaerobic conditions exist this will slow the degradation process, decrease temperatures and thus affect the hygiene of a system. The aeration conditions depend upon the type of waste, the stage the process is at and the moisture content of the pile (Guardabassi et al. 2003).

Aeration also helps to remove any excess moisture and gases in the system. Moisture is also an important factor which must be controlled. The initial moisture generally varies between 55 and 65%, depending on the substrate used, and this content is important as it influences the structural, thermal and degradation properties of the system (Guardabassi et al. 2003). Reduction of moisture content below 35% must be avoided as this will reduce the microbial activity, while contrasting with this, too much moisture will reduce the effect of aeration by clogging pores (Guardabassi et al. 2003). Moisture is able to be controlled by the simple addition of water, or by changing the aeration or temperature controls (Guardabassi et al. 2003).

Control of the carbon to nitrogen (C-N) ratio is critical for an optimal composting process. This is important as the rate of microbial activity is dependent on the availability of nitrogen as a nutrient source. Guardabassi et al. (2003) found that the optimal C-N ration for starting material is around 25. A lower ratio was found to slow the rate of decomposition and increase nitrogen loss through ammonia vaporisation. In addition a ratio which is too high slows the degradation process as the micro-organisms first oxidise the excess carbon (Guardabassi et al. 2003). This parameter can be controlled for faecal composting by the addition of bulking agent such as bark, wood chips or straw which increases the C-N ratio.

It was found by Vinneras et al. (2003) that when little or no insulation is used to contain the heat energy produced by decomposition inadequate disinfection takes place. Tests conducted by Vinneras et al. (2003) showed that insulated compost can easily reach temperatures over 60°C which effectively disinfected the faecal waste. The study concluded that insulation is required even in naturally high climatic temperatures for the compost to achieve relatively homogeneous temperatures this is significant for this dissertation as the community of Tangkae experiences similar climatic characteristics. In addition Vinneras et al. (2003) discussed a study in Ethiopia where the faecal matter was pre-treated with ash, and the resultant increased
pH created less viable conditions for micro-organism growth. This is a significant result as it influences the type of bulking agent used for the process.

The substrate used also determines the efficiency of the composting process. Given that a substrate with only faeces and food waste contains large amounts of energy which are easily transferred into heat, it was found that this combination produced the highest temperatures, and thus is the best combination for faecal disinfection (Vinneras et al. 2003). Vinneras et al. (2003) found that after only 18 days of composting the vessel with this substrate had degraded 53% compared to the same substrate but including urine of 39% decomposition. It was also noted that temperatures of up to 65°C were gained whilst the surrounding air temperature was averaged at 10°C. This is significant for the case of Tangkae, as it is highly likely that air temperatures within this range will be experienced at some parts of the year.

Another significant conclusion from the study undertaken by Vinneras et al. (2003) relates to the efficiency of disinfection of waste which contains urine. Different substrate mixes were tested and it was found that when the substrate contained urine, large amounts of bulking agent had to be added to create conditions where the dry matter ratio was acceptable for composting without active aeration. This resulted in large volumes requiring treatment which can be restricting if there is limited space, or financial support for construction materials. Substrate containing urine was also found to create high concentrations of ammonia. This in turn results in large ammonia emissions occurring during composting which can be detrimental to the environment (Vinneras et al. 2003). This result is significant for determining the most effective latrine design as it indicates that some type of urine diversion system would be optimal.

Co-composting is where two or more materials are blended to compost (NWP et al. 2006). Co-composting has optimal efficiency, compared with composting (with one material) as it can integrate excreta and solid waste management (NWP et al. 2006). In addition, co-composting when the substrate contains only faeces and food wastes has been found to produce the largest amount of heat, and thus maintain the highest temperature which is ideal for disinfection of the waste to be used for other purposes (Vinneras et al. 2003). This is also beneficial as it helps to control the C-N ratio.
Chapter 3: Methodology

The following section describes the methodology undertaken to complete this dissertation. This includes a combination of field work, stakeholder consultation and intensive review of literature.

3.1 Project Development

The project started on the 24th of January when the Australian project team, consisting of the three UWA engineering students and three EWB-AUS members (Kymberley Greenwood: *Timor-Leste Project Coordinator*, Kim Axworthy: *EWB-WA Chapter President* and Stewart Davies: *EWB-AUS National Director of Projects*) undertook pre-departure training. This included a two day intensive language training in the Timorese national language of Tetun with teacher and interpreter Domingos de Oliveira and cultural training directed by Australian Volunteers International (AVI). Following this, the Australian project team and Domingos de Oliveira travelled to Timor-Leste arriving on 2nd of February and staying for a period of 20 days. During this initial in-country field visit activities were undertaken to develop the project. This involved investigating the most appropriate project location, defining the focus and developing stakeholder relationships. The details of these activities are outlined in the following section.

3.1.1 Stakeholder Consultation

This project involves a broad range of stakeholders from both Timor-Leste and Australia. Interaction with these key partners was undertaken throughout the in-country field trip in order to begin developing the project scope and obtain the relevant information and data sets. Discussions were also held with various agencies and international NGOs currently involved with water and sanitation related projects in Timor-Leste. These were undertaken in order to gain insight into the issues arising when conducting such projects, as well as to investigate the successes and failures of sanitation, hygiene and waste disposal technologies available. A list of people and agencies consulted is presented in Appendix A3 These discussions were extended during the project period after the in-country visit and reports, advice and other details were sort to enhance the accuracy and effectiveness of this dissertation.
In addition to this, both formal and informal discussions were held with the UNTL students (as pictured in Figure 6) in order to construct details for the project focus. The formal consultation session which was conducted at the UNTL Hera campus involved the following two stages:

1. An initial meeting was held by the UWA project group in consultation with Domingos de Oliveira to develop and translate a list of issues to be addressed within the planned UNTL student consultation session.

2. Brainstorming activities and consultation with the UNTL students in order to stimulate discussion around the topics of water supply, quality and waste disposal. These activities involved the construction of the pictorial and descriptive flow charts displayed in Figure 7 and Figure 8 to collate ideas. In order to minimise confusion stemming from language differences within the group the charts were written in both Tetun and English and Domingos de Oliveira was present to translate discussion. Two sets of flow charts were constructed each with the three centre categories of water supply, quality and sanitation. The two sets focused on the following themes:
   i. Issues and definitions surrounding the three core topics – divided into causes and effects of each and categorising the negative and positive elements (Figure 7).
   ii. Survey questions which should be investigated when visiting Tangkae relating to physical and social aspects of water supply, quality and sanitation (Figure 8).

These provided the project team with a good basis to develop the surveys and questionnaires described in Section 3.1.5 and displayed in Appendix A2.
Further consultation with the UNTL students was conducted via email using email accounts set up for each student. This contact was maintained up until the violence occurring around June of 2006. It was the intention of the Australian project team that further surveys similar to those described in Section 3.1.5 would be undertaken by the Timor-Leste project team whilst research was undertaken by the UWA project team in Australia. As shown in Appendix A4 documents were drafted and presented to the students who were preparing for a visit to Tangkai in April 2006. These additional surveys were unable to be conducted due to the instability arising in mid 2006.


3.1.2 Determining Project Locality

Several assessment categories were used to determine which East Timorese community would be the focus of this project. The primary category used was the priority placed on the community by the Timor-Leste National Directorate for Water and Sanitation (DNAS). DNAS have placed each rural community within Timor-Leste into a priority listing founded on a needs based assessment of the individual community’s water supply and sanitation situation. Consequently it was decided that only communities at the highest level of priority (one) would be considered. The second constraint on determining the location of the project was the requirement that the village be within a reasonable travel distance to the UNTL Hera campus and Dili as this was where the project team were based.

Accounting for these constraints two Priority One communities were visited with the assistance of DNAS staff. In both villages the water sources were sampled and flow rates measured. Also, preliminary discussion with the village chefe (community leader) and other community members were undertaken relating to the water and sanitation situation. The first community Nama Lai, which was not selected, is located an approximately 40 minute drive south east of Dili, west of Hera. The access road to this village was in extremely poor condition due to the steep slope and resultant severe erosion and thus it was difficult to reach. Community consultation determined that very little water was available at the main water source in the dry season. After an additional meeting with DNAS staff the project team was alerted to the fact that there existed government plans to address the water and sanitation problems in Nama Lai beginning soon. This was the major factor which determined Tangkae to be the community in focus for this project.

3.1.3 Site Description

The chosen community is located in the Sub-village (Aldeia) of Tangkae, in the village (Suco) of Balibar, Sub-district Cristo Rei and Dili District. The community is located at latitude 125°36'20''E and longitude 08°36'10''S and is situated an approximately 40 minute drive south of Timor-Leste’s capital, Dili as shown in Figure 9. The population is approximately 206 people; with some discrepancies between this figure and the stated total number of families (given as 57 with 8-12 people per house by the community chief which equates to greater than 206 total population). The site is a mountainous region with an average elevation of 750 metres above sea level. The region is dominated by tropical-temperate forest vegetation, which is interspersed with agricultural plantations of banana, coffee and papaya trees. The region experiences two distinct seasons with a long dry season extending from 3-6 months through June-December and a tropical monsoonal rain pattern from December to May/July with varied annual volumes of around 1000 millimetres.
Figure 9 Location of Tangkae (Tanca on map) in relation to Dili (DNAS 2006)
The main community housing areas are in two clusters as shown in Figure 13. These are serviced by a steep, heavily eroded unsealed road which joins directly to the main sealed road connecting Balibar to Dili. The community are subsistence agriculturalists with the primary land use in the region being cropping and livestock grazing to support this system. There is no electricity supply to the community and no water supply infrastructure, with previous supply systems being damaged in the 1999 violence following the referendum. There are three main water sources, a well, spring and stream which vary from 500-3000 metres distance from the community centre. The village is listed by DNAS as Priority One due to the poor sanitation conditions and lack of water supply infrastructure.

3.1.4 Investigating Other Projects

In addition to general discussions with government agencies and organisations, other projects were visited to gain insight into common issues and the technical water and sanitation solutions available. These visits were not only useful in providing practical visual understanding of solutions, but also helped to generate discussion within the project team relating to the operation and maintenance of technology and infrastructure. Figure 10 shows a visit undertaken to a local water pumping station in Hera where issues were discussed relating to maintenance, and problems with electricity supply within the region. Figure 11 shows the visit undertaken to a UNICEF water supply project in Hera where the option of rainfall collection was implemented.
3.1.5 Community Surveys

On the 17th and 20th of February 2006 initial community surveys were undertaken of the social and physical characteristics of the community. The purpose of these were to ascertain information from representative persons in the community of Tangkae to enhance our understanding of the problems, issues and current water and sanitation practices of the village. The surveys were developed in consultation with the UNTL students, as described in Section 3.1.1. These were written in both English and Tetun and are included in Appendix A1.

Both social and physical surveys were undertaken. The social surveys involved interviewing the chefe of the Aldeia, along with other community members including the second-in-charge and their wives. This was undertaken by only several members of the project team to avoid intimidation and crowding and Martinho dos Santos, one of the UNTL students was appointed spokesperson. As displayed in Appendix A1 the survey aimed to obtain demographic information, details about water use and sanitation practices within the community, as well as investigating the agricultural practices and general health issues.

The physical survey was conducted by the remaining project team members and included detailed observations and measurements of local environmental factors, in particular the characteristics of the three water sources and nature of the terrain and physical and cultural landscape. A Global Positioning System (GPS) was used to measure elevation of key points within the community and this information was generated into two plots by Vaughn Grey which can be seen in Appendix A6. Flow rates and water quality measurements were taken for the three water sources, Laratema spring, Fatnamudu stream and Airabat well. As indicated in the physical survey in Appendix A1 water quality analysis was undertaken at the DNAS water quality laboratory. For further details on the methods and results undertaken for this aspect
of the survey see Heidi Michael’s paper entitled *Drinking-Water Quality Assessment in East Timor, Case Study: Tangkae.*

### 3.1.6 Tetun Lessons

In order to ensure ease of communication between all project team members, weekly Tetun lessons were taken by the Australian project team throughout the year. These lessons were critical preparation for the in-country field visit as well as provided the skills required for email communication between the UNTL students and other in-country contacts. In addition they provided opportunity for discussion with teacher Domingos de Oliveira about issues, such as cultural and historical questions, relating to Timor-Leste which arose throughout the study period.

### 3.1.7 Generating Community Awareness and Fundraising Activities

A significant aspect of this project is the financial and technical support provided by members of the engineering and international development community. As a result activities to generate awareness about the project were undertaken including two presentations given to the West Australian engineering community. These included a presentation given to the Women in Mining Western Australia function on the 19th May as well as at the EWB-WA chapter general meeting on the 31st of August. In addition, a press release was produced which generated interest from the local Perth radio station RTR fm who conducted a short interview, as did Perth local community newspapers. A university webpage was also created. Funding was sourced from a variety of areas including the UWA Vice Chancellery and the Faculty of Engineering, Computing and Mathematics.
3.2 Selecting Appropriate Technologies

As discussed in Section 2.5.1 the key to the successful implementation of a sanitation option in a developing community is the selection of the most appropriate technology. The technology must be acceptable to the community and account for economic, social, cultural and environmental factors. The following method for assessing the suitability of sanitation options involves utilising the ‘SHTEFIE’ criteria, (Social, Health, Technical, Economic, Financial, Institutional and Environmental) which was developed by Franceys and Ince (1995) at the Water, Engineering and Development Centre, Loughborough University (Parr & Shaw 2006). This method was used to rank the latrine options presented in Chapter 4 and evaluate each of these as discussed in Chapter 5. This method requires three stages as follows:

Stage 1 – Objectives
This stage involves establishing the primary purpose of the technology and includes the two steps:

(i) Identify the main aims and determine if they are realistic or achievable;
(ii) Prioritise goals (e.g. low cost, low maintenance vs. environmental benefits)

Stage 2 – Analysis
This stage involves investigating and recognising constraints on the project (e.g. physical: such as water, land availability, cultural perceptions etc.) which contribute to the success or failure of the project. These issues are grouped using the ‘SHTEFIE’ criteria in order to aid in analysis of the sanitation option. Table 10 shows the constraints considered when selecting the most appropriate sanitation technology.

Stage 3 – Output
This is the final stage where following the evaluation of each option the decision is made. At this stage it is important to consider options as well as targets/standards in order to determine the most appropriate solution.
<table>
<thead>
<tr>
<th>SHTEFIE criteria</th>
<th>General Constraints on Project</th>
<th>Factors Specific to Tangkae</th>
</tr>
</thead>
</table>
| SOCIAL factors         | • Cultural and religious aspects, including attitude towards eco-sanitation and sanitation practices such as anal washing or wiping  
                         • Housing facilities; type, distribution  
                         • Public desires and preferences; aesthetic considerations, previous experiences  
                         • Population distribution, welfare and equity considerations (gender, age, location; growth rates) | • Manure from livestock used on crops → concept of fertiliser from faeces understood. Compost from human waste substrate not used.  
                         • Three pit latrines exist → community is familiar with below ground systems.  
                         • Predominant practice for human waste disposal is to defecate in the pig enclosure.  
                         • A large percentage of the population are young children.  
                         • Not known whether anal washing or wiping is the common practice → assume separate washing facilities are implemented |
| HEALTH factors         | • Health statistics, significant diseases, morbidity and mortality rates  
                         • Health services available | • There is a high incidence of diarrhoeal diseases.  
                         • Several community members are trained about treatment (not prevention) of worms. |
| TECHNOLOGICAL factors  | • Availability of spare parts and materials  
                         • Availability of local knowledge and expertise  
                         • Design life of technology  
                         • Power and water requirements | • Corrugated iron, concrete, wood and bricks available throughout region. |
| ECONOMIC factors       | • Structure of economy, output by group, industrial and agricultural component  
                         • Trade relations, isolation of economy and vulnerability, distribution of incomes | • Subsistence agriculture with limited trading and buying/selling at markets.  
                         • The community situated relatively close to Dili and access road in moderate condition → not isolated |
| FINANCIAL factors      | • Finance available, ability and willingness to pay | • Ability to pay is low |
| INSTITUTIONAL factors  | • Relationships between organisations  
                         • Legislation, policing and regulations | • Operation and maintenance capabilities can be set up between HTO, DNAS and the community |
| ENVIRONMENTAL factors  | • Climate, hydrology, soil conditions, geology, groundwater characteristics  
                         • Water-resource availability  
                         • Impact of any technology: noise, smell, insects, visual impact, health considerations  
                         • Sustainability | • Groundwater levels are unknown  
                         • Very limited water supply especially during the dry season |
Chapter 4: Results

This chapter has three main elements which present the results from the stakeholder analysis, community surveys and details of sanitation technologies. Each of this is important to achieving the objectives of the project.

4.1 Stakeholder Information Flow

This project involves at least six groups of stakeholders, each with significant roles to play at different phases of the project. Most critical to every stage are the Tangkae community. This group can be characterised into several different subgroups, through the demographic characteristics of age, gender and social status, all which play essential roles in the outcome of the project. Figure 12 shows the information flow and interactions between stakeholders at the project development stage. It can be seen that the information type exchanged between the Tangkae stakeholder group and others at the project development phase is largely ‘right to know’ information, such as how the community is prioritised and the aims of the preliminarily community surveys. In addition the information provided by the community to the EWB-AUS and UWA stakeholder group is mostly data such as the information provided in the social and physical surveys.
The stakeholder group most critical to the success of the capacity building aims of this project are the six UNTL final year Civil Engineering students. Also at the project development, design and implementation stages key local and international NGOs are significant stakeholders. The most directly involved NGO for this project is HTO, a Timorese organisation which engages in water supply and sanitation community projects. Involvement with this organisation is also critical to the capacity building aims of the project, with the objective to help broaden HTO’s experience with multidisciplinary projects, thereby increasing their capacity to implement successful water and sanitation technologies in communities throughout Timor-Leste.

At a broader level, government institutions play a key role as stakeholders in the project. The most important agency for this project is DNAS, as they provide information to the Australian project team and are the governing decision making body. They also provide technical support through allowing access to the department water quality laboratory, transportation and technical assistance from technical staff and supplies such as survey equipment used in the physical community surveys. Other government bodies consulted during the in-country field trip such as the Department of Natural Resources Minerals and Energy and the Department of Agriculture, Land and Geographic Information Systems (ALGIS) are
considered important information providers. It is hoped that the completion of this project will contribute information in return to these departments.

The fifth key group of stakeholders are EWB-AUS and UWA, including the three UWA final year engineering students (including the author), who have played co-ordination and management roles. Informational flow between this stakeholder group and the others, as seen in Figure 12 is largely directed to this group, in the form of data and technical advice. However there is also a strong element of bi-directional information flow, stemming from the capacity building objective which promotes knowledge exchange between this stakeholder group and the UNTL, HTO and International NGO group. The final key stakeholder group is the donor organisations, which have been sourced and managed by EWB-AUS. These organisations are the stakeholders who provide the funding for all stages of the project and include EWB-AUS donors, AVI and UWA. This group is connected indirectly to all stakeholders through EWB-AUS
4.2 Community Survey Results

The following section describes the results collected from the physical and social community surveys conducted by the project team on the 17th and 20th of February. The direct answers by the community representatives to the social survey questions are displayed in Appendix A2 with the significant results from this interview and discussions summarised in Table 11.

4.2.1 Social Survey

The information collected from discussions with select community members over a range of issues relating to the community traditional practices and demographic information is presented in Table 11. From these discussions it was determined that the community water supply was not sufficient in the dry season. It was also found that access to the closest and most widely used spring, Laratema was dangerous and slippery in the wet season causing numerous injuries to those carrying water including miscarriages in several women. The survey found that the Aldeia had previously been supplied water through pipes constructed in 1997 from Fatnamudu stream. However the infrastructure was damaged during the violence in 1999 after the independence referendum and had not been repaired. From these discussions it was determined that the community wanted a new water supply system.

<table>
<thead>
<tr>
<th>Tangkak Social Survey Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demographic Information</td>
</tr>
<tr>
<td>Water Use Practices</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Sanitation Facilities</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Community Health</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Agriculture Practices</td>
</tr>
<tr>
<td></td>
</tr>
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<td></td>
</tr>
</tbody>
</table>

As displayed in Table 11 it was also determined from the social survey that there are inadequate sanitation facilities available in the Aldeia. With three latrines built to serve foreign Peace-Corp visitors and used only by a small group of the community, it was found that the primary method of faecal disposal was to defecate into a hole in the pig enclosure or into the surrounding environment (by young children). This method of disposal creates an ideal ascaris worm breeding cycle as the pigs consume the waste because of a lack of water. It was also found that there are no solid waste disposal facilities, with plastics thrown into the surrounding environment and organic wastes fed to the pigs. The only practice of waste management involves raking solid inorganic and organic wastes and incinerating them in the dry season whilst the land is being prepared for next seasons crops. The agriculture practices were also investigated and it was found
that irrigation was not used for crops, primarily due to the lack of water resources but that manure from livestock such as pigs, goats and cows was used as fertiliser. The primary crops include maize, tapioca, sweet potato, beans and coffee plantations. Livestock kept includes cows, pigs, chickens, buffalo, horses, and goats – some of which are penned, and some not.

Illnesses found to commonly affect the community included coughing, fever, headaches, running nose, diarrhoea and worms (particularly in children) and it was stated that the children are sick ‘all the time’ with a child mortality rate of approximately 1 death per year. There are three representatives from the village who were sent to a community education course on how to treat worms (it is understood that when the person has an upset stomach, treatment involves getting medicine from the chemist which helps to excrete the worms). It was found that no worm prevention was properly understood or taught, however it was understood that the children get worms from eating ‘anything’ and not washing their hands.
4.2.2 Physical Survey

The physical survey involved an investigation of the physical and anthropogenic landscape and the three water sources used by the community of Tangkae to determine water flow rates, water quality, elevation of water points and other characteristics. The two closest water sources, Laratema spring and Airabat well are shown on the topographic map (Figure 13) while Fatnamudu stream is located south-east of the community just off the map’s border. The results of the physical investigations are summarised in Table 12.

<table>
<thead>
<tr>
<th>Water Sources</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Laratema</td>
<td>• Spring closest to village</td>
</tr>
<tr>
<td></td>
<td>• 500 metres downhill from main community</td>
</tr>
<tr>
<td></td>
<td>• Very steep, narrow and slippery access</td>
</tr>
<tr>
<td>Fatnamudu</td>
<td>• Stream with larger flow rates than Laratema</td>
</tr>
<tr>
<td></td>
<td>• 3-4 kilometres from community</td>
</tr>
<tr>
<td></td>
<td>• Originally connected to Aldeia with pipes using gravity (slight altitude difference)</td>
</tr>
<tr>
<td>Airabat</td>
<td>• Well, concreted</td>
</tr>
<tr>
<td></td>
<td>• Approximately 3 kilometres from community</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Anthropogenic Activities</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste Disposal</td>
<td>• Solid waste is thrown into the open environment - on the ground or into the stream</td>
</tr>
<tr>
<td></td>
<td>• Many detergent packages observed around Laratema spring</td>
</tr>
<tr>
<td>Level of human activity</td>
<td>• Housing is scattered, with two main clusters</td>
</tr>
<tr>
<td></td>
<td>• Buildings constructed primarily of corrugated iron, concrete and wood combinations</td>
</tr>
<tr>
<td></td>
<td>• The main access road to the community centre is unsealed heavily eroded in some parts, allowing access only to 4WD vehicles</td>
</tr>
<tr>
<td></td>
<td>• Access paths to water sources are narrow and steep and also heavily eroded in parts</td>
</tr>
<tr>
<td></td>
<td>• Chickens, goats and pigs were free to roam around village, with several pig enclosures constructed of wood.</td>
</tr>
<tr>
<td></td>
<td>• No electricity supply exists</td>
</tr>
<tr>
<td></td>
<td>• Several disused concrete water tanks exist within the village</td>
</tr>
<tr>
<td>Sanitation Facilities</td>
<td>• Three latrines exist, one was observed to be a pour-flush pit design with western pedestal and was also used as a wash house</td>
</tr>
<tr>
<td></td>
<td>• A hole in the pig enclosure also presented as a defecation site</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Physical Environment</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Topography</td>
<td>• Generally steep slopes</td>
</tr>
<tr>
<td></td>
<td>• Highest elevation 755m above sea level (a.s.l) with average elevation 700-750m a.s.l</td>
</tr>
<tr>
<td>Soils and Geology</td>
<td>• Observed to be clay-like along path to Laratema as fine and very slippery when wet</td>
</tr>
<tr>
<td></td>
<td>• Hard rock forms the stream bed at Fatnamudu, and richer organic soil top layer along Fatnamudu access path, similar in the region surrounding Airabat</td>
</tr>
<tr>
<td>Vegetation</td>
<td>• Dense-moderate forest cover</td>
</tr>
<tr>
<td></td>
<td>• Scattered coffee plantations and fruit trees</td>
</tr>
</tbody>
</table>
As shown in Figure 14 both Laratema and Fatnamudu watering points have a bamboo pipe outlet to distribute the water and Airabat well is reinforced with concrete to store the water. Airabat well was built
by the region’s villagers when they discovered water coming up from the ground beside a stream which flows only in the wet season and thus the area was dug and concreted to provide a permanent water source. All sources reportedly have greatly reduced flow rates during the dry season and as a result water collection is a long process requiring some community members to travel to Fatnamudu or Airabat as Laratema alone does not supply great enough volumes.

Figure 14 Three water sources servicing the Tangkae community. Laratema spring, Airabat well and Fatnamudu stream.
### 4.3 Sanitation Technologies

As described in Section 2.5.1 it is important that the most culturally, environmentally and economically appropriate option is applied when implementing sanitation technology. Table 13 shows the range of the most commonly implemented sanitation technologies applied in developing countries and identifies the range of options known to have been employed in Timor-Leste. In order to evaluate these options and determine the most appropriate sanitation technology for adoption in Tangkae the function of each technology must be understood. The following section describes the function and advantages and disadvantages of each option in order to aid this assessment.

| Table 13 Commonly implemented sanitation technologies for developing nations |
|---------------------------------|---------------------------------|
| Pit Pour-Flush Latrine          | Yes                             |
| Ordinary Pit Latrine            | Yes                             |
| Ventilated Improved Pit Latrine | Yes                             |
| Bucket Latrine                  | No                              |
| General Composting Latrines     | Yes²                            |
| Urine Diversion Latrine         | No                              |
| Waterless Urinal                | No                              |
| Arborloo                        | No                              |
| Fossa Alterna                   | No                              |

1Those marked as ‘No’ are not known to have been implemented in Timor-Leste (to the authors’ knowledge)

2Only known to have been implemented by Rotary Australia in Samalette Timor-Leste (to the authors’ knowledge)

#### 4.3.1 Pit Pour-Flush Latrine

The pour-flush latrine is a system commonly implemented in government water and sanitation programs within Timor-Leste. Figure 16 displays the standard drawing of a double side pour-flush system produced by DNAS. The latrine design consists of a water seal squatting pan connected to a container outside the latrine which leads to one (or often two) below ground leaching pits (IRC 1997). The pan has a U-shaped facility which is partially filled with water and a pipe with a 2% slope (DNAS 2003). The pipe’s narrow diameter of 70mm, and water seal created by the u-shape trap ensures that flushing only requires 1-4 litres of water (IRC 1997). The water seal has the benefit of reducing odour problems by limiting air flow from the pit into the superstructure and prevents fly and mosquito breeding.

When the pan is flushed, the waste is passed through the pipes and into one of the pits. The solids accumulate in the pit and the liquid is encouraged to percolate into the surrounding soil through the
bottom of the pit (IRC 1997). The principal of the double pit system is that when one pit has been filled the pipe is blocked and flow diverted to the second pit. In the time it takes for the second pit to fill the original pit is left to decompose, and over a period of at least 18 months the pathogens will expire, thus leaving organic humus which can be safely handled and used as a fertiliser (IRC 1997). As a result, the original pit can then be emptied and reused, creating a complete cycle.

The primary maintenance requirement for this system is regular checks for blockages. Over the period of 2003-2005 the Timor-Leste UNICEF Water and Environmental Sanitation project aided the implementation of 4184 pour-flush latrines. Each household was provided with a latrine pan, base, five concrete rings for pit lining, drain block and pit cover. The cost of these systems, including US$ 21.60 fee charged by construction workers was US$ 53.70, broken down the cost of the pit alone was US$ 24.3 (Wan & daCruz 2005). It was determined at the completion of this project that the approach of implementing these pour-flush latrines was not sustainable due to the high capital cost (Wan & daCruz 2005).

The main advantages and disadvantages associated with this system are summarised in Table 14 below. The key disadvantage associated with the pour-flush design relates to the leaching mechanism characteristic of the system. This is a concern due to the potential for groundwater contamination. As
discussed in Section 2.4.2 groundwater contamination is of concern if the subsurface water displays connectivity with the local spring which is the current community water supply. In addition, another significant disadvantage of this system is the reliance on water supply. The pour-flush system can only be applied in regions where water is readily available for flushing and where infrastructure can be provided to manage the wastewater (NWP et al. 2006). Furthermore the use of water increases the potential for contamination as pathogens are diluted and thus spread over a larger volume.

Table 14 Advantages and Disadvantages of Pour-flush system

<table>
<thead>
<tr>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Suitable for communities where anal washing is the common practice</td>
<td>- Requires sufficient water supply for proper operation and maintenance</td>
</tr>
<tr>
<td>- Highly convenient for user</td>
<td>- Has the tendency for blockages</td>
</tr>
<tr>
<td>- Design reduces the need to handle excreta</td>
<td>- Requires appropriate infrastructure to manage wastewater</td>
</tr>
<tr>
<td>- Can be used indoors</td>
<td>- Below ground pits increase the risk of groundwater contamination</td>
</tr>
<tr>
<td>- Achieves primary objective; to reduce chance of disease by minimising pathogen transfer</td>
<td>- Pathogens mix with water, thus spread over a large volume</td>
</tr>
<tr>
<td>- Familiar to the community, thus likely to be better maintained, and requires less education about operation and maintenance</td>
<td>- High initial cost</td>
</tr>
<tr>
<td>- Less pit volume required</td>
<td>- Minimal odour and no fly problems when maintained correctly</td>
</tr>
</tbody>
</table>

4.3.2 Ordinary Pit Latrine

An ordinary pit latrine is another commonly implemented design in Timor-Leste. Pit latrines can be constructed using various local materials and all work on the same general principal. As inferred by the title, this involves collection and containment of faecal waste into a pit, generally of diameter approximately 1m, and depth 1.5-3m with a hole above which holds a pan and is usually enclosed by a small house to provide privacy to the user (Anon. 1990; IRC 1997). The pit can be lined with concrete, bricks or some material which prevents the walls from collapsing, where soft soil types are characteristic of the area (Anon. 1990; IRC 1997).

As this latrine option is the simplest and cheapest, it is the most commonly used in developing countries (FAO 1998; Schöning 2001). The only materials required for the system are concrete or wood for the main slab above the pit, and locally available materials for the hut. The main maintenance requirement is
associated with the problem of odour and fly breeding (DNAS 2005a). To reduce these problems the latrine must be kept covered when not in use and the addition of some water for cleaning can promote the slow digestion of excreta (Anon. 1990). Another issue relates to pit latrines used by multiple families, where cleaning and maintenance responsibilities can be neglected due to confusions relating to ownership. As a result shared latrines often become soiled (IRC 1997). This creates an ideal fly breeding environment and generates offensive odours (IRC 1997).

After a given length of time, depending on the frequency of use and dimensions, the pit will fill. At this stage there are various alternatives which can deal with the remaining pit. The pit is required to be filled with soil so the faecal waste is completely covered. It must then be left undisturbed for at least two years, to ensure harmful pathogens are destroyed (MSF-USA 2005). The fertile area can be used to grow a tree but should not be used to grow root or salad vegetables as these can uptake pathogens which may be transferred to humans via consumption. This can be a disadvantage to communities with limited space, and thus a second option for treatment of the pit is to excavate the material. This can result in further complications as it increases the risk of disease through direct contact with pathogens due to handling requirements. Therefore, for this practice to be successful the user must be well educated about the risks, and best practice for handling the waste. These options are described in greater detail in Section 4.3.7. The primary disadvantages and advantages of the ordinary pit latrine are summarised in Table 15. The disadvantages relating to contamination of groundwater are examined in more detail in Section 4.3.3.

<table>
<thead>
<tr>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Simple and inexpensive.</td>
<td>Extreme odour and fly breeding problems</td>
</tr>
<tr>
<td>Easily constructed, utilises local materials and unskilled labour</td>
<td>Below ground level design; increases risk of ground water contamination.</td>
</tr>
<tr>
<td>Familiar to the community, thus likely to be better maintained, and requires less education about operation and maintenance.</td>
<td>Dimensions of pit depend on water table depth; a high water table, restricts to shallow pit with a short lifespan, because of the reduced capacity</td>
</tr>
<tr>
<td>Achieves primary objective; to reduce chance of disease by minimising pathogen transfer.</td>
<td>Once full, pit must be left undisturbed for at least 2 years, disadvantaging communities with limited available space</td>
</tr>
</tbody>
</table>

4.3.3 Ventilated Improved Pit Latrine

The VIP Latrine is a modified ordinary pit latrine, which was invented in 1973 at the British Ministry of Health’s Blair Research Laboratory (Robinson 2002). The main feature of the VIP latrine is the narrow, vertical ventilation pipe of approximately 150 mm diameter extending from the pit adjacent to the latrine.
superstructure (DNAS 2005a; Robinson 2002). The pit is constructed and utilised in the same way as a
conventional pit latrine, and once full must be covered with soil and a new pit used. The main variation is
that the covering slab has two holes (Anon. 1990), the latrine hole (to one side) and ventilation pipe hole
to the opposite side, as can be seen in Figure 16. As previously discussed in Section 4.3.2, the main
disadvantage of the ordinary pit latrine are related to the odour and fly breeding problems. The
modifications of the VIP design help to eliminate these problems.

As can be seen in Figure 16, the VIP latrine eliminates odours by promoting air circulation which is
induced by heating of the ventilation pipe by the sun. As the air in the ventilation pipe is warmed it
becomes less dense, and thus rises towards the top of the pipe and wind blows across the top of the pipe
drawing air from the latrine (DNAS 2005a). Due to this displacement the cooler, odorous air moves into
the space created by the movement of the warm air. This air is then also warmed, and similarly becomes
less dense and rises out of the ventilation pipe. Through this action of warming and displacement an air
circulation system is set up as is displayed in Figure 16. This cycle removes the odorous gases from the
system. The main requirements in order to set up this circulation are that the pipe be coloured black to
optimise heat absorption, and that the system be oriented so the pipe faces north, to further encourage solar heating.

As can be seen in Figure 17 the VIP design also eliminates the fly breeding problem associated with the ordinary pit latrine. Flies are generally drawn to latrine systems due to their characteristic odours. Given that these are reduced by the air circulation less flies are attracted in the first instance. In addition those which are drawn to the latrine due to odour will be attracted to the top vent, rather than the latrine hole, and they are prevented to enter due to the screen covering (Robinson 2002). If there are any flies present in the system, these will be drawn to the light at the top of the ventilation pipe. As shown in Figure 17 this opening should be fitted with a screen which will enable sufficient air flow, but prevent the flies from leaving. In order for this to be effective the latrine house should be designed so the latrine hole is kept semi-dark (Robinson 2002).

There are two most widely used designs for keeping the latrine hole in semi-darkness. These are the spring door and the spiral entrance (Anon. 1990). As is shown in Figure 18 the spiral entrance removes the problem of a door being accidentally left opened as the entrance to the latrine is curved which blocks entrance of any direct sunlight whilst still providing the privacy of a door. The spring hinged door also addresses this problem as the mechanism ensures the latrine door is always closed (Anon. 1990). The effectiveness of this fly control is demonstrated in the case study in Zimbabwe discussed by Robinson (2002). Comparing an unvented, ordinary pit latrine to a VIP design over a three month period an average of 2 flies per day were caught in the VIP latrine compared to 179 per day from the ordinary system.
Results

Minimum 0.5 m flies getting in

Screen on top of vent to prevent flies getting in

Smell

Wind

Odours

Shady interior to discourage flies

Air flow down into pit

Good fitting door kept closed

Floor area for washing raised edge around floor to contain waste water floor sloped in direction of drain

Waste water discharge

Base of Pit above ground water level

Air flows down into pit and up the vent pipe

Pit

Impermeable zone (concrete ring)

Permeable zone: Natural soil if Stable, Batak, Stone and mortar etc.

Air flow into toilet

Waste water discharge

Figure 17 VIP Latrine showing air circulation and fly trap (DNAS 2005a)
In addition to the primary advantage of reducing odours and fly breeding problems, the VIP design also has the advantage of being familiar to the community of Tangkae. Given that the main structural, and maintenance characteristics are similar to the pit latrines currently in the village, the system is likely to be better maintained. In addition the system achieves the primary aim of implementing a sanitation system in Tangkae, which is to reduce chance of disease by minimising pathogen transfer.

Table 16 compares these advantages with the main disadvantages of the VIP latrine design. As can be seen the most significant disadvantage of this system relates to the fact that it must be below ground level. This causes two main problems due to the interaction with the groundwater table. Firstly a below ground system increases the risk of groundwater contamination as there is potential for pathogens to leach into the saturated zone from the pit. Also, the dimensions of the pit are restricted by the water table conditions, as a high water table will require a shallow pit which decreases the lifespan of the system by reducing the capacity.

<table>
<thead>
<tr>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Encourages air circulation to reduce odour and fly breeding problems</td>
<td>Below ground level design; increases risk of groundwater contamination</td>
</tr>
<tr>
<td>Does not require water to operate</td>
<td>Dimensions of pit depend on water table depth; a high water table restricts the design to a shallow pit with a short lifespan because of the reduced capacity.</td>
</tr>
<tr>
<td>Achieves primary objective; to reduce the chance of disease by minimising pathogen transfer.</td>
<td>Once full the pit must be left undisturbed for at least two years, disadvantaging communities with limited space.</td>
</tr>
<tr>
<td>Easily constructed, utilises local materials and unskilled labour</td>
<td>Requires separate washing facility and wastewater management</td>
</tr>
</tbody>
</table>
4.3.4 Bucket Latrine

The advantages and disadvantages of the bucket latrine are summarised in Table 17. This system is also termed a dry toilet, because the system requires no water to flush wastes and consists of a simple collection system such as a bucket, shallow pit or chamber (IRC 1997; NWP et al. 2006). This container is generally placed either on the floor indoors, or in a small vault under the base of a latrine superstructure (IRC 1997). The vessel must be periodically emptied with proper handling techniques to minimise contact with faecal waste. Often these collection systems are associated with health hazards and viewed as physically, socially and culturally unacceptable (IRC 1997). As a result, successful implementation of such systems requires a significant level of community involvement in developing the most appropriate mechanism of collection and disposal.

<table>
<thead>
<tr>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easily constructed, utilises minimal materials</td>
<td>Requires secondary space for storage and treatment of excreta</td>
</tr>
<tr>
<td>Inexpensive</td>
<td>Must be emptied frequently</td>
</tr>
<tr>
<td>Achieves primary objective; to reduce the chance of disease by minimising pathogen transfer.</td>
<td>Not suitable for communities where anal washing is the common practice</td>
</tr>
<tr>
<td>Does not require water for flushing, thus suitable for water scarce environments</td>
<td></td>
</tr>
<tr>
<td>Ideal for areas characteristic of solid soils or flood prone which are not suited to pit latrine options</td>
<td></td>
</tr>
<tr>
<td>Can be used indoors, utilises minimal space</td>
<td></td>
</tr>
</tbody>
</table>

The largest benefit of these systems is experienced in environments of water scarcity, flood prone regions or areas characteristic of solid soils (NWP et al. 2006). In flood prone regions pit systems are unsuitable as they will be damaged once filled with water and can cause health problems through the dispersal of pathogens. Also areas with solid soil conditions may require bucket latrine systems due to the difficulty in excavating to construct pits. Another advantage of this option is that it may be used indoors. Also as is discussed in more detail in Section 4.3.5 these systems can be used in conjunction with above ground composting to promote ecological sanitation.

The main requirement of bucket latrines are that they be emptied frequently especially when located inside (NWP et al. 2006). There must also be sufficient space available for storage, treatment and use of the excreta when implementing these systems. As previously discussed in Section 2.5.3, dry systems are preferable used when anal wiping (using paper, leaves etc) for cleaning is the usual practice (NWP et al. 2006). This is also the case for the bucket latrine however there is also the alternative option of combining
a dry system with special anal washing facility, where washing water is collected separately (NWP et al. 2006). The costs for the concrete squatting plate have been estimated to be US$ 9-11 (NWP et al. 2006).

4.3.5 Composting Latrines

As described in Section 2.5.4 composting latrines utilise micro-organisms in aerobic conditions to decompose the faecal waste. The most significant benefit of these systems is related to the fact that a useful and safe product can be generated which promotes ecological sanitation. If properly operated these systems produce humus which can be applied in agriculture practices with minimal risks of pathogen transfer. The following section outlines variations in latrine designs which apply the principal of ecological sanitation, describing their function and highlighting the advantages and disadvantages of each.

Windrow System

Figure 19 displays the windrow composting system which is considered the least expensive and most commonly used method (Guardabassi et al. 2003). For this system the substrate is stacked in rows (windrows) and the composting system is aerated by turning the system as is pictured in Figure 19. Often temperature is used as an indicator for when turning should occur, usually when 55-60°C is reached (Guardabassi et al. 2003).

![Windrow System](image)

This design can be altered to suit a developing community situation. With the substrate placed into a horizontal cylindrical vessel, such as a drum, which can then easily be rolled to provide aeration. For ease of access a section of the drum should be cut, and hinges placed along one side with fasteners to the opposite side. Handles should also be attached to enable opening and closing. Such a system is easy to implement and cost effective with the only materials being the drum, hinges and catches. The key advantage of this system is that the aerobic conditions required for optimal decomposition and disinfection are easily achieved. Air exchange is maintained with rotation of the system, and the periodic opening when additional waste is added. The use of a plastic or metal drum also ensures the system is sealed, which reduces the risk of groundwater or water supply contamination. The latrine superstructure can use
the same principal as the bucket latrine (described in Section 4.3.4) and to further reduce the chance of leaching contamination a waterless urinal (described further in Section 4.3.6) can be implemented concurrently.

Table 18 Advantages and Disadvantages of Windrow Composting System

<table>
<thead>
<tr>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Simple to construct and easy to maintain and operate</td>
<td>• Requires user education to ensure regular rotation is carried out</td>
</tr>
<tr>
<td>• Waste fully enclosed, thus reduces risk of environmental pathogen contamination</td>
<td>• Requires manual transfer of faecal waste from latrine to composting system, which increases risk of pathogen transfer through direct contact and handling</td>
</tr>
<tr>
<td>• Ensures required aerobic conditions are maintained</td>
<td></td>
</tr>
<tr>
<td>• Achieves primary objective; to reduce chance of disease by minimising pathogen transfer.</td>
<td></td>
</tr>
<tr>
<td>• Inexpensive</td>
<td></td>
</tr>
</tbody>
</table>

Composting Toilet Systems Inc. (CTS)

Displayed in Figure 20 is a diagram of the CTS composting toilet. This is not designed specifically for use in developing countries, as the materials used such as fibreglass are not prevalent in such communities. However, the important principles of anaerobic decomposition are demonstrated, as are some specific design conditions which are applicable to all situations.

![Figure 20 CTS composting latrine diagram (CTS 2003)](image)

In this model the digester tank has a sloping floor which the waste will accumulate upon. The purpose of this angle is to promote movement of the digesting waste slowly downwards. Over time up to 90% of the waste volume will be eliminated by evaporation and the decomposition process (CTS 2003). An oxygen rich environment is provided through the air channels ventilating the digester tank. These aerobic
conditions encourage the micro-organisms to thoroughly digest and decompose the accumulating organic materials.

As explained previously the decomposition process generates heat, and this works favourably to reduce odours. As the heat rises it carries moist air and carbon dioxide up and out the vent stack (CTS 2003). This natural ventilation, driven by the circulation of hot air draws odorous gases upwards, leaving the latrine room relatively odourless (CTS 2003). This design is also simple from a construction and maintenance perspective, because the only moving parts are the ventilation fan and the toilet seat cover (CTS 2003). For the situation of Tangkae the logistics of implementing a latrine with a power-driven ventilation fan may be difficult. The final product from this latrine system is fertile, organic humus which can be used as garden soil and is easily removed through the access door.

Table 19 Advantages and Disadvantages of CTS system

<table>
<thead>
<tr>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Does not require water for flushing</td>
<td>• High cost for materials</td>
</tr>
<tr>
<td>• Generates natural air circulation which reduces odour problems</td>
<td>• Below ground level design; increases risk of groundwater contamination.</td>
</tr>
<tr>
<td>• Sloped pit reduces waste pile and enhances decomposition</td>
<td></td>
</tr>
<tr>
<td>• Design reduces the need for handling of fresh excreta</td>
<td></td>
</tr>
<tr>
<td>• Achieves primary objective; to reduce chance of disease by minimising pathogen transfer.</td>
<td></td>
</tr>
</tbody>
</table>
Thermophilic Aerobic Above Ground Composting Latrine

The above-ground thermophilic aerobic composting latrine was designed specifically for a community in Honduras and the effectiveness of this design is examined by Robertston and Sieber (1996). This system demonstrates the application of the composting process with an above ground collection and treatment system. The system uses the bucket latrine (Section 4.3.4) principal for collection of excreta which is then periodically emptied into above-ground vaults. Table 20 summarises the functions and collection mechanism of the system.

<table>
<thead>
<tr>
<th>Collection Mechanism</th>
<th>THERMOPHILIC AEROBIC COMPOSTING LATRINE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>▪ Excrement is collected in a 5 gallon bucket which is located in the house.</td>
</tr>
<tr>
<td></td>
<td>▪ Bucket generally used for up to 7 days for a family of 6-8 people.</td>
</tr>
<tr>
<td></td>
<td>▪ After use the fresh excreta is covered with dry rice chaff, which eliminates odours and flies.</td>
</tr>
<tr>
<td>Compost System</td>
<td>▪ When the bucket is full it is emptied into an above ground, double vaulted composting bin made of wood with a thatched roof, the roof is necessary due to the extreme rainfall and sun events.</td>
</tr>
<tr>
<td></td>
<td>▪ Each vault is 5x5x5 ft, for 6-8 pple should fill after a period of 6 months.</td>
</tr>
<tr>
<td></td>
<td>▪ Only one vault is used at a time, when one is filled the other is used and the first one is left to decompose for at least 6 months. When the second one is filled, the first one is emptied of the aged compost which can be used as a soil conditioner and the process starts again.</td>
</tr>
<tr>
<td>Bulking Agent</td>
<td>▪ After emptying the bucket into the compost bin the fresh deposit is covered by dry leaves grass or hay, or food scraps.</td>
</tr>
<tr>
<td>Aeration</td>
<td>▪ The pile is not turned or actively aerated, but remains anaerobic due to the air trapped in the large bulky materials used to cover the waste. Also as the pile is augmented, i.e. not all one batch, the fresher, more degradable material remains on the top and is exposed to air until it has sufficiently stabilised.</td>
</tr>
<tr>
<td>Cost</td>
<td>▪ Cost ~ US$20 including construction materials for compost bin, wood posts and thatching material. Also the plastic bucket and wooden seat for the indoor component. All these materials are locally available.</td>
</tr>
</tbody>
</table>

It was found that the system implemented in Honduras remained mostly at about 47°C with temperatures up to 55°C recorded deeper into the compost (Robertston & Sieber 1996). Although the temperatures recorded at the core of the pile support the requirements for pathogen removal, requirements must be meet for the entire system. Even so, given it is a double vaulted system, a six month residence time is able to be provided and thus this was found to successfully destroy the faecal pathogens (Robertston & Sieber 1996). The system implemented by Robertston and Sieber (1996) was not insulated as the warm climatic conditions were considered sufficient to maintain high temperatures. Given that temperatures only just reached optimum for pathogen reduction in the core of the pile it can be concluded that insulation should have been used. As previously discussed, Vinneras et al. (2003) concluded that insulation is required, even
in naturally high climatic temperatures, for the compost to achieve homogeneous temperatures and adequate disinfection to occur.

As displayed in Table 21, the primary advantage of this system is related to the storage and treatment of wastes above ground level. This has important environmental benefits as it greatly reduces the risk of leaching into the groundwater system, thus preventing contamination from pathogens and high nutrients. This is also an important advantage where soil conditions are difficult to excavate such as rocky, or permafrost regions. In addition it is an advantage to contain the faecal wastes above ground in areas which are prone to flooding or have frequent high intensity rainfall events. This is due to increased risk of pathogen contamination if wastes become diluted as they spread over a larger area. The composting process is also inhibited when the moisture of the substrate is high. In addition, as discussed in Section (X composting lit review) the increased requirement for handling of faecal wastes introduced by composting is a significant disadvantage of eco-sanitation systems. As displayed in Table 21 the disadvantages of the thermophilic aerobic latrine are linked to this health issue. The users of this system require a high level of education and training about the composting process and operation in order to reduce the risk of pathogen transfer associated with improper use.

<table>
<thead>
<tr>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Above ground storage and treatment of faecal wastes, thus:</td>
<td>- Requires manual transfer of faecal waste from latrine to composting system, which increases risk of pathogen transfer through direct contact and handling</td>
</tr>
<tr>
<td>- Reduces chance of groundwater contamination</td>
<td></td>
</tr>
<tr>
<td>- Valuable in rocky or permafrost soil conditions</td>
<td></td>
</tr>
<tr>
<td>- Can be implemented in regions where flooding occurs</td>
<td></td>
</tr>
<tr>
<td>- Generates sufficient temperatures to disinfect waste, thus provides safe agricultural product</td>
<td>- Requires good understanding of composting process by user, thus significant educational requirement</td>
</tr>
<tr>
<td>- Improves agricultural productivity through production of nutrient rich organic humus</td>
<td>- Requires monitoring to ensure parameters of temperature, moisture content and carbon-nitrogen ration are balanced</td>
</tr>
<tr>
<td>- Simple and inexpensive.</td>
<td></td>
</tr>
<tr>
<td>- Easily constructed, utilises local materials and unskilled labour</td>
<td></td>
</tr>
<tr>
<td>- Achieves primary objective; to reduce chance of disease by minimising pathogen transfer.</td>
<td></td>
</tr>
</tbody>
</table>

### 4.3.6 Dry Urine Diversion Latrine and Waterless Urinal

As the name suggests, dry urine diversion latrines are systems which separate solid wastes from urine with two compartments. The urine is diverted through an angled pipe and both men and women are required to sit while urinating so as to ensure the urine is diverted into the correct channel (NWP et al. 2006). The faecal waste is stored directly beneath the latrine hole and after use dry soil, ash or leaves should be spread
to cover waste to reduce odour problems, prevent fly breeding and absorb moisture (NWP et al. 2006; World Bank 2005). The main principal of the urine diversion latrine is to separate solid from liquid waste and separate the primary source of pathogens (faeces) from the nutrient rich urine. In domestic wastewater urine contains approximately 80% of the nitrogen, 55% of the phosphorous and 60% of the potassium (Schönning 2001). As a result urine can be considered a concentrated fertiliser which is useful in improving the productivity of plant growth (Schönning 2001).

There are also several other key benefits associated with separation of wastes, including the reduced volumes remaining in the collection system which increases the lifetime of a system, as well as a reduction in odour which provides benefits for handling and use of the system (Schönning & Stenström 2004). In addition a drier faecal waste pile will reduce the risk of nutrient leaching and pathogen transfer into the groundwater and surrounding environment because less fluids are available for transport (Schönning & Stenström 2004). This drier faecal waste is also beneficial for pathogen reduction and makes the final substrate easier and safer for handling (Schönning & Stenström 2004).

Other key advantages of this option relates to the nutrient recovery potential. The faecal waste can be transferred to above ground vaults, of similar principal to the above ground composting system implemented in Honduras, discussed in Section 4.3.5. The waste in the vault is then processed and the resultant decomposed material can be utilised as a soil conditioner. Again a double vault system is optimal, to avoid handling fresh material so whilst one vault is filling up excreta in the other vault is processed (NWP et al. 2006). These systems are beneficial for implementation in regions which have hard subsurface soils, or high ground water levels. An important design requirement for the above ground vaults is that they be placed on water tight, impermeable material so as to avoid leaching into the subsurface zone (NWP et al. 2006). Also as discussed in Section 2.5.4 the composting process is optimal when the substrate contains faecal and vegetable matter, without urine. Thus this urine diversion design provides a method of applying these results providing an optimal composting process.

The estimated costs of this system are also a significant disadvantage in implementation within a developing community of low income. The costs of the double vault free standing system have been estimated to be US$160 (Mexico 1998), whilst a within-home double vault system is approximately US$35 (China 2002) (NWP et al. 2006). In addition the costs of the urine diverting pedestal were estimated as US$40 (based on 20 units) using fibre glass and US$14 (based on 400 units) for a ceramic design (NWP et al. 2006). This economic disadvantage may be considered a constraint towards adoption of the system, conversely as summarised in Table 22 there are many benefits with the most important being the potential for nutrient recovery and the application for agriculture.
Table 22 Advantages and disadvantages of the Dry Urine Diversion Latrine

<table>
<thead>
<tr>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ Large scale nutrient recovery possible, therefore suitable for rural areas where urine and faeces can be used for agriculture</td>
<td>▪ Operation requires clear instructions and close attention, may be difficult for small children</td>
</tr>
<tr>
<td>▪ Can be used indoors</td>
<td>▪ Regular removal of collected urine and faeces is required</td>
</tr>
<tr>
<td>▪ Does not require water for flushing</td>
<td>▪ High cost for materials</td>
</tr>
<tr>
<td>▪ Design reduces the need for handling of fresh excreta</td>
<td></td>
</tr>
<tr>
<td>▪ Reduces waste volumes therefore increasing lifespan of system</td>
<td></td>
</tr>
<tr>
<td>▪ Produces dryer faecal waste, which reduces the risk of leaching and increases ease of handling</td>
<td></td>
</tr>
</tbody>
</table>

Waterless Urinal

The waterless urinal is an option which can be implemented in combination with a urine diversion latrine, and allows men to urinate whilst standing up thereby avoiding any cultural constraints (NWP et al. 2006). This is a hygienic and low cost option for collecting urine, which also helps to reduce water use. The systems are generally wall mounted if prefabricated, however a cheaper design consists of a liquid container, such as a jerry can, fitted with a funnel and sealing valve to reduce odour, as displayed in Figure 21. The seal can be constructed using an expired light bulb or similar shaped object which fits into the funnel and floats to allow urine to travel into the container and seals the opening when the liquid has drained (World Bank 2005). This design was created in Ethiopia and is termed the ‘Eco-Lily’ (NWP et al. 2006; World Bank 2005).

![Figure 21 Diagram of 'Eco-Lily' waterless urinal with light bulb seal](image-url)
4.3.7 Arborloo Latrine

An Arborloo latrine is a variation of the ordinary pit latrine described in Section 4.3.2 and consists of a shallow, unlined pit of about 1-1.5m depth with a portable latrine superstructure, covering slab and squatting pan (NWP et al. 2006; Smet & Sugden 2006; Morgan 2000). The excreta is deposited into the pit and after use covered with soil, ash or leaves. When the pit is almost full it is topped up with soil and as can be seen in Figure 22 a tree is planted which utilises the waste nutrients. The toilet and superstructure are then transferred to a second pit.

![Schematic Arborloo latrine system](image)

Figure 22 Schematic Arborloo latrine system (adapted from (Smet & Sugden 2006))

As can be seen in Table 23 the primary advantage of the Arborloo system is that it is low cost alternative (estimated at US$5-15 in Zimbabwe (NWP et al. 2006)), which is easy to construct and requires no handling of fresh excreta. Conversely, the system can only be used where there is large amounts of available space, space can be used most effectively if the tree variety provides agricultural benefits. If there are significant spatial restrictions this can be overcome by excavating the pit after at least 12 months when the wastes have sufficiently decomposed to reduce the concentration of harmful pathogens.

<table>
<thead>
<tr>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ Simple and inexpensive.</td>
<td>▪ Requires large amounts of available space</td>
</tr>
<tr>
<td>▪ Easily constructed, utilises local materials and unskilled labour</td>
<td>▪ Below ground level design; increases risk of</td>
</tr>
<tr>
<td></td>
<td>▪ Design must be altered for communities where</td>
</tr>
<tr>
<td></td>
<td>▪ Cannot be implemented in regions where</td>
</tr>
<tr>
<td></td>
<td>▪ Anal washing is common practice</td>
</tr>
<tr>
<td>▪ Requires no handling of fresh excreta</td>
<td>▪ Cannot be implemented in regions where</td>
</tr>
<tr>
<td></td>
<td>▪ flooding is common</td>
</tr>
<tr>
<td>▪ Requires only shallow pit, thus reduces chance of groundwater contamination and helpful in rocky soil conditions</td>
<td></td>
</tr>
<tr>
<td>▪ Improves agricultural productivity and provides opportunity for growing trees for fuel wood</td>
<td></td>
</tr>
<tr>
<td>▪ Achieves primary objective; to reduce chance of disease by minimising pathogen transfer.</td>
<td></td>
</tr>
</tbody>
</table>
Importantly, this system cannot be used where flooding is common and minimal water should be used for cleaning because high moisture content inhibits the decomposition process (NWP et al. 2006). To ensure that the moisture content of the pits is optimal a raised ring beam can be built around the head of the pit. This provides stability to the edge of the pit, and raises the latrine above ground level which helps direct rainfall away from the pit (Morgan 2000). The ring can be removed and reused once the pit is full. It is also important that the superstructure is roofed to seal the pit from rain inflow. In addition if anal cleaning is preferred above wiping the resultant wastewater should be collected separately using a well designed drainage system or provision of a special washing area (NWP et al. 2006). In addition it is critical that soil and if possible wood ash are added regularly to the pit as this accelerates the decomposition process. The ash helps raise the pH and reduce odours. The optimal ratio of soil to ash is 4:1 (Morgan 2000).

4.3.8 Fossa Alterna Latrine

This alternative is very similar to the Arborloo latrine except this system overcomes the problems associated with spatial restrictions. The system consists of two, shallow permanent pits, of 0.5-1.5m depth, and a portable superstructure. When one pit is full it is covered with soil and the superstructure moved to the adjacent pit. After a period of at least 12 months, the contents of the original pit can be safely removed, and the superstructure is returned to the first pit (NWP et al. 2006; World Bank 2005). As with the Arborloo the system works best when soil, wood ash and leaves are added periodically to enhance the composting process (NWP et al. 2006; World Bank 2005; Morgan 1999).

To ensure the permanency of the pits they should be at least partially lined with bricks to form an upper lining and ring beam (as described in Section 4.3.7) to prevent collapsing. The two pits can be spaced only 0.3 metres apart and thus the pit linings and ring beam can be built as one component (Morgan 1999). The brick lining should be of a depth, at least 0.5m and only one slab with squatting pan is required for the superstructure to be mounted on (Morgan 1999). The unused pit should be covered for safety purposes with an additional concrete slab.

Figure 23 Fossa Alterna latrine cycle (Morgan 1999)
The primary limitation of this system is that there is not full recovery of nutrients, and a relatively large amount of space is required. In addition, the crucial educational requirement for this option relates to the addition of soil or organic matter after defecation to ensure operation is successful and sufficient decomposition occurs (NWP et al. 2006). Similarly to the Arborloo, this system cannot be implemented in flood prone regions as decomposition of waste will be inhibited if there is high moisture content. Therefore, regions of solid or highly impermeable soils are unsuited to this option as this will prevent drainage, and wastewater used for anal cleaning should not enter the pits (NWP et al. 2006). In addition, the design cannot be implemented in regions of high water table with permeable soil which can collapse and infill the pit. The cost of construction has been estimated to be US$20-30 (for Mozambique) which is relatively low in comparison with other alternatives (NWP et al. 2006).
Chapter 5: Discussion

This section analyses the results and issues raised through conducting this project. From this discussion, perspective can be drawn as to the importance of these results and conclusions can then be made about the future phases of the project. This discussion focuses on four areas, being the project working environment and its impacts on the outcomes, the implications of the community survey results, evaluating the appropriate technologies as well as the issues surrounding applying the sanitation options.

5.1 The Working Environment

The nature of the international development sector’s working environment can often be unstable and constrained by factors such as limited facilities, infrastructure, policy support and information. In contrast to these challenges it is a very rewarding environment to work in, in that the project outcomes can positively and directly impact the lives of communities by increasing their standard of living. This section discusses the project constraints as well as the importance of the integrated inter-disciplinary project structure.

5.1.1 Project Constraints

There are many constraints related to the working environment of this project. Some of these constraints are unique to the specific project, whilst others are common issues associated with working in a developing nation. Most of these constraints relate to the restriction of information caused by issues such as distance to project study site, communication and language barriers, the national instability and available time. Although restricting, by recognising their existence, these limitations can often be overcome with careful planning. This is discussed further in this section.

Availability and Accessibility of Information

As is discussed in Section 2.3.3 the newness of Timor-Leste as a nation and the political history has meant that there are limited data sets and information available. There is also a limit to the capacity to acquire and develop such data sets due to the technical and resource constraints. For Tangkae it was found that there is little information on environmental parameters such as groundwater characteristics, local geology and meteorological information. This restricts the decision making capacity for the project design stage and decisions such as which is the most environmentally appropriate technology can only be made using broad assumptions based on research and the limited information available.
As the project is an investigative study of a village in Timor-Leste but the majority of research is conducted in Australia there are major limitations relating to the distance from the project site. These limitations are associated with the difficulties in collecting physical and social information specific to the community whilst in Australia. As a result of this the time in-country is extremely precious and must be well planned and managed. This problem can be managed through the assistance of the in-country project team, namely the UNTL students, HTO staff and Natalie Young (EWB-AUS member and Timor-Leste resident).

**The Recent National Instability**

Timor-Leste’s current unstable national climate has restricted the project in a number of ways. In particular the changes in security resulted in the deferral of the second in-country field trip, which reduced the ability of the project team to obtain further information about the community of Tangkae. The situation also resulted in the cancellation of the planned surveys of the Tangkae water sources and other research to be undertaken by the UNTL students throughout the year. A major consequence of limited access to information is that the assumptions made about the community are based on information received prior to the recent instabilities and thus may be inaccurate. Since February 2006 there may be significant changes which affect the project aims and outcomes which are currently unknown.

The new political climate has also impeded communication between project members. In particular the UNTL students have not been able to continue their studies and as a result have very limited access to email facilities. This in turn has reduced the ability of the project to achieve its capacity building outcomes as ongoing communication is a key tool to this objective. Management of these communication problems occurred through the use of other forms of communication (i.e. other than email) and through indirect means such as contacting the UNTL administrative persons, or through word-of-mouth via Natalie Young. However, still several of the students have not yet been able to be contacted. Given the current climate communication between stakeholders is even more vital, to demonstrate the support from the Australian project team members, and in order to maintain motivation within stakeholders for the project to continue. This is expressed further in Appendix A7 in the trip defence and trip plan.

**Communication and Language Barrier**

Another major constraint on the project progress is communication difficulties experienced due to cultural and language differences within the project team and stakeholders. This barrier was managed on the first in-country placement through the help of Domingos de Oliveira who interpreted and translated throughout the trip. In addition the most effective way to reduce communication difficulties was by detailed activities and meeting planning which increased the efficiency of all activities while in country. This was achieved through daily meetings and planning with the Australian project team so that any discrepancies or
confusion were dealt with prior to conducting planned activities and meetings. Also as discussed in Section 3.1.6 ongoing Tetun language lessons helped to bridge the language gap.

**Institutional and Policy Boundaries**

The project's primary aim, to empower the community to initiate improvements in their lifestyle promotes the need to explore a broad range of educational and capacity building techniques and processes as possible options for this community. Constraints exist to the extent that such options can be explored as the stakeholders such as DNAS and HTO are bound to using previously developed capacity building frameworks, such as the Community Action Plan. Although this is not necessarily a negative constraint it is important that it is acknowledged, as such policy constraints have a strong influence on the direction of the project’s final outcomes.

**Time and Technical Constraints**

Time is another major constraint on this project given the limited time in-country which confines the amount of data collection and the extent that research can be undertaken. Management of this issue is similar to that relating to the distance from the project in that communication and use of the in-country team provides access to further in-country information. Also related to this constraint are the technical difficulties due to the remoteness of the project. Poor internet and printing facilities within Timor-Leste provide limited email communication and are extremely time consuming. Other technical constraints such as poor infrastructure including community access roads restricts the ease in which research can be undertaken. However these are factors which once acknowledged can be overcome with careful planning considerations.

In addition, time was also found to be a significant cultural constraint due to the East Timorese tendency to not attend appointments at the agreed time, or for tasks to commonly be completed at a much slower pace than typical in a developing nation. This is termed ‘Timor Time’ and must be accepted as a condition of the project working environment. This phenomenon which is common to most developing nations can be attributed to resource constraints as well as inexperience and the general nature of Timorese bureaucracy. The difficulties faced with this constraint can be managed through providing clear instructions when making such arrangements and also by being prepared to carry out other activities while waiting for such appointments to commence. This is also recognised as a significant constraint to the project at the implementation stage and must be taken into account when planning this phase.

**Financial Constraints**

The funds available for this project were largely reliant on the generosity of EWB-AUS’s donors, as well as funds being sort from the UWA Vice Chancellery and the UWA Faculty of Engineering, Computing
and Mathematics. As a result the extent to which detailed investigations such as groundwater monitoring or latrine trials could occur was restricted by funding availability. Given that extensive investigations of this nature were not undertaken the final cost of the project is mainly related to the trip to Timor-Leste and the associated living expenditures and resource costs such as communication and in country travel.

5.1.2 Interdisciplinary Programs

In the water and sanitation sector, there are significant connections and dependencies between water supply, quality and management, waste management and sanitation, environmental health and agricultural productivity. Given that the problems facing this sector such as lack of sanitation, water resources and environmental pollution are multifaceted it is appropriate that the solutions and management are of the same nature. This project, in collaboration with Vaughn Grey and Heidi Michael presents a holistic and interdisciplinary working environment, to produce options for the community water supply and sanitation situation for Tangkae. It can be seen that a holistic, integrated approach to water and sanitation projects such as this is inherently important for its successful outcomes. The success in reaching the MDGs also depends on the ability to work cooperatively within and across sectors (Fewtrell & Colford 2004) as does the success towards producing long-term sustainable outcomes.

Highlighting the significance of the interdisciplinary concept is Figure 24 which shows the path of disease transmission common in a developing community. Given that the ultimate goal of this project is to improve the health and livelihood of the Tangkae community, the barriers displayed in Figure 24 to prevent disease transmission must also be the ultimate aim. It can be seen that these barriers cross disciplinary fields, including the implementation of hygiene for food handling and personal situations, as well as latrines and water disinfection. The broad nature of these barriers demonstrates the significance of a holistic approach to water and sanitation which is vital to achieve sustainable and optimal outcomes.
5.2 Implications of Tangkae Community Surveys

Although not entirely comprehensive the results from the community surveys have allowed assumptions relating to the sanitation and hygiene situation in Tangkae to be made, and as a result have enabled a detailed assessment of options to be undertaken. The results of the survey show that there is a definite lack of appropriate sanitation facilities to support the population of the community, as well as inadequate water resources. Therefore it is very important that this project provides improvements to the situation. From the discussions with the community it can also be concluded that there is already a demand for a water supply project. However it was not articulated whether there exists demand for implementation of sanitation facilities in conjunction with water supply and thus it is likely that this demand may have to be generated through community consultation and education.

Within the information obtained through the surveys, a number of assumptions can be made which have implications towards determining the most appropriate sanitation technology for the community. From the agriculture practices discussed it is an encouraging result that manure from livestock is already understood by the community to provide increased crop productivity and is applied as a fertiliser. This is positive as it suggests that the benefits of composting latrines are likely to be better understood than if this was a new concept. Therefore it can be concluded that implementation of eco-sanitation options may be potentially acceptable to the community.

The results of the survey in relation to the current sanitation practices did not conclusively determine whether anal washing or wiping was the common practice. However given that the latrine investigated was found to be a pour-flush design this implies that the community is at least familiar with this option and thus will be more familiar with all below-ground, pit based options. As a result this factor influences
the likelihood for adoption of above ground options negatively, and pit options positively. Also from the results of the social survey it was found that water is currently already boiled before use, and that there is a relatively good understanding of illnesses caused by worms. This is a positive outcome as it can be assumed that given this prior understanding, hygiene education programs may be easier to implement as support and demand from the community may be greater.

In addition, given that Laratema water source is a spring, it is likely that it is connected directly to the groundwater system in the region. As a result the chance of the groundwater table being close to the surface is increased, and thus this may increase the probability of the most appropriate latrine option being above-ground rather than pit. On the contrary, as Fatnamudu stream was originally piped to the community it is likely that this could again be implemented as a water supply option. As a result contamination of water supply through below ground pit systems is less likely as the distance from the watering point will be great. In addition the probability of contamination of the water point from implementation of below ground latrines is reduced because bores or wells as a water source option for the community is considered less likely than pumping or piping from the springs (see Vaughn Grey’s report for further details).

### 5.3 Ranking and Evaluation of Appropriate Sanitation Technologies

In order for a sustainable solution to be implemented the most appropriate and practical infrastructure should be selected. As discussed in Section 2.5.2 there are many factors which influence the adoption of a particular latrine technology by a community, and the following section discusses some of these key factors and their consequences, utilising a ranking system to portray the latrine options in order of relative viability. The SHTEFIE criteria as explained in Section 3.2 is utilised and considers issues such as the long term feasibility of the option, economic considerations, social and health related impacts, the environmental effects as well as technical and institutional aspects of each technology. Each of the criteria was given a weighting based on the relative importance, with 5 the maximum value (and 0 minimum) as shown in Table 24.

Social, health and environmental factors were each given the maximum relative weighting as they are considered key factors towards achieving the primary aims of the project – to improve community health and lifestyle through implementation of sanitation and hygiene technologies whilst protecting the surrounding environment and thus producing sustainable outcomes. The technical, economic and financial factors were given the second highest weighting as these are key factors which influence the decision making process, however they were not considered as vital towards achieving the project objectives. Finally institutional factors which are important constraints to directing the project outcomes were not
considered as significant a factor in determining the appropriateness of technology and thus were given the lowest rating.

<table>
<thead>
<tr>
<th>SHTEFIE Criteria</th>
<th>Weighting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Factors</td>
<td>5.0</td>
</tr>
<tr>
<td>Health Factors</td>
<td>5.0</td>
</tr>
<tr>
<td>Technological Factors</td>
<td>4.0</td>
</tr>
<tr>
<td>Economic &amp; Financial Factors</td>
<td>4.0</td>
</tr>
<tr>
<td>Institutional Factors</td>
<td>3.0</td>
</tr>
<tr>
<td>Environmental Factors</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Each of the latrine options was then rated from 0-5 for each criteria and the product of this score and the weighting reflects the strengths and weakness of the technology. This is displayed in Table 25 with the relative totals reflecting the most appropriate technology.
Table 25 Weighting and ranking of latrine technologies applying the SHTEFIE criteria

<table>
<thead>
<tr>
<th>SHTEFIE Criteria</th>
<th>Pour-Flush</th>
<th>Ordinary Pit</th>
<th>VIP</th>
<th>Composting</th>
<th>Urine Diversion</th>
<th>Arborloo</th>
<th>Fossa Alterna</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Factors</td>
<td>4.5</td>
<td>22.5</td>
<td>3.5</td>
<td>17.5</td>
<td>4.0</td>
<td>20.0</td>
<td>4.5</td>
</tr>
<tr>
<td>Health Factors</td>
<td>5.0</td>
<td>25.0</td>
<td>3.5</td>
<td>17.5</td>
<td>5.0</td>
<td>25.0</td>
<td>4.5</td>
</tr>
<tr>
<td>Technological Factors</td>
<td>4.5</td>
<td>18.0</td>
<td>5.0</td>
<td>20.0</td>
<td>4.8</td>
<td>19.2</td>
<td>4.0</td>
</tr>
<tr>
<td>Economic &amp; Financial Factors</td>
<td>3.0</td>
<td>12.0</td>
<td>5.0</td>
<td>20.0</td>
<td>4.5</td>
<td>18.0</td>
<td>4.5</td>
</tr>
<tr>
<td>Institutional Factors</td>
<td>5.0</td>
<td>15.0</td>
<td>4.5</td>
<td>8.0</td>
<td>13.5</td>
<td>5.0</td>
<td>15.0</td>
</tr>
<tr>
<td>Environmental Factors</td>
<td>3.0</td>
<td>15.0</td>
<td>3.5</td>
<td>17.5</td>
<td>3.5</td>
<td>17.5</td>
<td>4.5</td>
</tr>
<tr>
<td>Total</td>
<td>107.5</td>
<td>106.0</td>
<td>114.7</td>
<td>113.5</td>
<td>113.5</td>
<td>110.25</td>
<td>111.0</td>
</tr>
</tbody>
</table>

1: Supported by DNAS guidelines and commonly implemented in Timor-Leste, thus positive institutional support.
2: High water demand
3: Below ground, risk of groundwater contamination
4: Fly breeding and odour problems
5: Assuming only properly treated faecal material handled
6: Policies relating to handling of faecal wastes and application to agriculture may be restricting
7: Minimal leaching, low volumes of liquid in substrate
8: Supported in DNAS guidelines but ranked lower than pour-flush and VIP
As can be seen from these totals the following ranking from most appropriate to least was found to be:

1. VIP Latrine;
2. Composting and Urine Diversion technologies;
3. Fossa Alterna;
4. Arborloo;
5. Pour-Flush pit Latrine; and
6. Ordinary Pit Latrine

In this evaluation the bucket latrine option was not included, as this option requires a secondary collection mechanism which would be based on the principals of either a pit latrine or composting system. Interestingly, experience with the VIP and pour-flush options in Timor-Leste indicates that given a choice people prefer the pour-flush over the VIP due to the associated higher status of the pour-flush (Dwan 2006). However, this analysis has resulted in a large and reverse difference in relative ranking between the two options.

### 5.3.1 Pour-Flush Latrine

As briefly noted in the footnotes, several key assumptions were made for the evaluation of each option. In particular the four reduced criteria for the Pour-Flush option were the technical, economic, social and environmental factors. The technical and economic scores are directly related to the specific technical materials required such as the u-shaped pipe which contributes to the high capital cost. However the technical score was only slightly reduced due to the longevity and thus positive contribution to long-term sustainability of the required high quality material. The environmental score was low for this option due to the demand for water and the resultant increased risk of leaching. The score is also reduced due to the below-ground nature of the system. In addition, the high water use for this option lowered the social score, as increased water demand increases the burden on women and children as the primary water collectors.

### 5.3.2 Ordinary pit and VIP latrines

The social value of the ordinary pit latrine was reduced as in general though acceptable to the community, it does not bring as high a social status as more complex technologies such as the Pour-Flush system or VIP. The main reduction in score for this option is associated with the odour and fly breeding problems which are encompassed in the health criteria as well as the environmental risks associated with below-ground technologies. This is similar for the VIP scores (without the odour and fly problems).
5.3.3 Composting and Urine Diversion

The main influence on the scores for the composting option is related to the educational effort required to implement eco-sanitation, which reduced the social and technical scores. In addition, institutional factors were rated low compared to other options as it was determined to be highly likely that policies regarding handling and application of faecal waste may restrict implementation and acceptability of the option. This assumption is subjective and if assumed wrong would increase the rank of this option making it appear much more feasible. This option is likely to increase in acceptability with time as increased use and thus familiarity with the concepts will reduce the level of educational effort required. Therefore it is likely to be a sustainable option in the future given that trends indicate a shift in values favouring eco-sanitation options within the international development sector.

The urine diversion option scores were similar to the composting option except for higher health and institutional values. This is because this option was considered a more efficient method of pathogen reduction due to the removal of urine from the composting substrate which reduces the health risks associated with eco-sanitation. The more conventional nature of the technology also increased the institutional score compared to composting. However this also reduced the economic and technical score due to the increased number of materials required and associated educational effort. The environmental score was also higher than that of composting as urine diversion reduces the chance of pathogen contamination through leaching.

5.3.4 Arborloo and Fossa Alterna

The Arborloo and Fossa Alterna are very similar systems, with the main difference being the permanent nature of the Fossa Alterna latrine. As a result both were ranked similarly for social, economic and environmental factors. However the Fossa Alterna scored higher for technical criteria as the capital costs and maintenance are only initial costs, whereas the Arborloo are required to be built periodically. Fossa Alterna had a lower score for health criteria as it requires the handling of decomposed excreta, which increases the risk of pathogen transfer. However, both were low scoring due to the odour and fly breeding problems.

This method of technology evaluation has helped to quantify the relative attributes of each sanitation option. The VIP option has shown to be the most viable, demonstrating the high value technical simplicity and economics plays in determining appropriate technology. The more complex eco-sanitation options (composting and urine diversion) have ranked second most viable also demonstrating the weight environmental sustainability has in influencing the appropriateness of technology. This method was
undertaken to reduce the subjectiveness of technology selection. However it is by no means the final decision making process as the most important factor in determining appropriate technology comes from community demand. This demand can not be determined without extensive community consultation. This should take place in the next phase of the project so that the community may make an informed decision about implementation.

5.4 **Implementation Phase and Applying Sanitation Technologies**

Although the sanitation technologies have been evaluated for their relative viability there are several additional details and issues associated with implementing some of the options. This section discusses these issues as well as addresses the general concerns relating to construction, operation and maintenance in the implementation phase of the project. The importance of managing wastewater and solid waste disposal in conjunction with the implementation of sanitation infrastructure is also examined. Finally, the methods for investigating groundwater characteristics are discussed as this environmental parameter is an important factor to be considered prior to implementation.

5.4.1 **Composting and Eco-sanitation**

A case study examined by Robertston and Sieber (1996) looks at the effectiveness of the implementation of composting latrines in a community in Honduras. This case study is highly applicable to this project given the similarities in the situation relating to the climatic conditions and the limited availability of funds and amenities (such as electricity). The Honduras community experiences an extreme wet season and distinct dry season with high temperatures almost all year round. This is very similar to the climatic conditions generally experienced in the village of Tangkae, with the main difference being that Tangkae experiences relatively low evening and night temperatures due to the high altitude of the community. This study is also a valuable illustration of how a situation can be managed where set criteria are put in place for the selection of latrine technology. Significantly, these criteria are comparable with conditions preferable for this project and are described as follows:

1. The latrine had to be made with local materials and cost less than US$20
2. The latrine had to be simple enough so the villagers could build and maintain it themselves.
3. Given that the area had an extremely high water table of less than 2 feet from the surface in the rain season, and that drinking water was supplied from hand pumped wells, there had to be a solution which did not endanger the ground water quality.
4. The latrine had to be free of odour, flies and pathogen transmission.
Criterion 1 is an vital element to this project, given that low cost is a significant priority in the selection process for the most appropriate technology. It provides optimal project efficiency if materials used can be easily sourced by the community. Criterion 2 is also a critical parameter for the outcome of this project. Given the core capacity building objectives, and the aim of the project to provide a sustainable long term solution to the community, it is vital that the solution is one which can be easily constructed and maintained by the community. This criterion is not a constraint on the project, but a necessity.

In addition, it is highly likely that Tangkae also has high water table conditions, given the characteristics of Laratema spring, which surfaces from mid-hill slope. Consequently, criterion 3 for the Honduras case study is a key consideration for this project, as it generates a latrine option which may be very significant for Tangkae if high groundwater conditions are discovered. Finally criterion 4 is also an imperative as an option which addresses the issues of odour, flies and pathogen transmission is one which will provide a holistic solution through addressing the health and hygiene considerations of the sanitation situation in the community.

Another critical detail in this case study is that the choice for the technology was made by the community leaders, and not the foreign engineers. In this case the decision was made to implement what is termed a thermophilic aerobic composting latrine. A description of the latrine system is presented in Section 4.3.5. The system implemented by Robertston and Sieber (1996) is most significant to this project because of the above-ground scenario it provides. Robertston and Sieber (1996) found that as the vault was situated above-ground and the roof was secure for no leaching during heavy rain the potential for ground water contamination was minimised. Unfortunately, the study does not note which season it was this conducted and whether groundwater quality tests were undertaken. However it does provide an ideal example of the successful implementation of a low cost, effective eco-sanitation option.

### 5.4.2 Siting of Arborloo

The siting of an Arborloo latrine must take into account several factors. As with all pit latrines the location must account for distance from water sources as discussed in Section 2.4.2. In addition the choice of site must consider the future location of trees. The spacing of latrines can depend on the type of tree planted as many trees such as mango and avocado require several metres of space for optimal growth (Morgan 2000). Papaya and banana plants are observed to grow well in these pits (NWP et al. 2006; Smet & Sugden 2006; Morgan 2000) and are more suitable for smaller plots as the require less space and have short life spans and soft wood which provides ease for removal after several years.
5.4.3 Management of Urine Diverting Systems

It is crucial that cross contamination of urine with faecal waste does not occur in urine diverting systems. Faecal waste has a much higher concentration of harmful pathogens than urine and thus if urine is accidentally cross-contaminated it must be handled with the same care as the faecal substrate. As a result, any wastewater from anal cleaning should be kept separate to ensure faeces are not diluted, and urine is not contaminated with faecal pathogens. This cross contamination has been identified as the most significant health risk with urine diversion systems, given that cross contamination may occur unknowingly and thus the user is at higher health risk (Schönning & Stenström 2004). In addition, as with other dry options the health risks related to handling of fresh excreta have to be taken into consideration.

5.4.4 VIP Latrine

Given the VIP latrine option was ranked highest in Section 5.3 there are a number of specific considerations which must be presented to the community to determine the final feasibility of implementing this option. These are summarised in Table 26 along with suggested methodology in addressing these considerations and this idea can also be transferred for evaluation of other options. The issue of sufficient sunlight to generate air circulation for the latrine design and some alternative options for latrine ventilation in the event that there is not sufficient heat available must be considered. In addition determining the groundwater table conditions of the region is an important element prior to implementation of any pit options.
### Table 26 Considerations and Methods to determining applicability of VIP latrine option to community of Tangkae

<table>
<thead>
<tr>
<th>Considerations to determine option suitability</th>
<th>Method of determination</th>
</tr>
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<tr>
<td>▪ Assess cultural attitudes towards defecating in a semi-dark, enclosed structure.</td>
<td>▪ Community social and cultural surveys and informal discussions relating to the idea/issue</td>
</tr>
</tbody>
</table>
| ▪ Determine the available intensity of sunlight in Tangkae  
  - is the region too shady to provide sufficient heat to induce air currents  
  - What ventilation options are viable | ▪ Evaluate through physical observation areas near housing as to whether direct sunlight hits space  
  ▪ Discuss with community their observations of sunlight intensity |
| ▪ Determine most readily available materials for superstructure considering:  
  - Brick  
  - Concrete  
  - Wood and thatched roof  
  - Tin/corrugated iron roof  
  - Other | ▪ Consultation with community relating to skilled community members available to undertake construction  
  ▪ Detailed investigation of materials used for current latrine structures in the community  
  ▪ Investigation of latrine structures used in other local projects |
| ▪ Investigate soil characteristics to determine whether pit lining is required | ▪ Physical survey and observations of soil and surrounding geology  
  ▪ Discussion with community members about their observations of soil characteristics |
| ▪ Determine depth to groundwater table | ▪ Discussion with community about their observations of soil saturation and depth, and knowledge relating to bores in any surrounding communities  
  ▪ Investigation of the Laratema spring region and above the main outlet |

#### 5.4.5 Latrine Superstructures and Materials

With the exception of the spiral latrine superstructure which provides the semi-darkened condition required for optimal function of the VIP latrine, superstructures can be similar no matter which option is being implemented. In general the superstructure should be defined and constructed by the user and using locally available materials and labour. In the case of pit latrines such as the Fossa Alterna, and Arborloo the superstructures must be robust and portable as the shallow pits have a shorter lifespan and so latrines will need to be repositioned more regularly (Morgan 2000). Careful selection of materials can help to reduce the economic burden of implementing improved sanitation facilities.
As shown in Figure 25 the use of a broad range of local materials is already common practice for structures built in Tangkae. Some materials suggested by Morgan (2000) range from the use of simple bamboo poles covered with grass or other materials practical and readily available, to wooden structures with corrugated iron or tin sheets. Most latrines also require a simple concrete slab with squatting hole, and depending on budget different pans, and pedestals can be used. Also double or single pit is a common option for all below ground systems, and although initially more costly, a double pit design is generally more effective in reducing waste volumes, pathogen content and have longer life spans.

5.4.6 Sullage Disposal

Independent of whether dry or flush sanitation is chosen, all latrine options require hand washing facilities. As a result of the presence of water containers, latrines often double as household washing and ablutions amenities. It is important that the wastewater from these practices is kept separate from excreta especially where dry sanitation is implemented. As a result specially designed drainage and sullage disposal facilities must be incorporated. The detailed design of these systems is required after selection of latrine option and it is important that the necessity of these facilities is acknowledged for planning.

5.4.7 Solid Waste Disposal

From the results of the physical community survey it can be concluded that there is no defined solid waste disposal facilities in Tangkae. The environmental impacts associated with indiscriminate disposal of solid, inorganic waste into the open environment can be extensive, and as a result it is important that in conjunction with implementation of appropriate sanitation and hygiene facilities a solid waste disposal
program is included. The details of this should be investigated in a similar method to the investigation of appropriate sanitation technology undertaken in this project, with different waste categories being targeted such as organic and inorganic. Disposal of organic wastes such as food scraps can be managed using the principals of composting as described in Section 2.5.4 with optimal results produced when combined with composting latrine facilities. Inorganic waste disposal is more difficult however the application of any management system to confine the impact of these will contribute to improving the environmental and social health of the community.

5.4.8 Investigating Groundwater Characteristics

Investigation of the groundwater characteristics of the local region is a very important factor which needs to be conducted prior to implementation of sanitation technologies. Due to the data limiting situation provided by the working environment this is a difficult task. There are a number of ways in which this can be investigated, the simplest, but most costly being to drill groundwater bores and determine the depth to the groundwater table. Another method is through simple community consultation relating to their observations of groundwater depth from excavation undertaken for daily tasks. This can also be combined with an investigative excavation by the project team during the wet season to observe the presence or not of a shallow water table.

An additional method for determining groundwater characteristics is through environmental systems modelling. Models such as TOPMODEL (Topographic based hydrological model) and GIUH (Geomorphology Instantaneous Unit Hydrograph) can be used to model the relationship between the physical characteristic of topography and catchment hydrological properties. The use of data, such as digital elevation or terrain maps (DEM or DTM), can efficiently represent the topography of a catchment and as water has a tendency to flow downhill (Beven 1997), knowledge about the form of the local topography can be useful in modelling groundwater characteristics. These models can help generate water table maps which are useful in determining basic direction of flow, zones of discharge and recharge and evaluate anthropogenic stresses on the groundwater system. All of this information can then be used to minimise contamination through the implementation of sanitation technology.
CHAPTER 6: Conclusions

Throughout the world there remains an extreme gap in equality between the developed and developing nations, with access to improved sanitation facilities being less than 40% across the world (WHO 2000; WHO et al. 2004). The conditions of health, access to adequate water resources and sanitation facilities in the Timorese village of Tangkae are an example of this inequality and are characteristic of the conditions throughout Timor-Leste. The primary aim of this dissertation has been to investigate the issues associated with implementing appropriate sanitation technologies in a development context and evaluate the available technologies, in order to help address the sanitation and health situation within Timor-Leste. In addition the aim of the EWB-AUS Timor-Leste Student Program has been to empower the Timorese stakeholders through increasing their capacity to address their own development concerns. Reaching this objective is a continual process with sustained interaction with stakeholders required in the next stages of the project.

This dissertation has presented the importance of the processes of stakeholder analysis, capacity building, monitoring and evaluation and community consultation. The key value of undertaking these processes is the ability to attain a sense of community ownership for the project outcomes through empowering and involving the community. It has been highlighted throughout this dissertation that an interdisciplinary approach achieves more holistic and effective outcomes than the traditional international development approach which focuses largely on implementation of infrastructure with minimal engagement of the local community. This dissertation as part of the broader EWB-AUS Timor-Leste Student Program illustrates a successful holistic method to undertaking capacity building and water and sanitation projects. As a result it contributes towards achieving the global MDGs.

The results of this dissertation established that there is not one optimal solution applicable to all sanitation projects. However, if supported by the community and acceptable groundwater and environmental conditions are present the VIP latrine stands as the most viable option for implementation within Tangkae. This was determined through an assessment of the relative social, health, environmental and economic attributes specific to the latrine design. It was concluded that the VIP option provided the most simplistic, economic and culturally acceptable features. However, it was also found that with increased community awareness and education eco-sanitation options such as general composting designs and urine diversion latrines are highly sustainable alternatives. Although more health risks are associated with operating composting latrines, when these are weighed up against the potential to improve a community’s nutrition and economy through improved agricultural productivity the value of the options increase. Therefore the use of the principals of eco-sanitation has the potential to improve the development situation of a
community further than other options, using resources to enable the broader issues associated with poverty to be addressed.

Finally, the importance of the outcomes of this project is in its potential to improve the quality of life for the Tangkae community. As articulated in the Millennium Declaration all people deserve to have access to sanitation facilities, and have a right to know and understand how to prevent further illness through better sanitation and hygiene practices. While each sanitation technology discussed in this dissertation has been shown to have disadvantages and difficulties it is important to compare the benefits provided by the presence of a latrine to where none exist at all. Most importantly the final outcomes when applied to Tangkae must be sustainable solutions, which empower the community to maintain good sanitation practices, throughout future generations.
CHAPTER 7: Recommendations for Further Work

Due to a number of constraints discussed in Chapter 5 there remains further investigative work to be undertaken to provide sufficient information to help this project continue into the next phase. These investigations are to collect both physical and cultural information specific to Tangkae. In particular some specific cultural information to be determined includes:

- Cultural values and attitudes towards open defecation;
- Social status and meaning of owning a latrine;
- Available labour and technical expertise for construction and maintenance within the community;
- Cultural practice relating to anal washing or wiping, feelings relating to these; and
- The cultural attitudes towards dry system, indoor collection.

Further environmental and physical information required includes:

- Investigating soil and geology characteristics to determine ease for pit excavation;
- Determine whether the region is flood prone; and
- Investigating physical surface and subsurface hydrology – including determining connectivity of Laratema with subsurface water, and depth to water table.

(Further details relating to the planned future work is displayed in the trip plan in Appendix A7.)

In addition stakeholder consultation must be revised to determine the current stakeholder expectations and to reconsider each individual’s preferred involvement and role since the changes and disruption caused by the current political instability. It is critical that stakeholder motivation to continue the project is maintained. Consultation to assess individual expectations, consider specifics such as potential issues and determine how each stakeholder envisages the project’s future course is essential.

As well as further investigations of this nature, there are several key steps required to progress to the implementation phase. As discussed throughout this dissertation, community consultation is the key stage which enables implementation to provide holistic and sustainable outcomes. Therefore this is the most important element to future planning, design and implementation stages. Development of appropriate consultation and information sharing tools is an imperative stage which should be applied by the project team. The aim of this step is to inform the community of all available options so that technology selection is then made by a knowledgeable community. After this stage design and planning for hygiene education programs should be undertaken, as well as detailed design of the technology to be utilised, again in consultation with the community. This is then followed by the implementation stage which should be managed by the community and utilise local technical skills and labour. Importantly, to ensure a sustainable solution is provided, implementation should not be considered the final step. Ongoing
monitoring and evaluation is vital to improve the situation in Tangkae as well as provide valuable feedback to the stakeholders especially EWB-AUS.
References


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OEC, (24/02/2005), *The Online Ethics Centre Glossary* [Online], The Online Ethics Centre for Engineering and Science, Available: http://onelineethics.org/glossary.html#anchS [08/08/2006].


Appendices

A.1 Physical and Social Survey

Conducted in Aldeia Tangkae, Suco Balibar, Sub-district Cristo Rei, District Dili.

Friday 17th and Monday 20th February 2006

Conducted By:
UNTL and UWA students with assistance from Domingos de Oliveira, DNAS staff and EWB members Stewart Davies and Natalie Young.

Introduction (made by UNTL student Martinho dos Santos to Tangkae community):
These are engineering students from UNTL and UWA who are doing studies on water supply, water quality and sanitation here in Timor-Leste. They would like to ask some questions, please tell us if any of the questions are too obtrusive or if you wish not to answer them. If you have any difficulty in understanding the questions please ask our friend Domingos to explain.

Social Survey

Demographic Information

1. What is the village population?  
   *Ema hira hela iha aldeia ne’ e?*

2. How many households?  
   *Iha familia hira?*

3. How many people in each household?  
   *Uma ida iha ema hira?*

   *Uma ida iha labarik hira? Mane hira? Feto hira?*

Water Use Information

1. How much water is collected per household per day in the dry season?  
   *Iha bailoro loron ida imi kuru be’ e plastiku hira?*

2. How much water is collected per household per day in the wet season?  
   *Iha tempu udan loron ida imi kuru be’ e plastiku hira?*

3. Can you show us the containers?  
   *Bele hatudu plastiku mai ami?*

4. In the dry season, how many times is water collected each day?  
   *Iha bailoro loron ida imi ba kuru bee dala hira?*
5. In the wet season, how many times is water collected each day?
   *Iha tempu udan loron ida imi ba kuru bee dala hira?*

6. Who collects the water? And when (morning, night)?
   *Se maka ba kuru bee? Bainhira? Dader ka loraik?*

7. Who uses the water?
   *Se maka utiliza bee ne’e?*

8. What is the water used for?
   *Bee ne’e utiliza ba sá?*

9. Is there any waste water? And if yes, where does it go?
   *Iha bee restu ruma? (loos karik) so’e ba ne’ebé?*

10. Is anything done to the water before drinking?
    *Imi halo saida molok atu hemu bee?*

11. Do you boil water before drinking?
    *Imi nono bee molok atu hemu?*

12. Why? How do you know how to do this?

13. When the pipes were still good, was there enough water to the village?
    *Bain hira kanu sei diak bee naton ba aldeia?*

14. Was the water okay for drinking?
    *I bee ne’e diak atu hemu?*

15. What problems do you have with Laratema spring?

16. How can these problems be fixed?

17. Who else uses the water source?
    *Sè mós kuru (uza) bee ne’e?*

### Agricultural Information

**Seasonal activities:**

1. What type of agricultural practices exists in this village?
   *Iha aldeia ne’e imi halo doos oinsa?*

2. What agricultural activities do you do in the wet season?
   *Iha tempu udan imi halo saida iha doos?*

3. What agricultural activities do you do in the dry season?
   *Iha bailoro imi halo saida iha doos?*

**Irrigation methods:**

4. How do you water your plants? How often? How much?
   *Oinsa imi rega imi-nia toos? Dala hira? Imi rega barak?*

**Use of Fertilisers:**
5. Are any fertilisers used for any agricultural practices?

Imi tau adubu ba imi-nia toos? (Lit: Do you put any chemicals on your crops?)

6. Do you use manure on your crops?

Imi tau karau-ten, bibi-ten, kuda-ten ka manu-ten?

Livestock Agriculture:

7. What livestock do you have? How many?

Imi iha sa animál? Hira?

8. Are they penned?

Iha animál luhan?

9. What do you give them to eat? And how often each day?

Imi fo saida ba sira han? Loron ida dala hira?

Sanitation Practices

Location of human waste disposal:

1. Do you have a latrine?

Imi iha santina?

2. If yes, where are they located?

(Sin karik) Imi-nia santina iha ne’ebé?

If no, where do you go for ablutions?

(Lae karik) Imi ba liur iha ne’ebé?

Practice of solid waste disposal:

3. What do you do with things such as plastic bottles and bags?

Imi halo saida ho sasan hancesan botir ho kaut plastiku?

4. What do you do with organic waste, for example food scraps?

Imi halo saida ho sasan hancesan ai-nanás kulit ka hahan restu?

Household practices:

5. How do you wash your body? Where? How often?

Oinsá imi fase imi nia isin? Iha ne’ebé? Dala hira?

6. How do you wash your clothes? Where? How often?

Oinsá imi fase imi nia hena? Iha ne’ebé? Dala hira?

7. What do you do with your food before cooking?

Molok atu tein imi halo saida ba imi nia hahan?

8. How do you cook your food?

Oinsá imi tein imi nia hahan?
**Health Survey**

1. What diseases are common in the community?
   
   *Moras sa maka kumunidade iha dala barak liu?*

2. What diseases are less common but still occur in the community?

   *Maros sa maka kumunidade la dun iha?*

3. What do you do when someone is sick?

   *Imi halo saida bainhira ema ruma moras?*

4. What is the ratio of child sickness to adult sickness

   *Ema moras barak liu labarik? Labarik sira maka moras barak liu?*

5. Can you tell us how many children die each year?

   *Ita bele dehan labarik hira maka mate iha tinan ida?*
Physical Survey

The following survey was conducted in consultation with Tangkae community members. A map of the community was made, with the following features noted where relevant:

Topographical Map:
- Location of all houses/ schools etc
- Location of all springs/water sources
- Distances between
- Altitudes/Relative heights
- Contours
- Hills/ Obstructions. Noting hills/obstacles between the aldeia and water source
- Current Infrastructure (including Latrines etc)
- Access Roads and Paths
- Location of other villages
- Land ownership
- Other Land Uses

Observations to be made of the physical characteristics:
- Nature of terrain
  - Vegetation (density, species etc)
  - Soils & Geology (soil type, erosion, rock formations)
  - Fauna (wildlife & agricultural)
  - Water flow channels (catchment areas)
  - Slope (direction and angle)
- What natural attributes are likely to be favourable to help with possible projects?
- What natural attributes are likely to be of hindrance to our projects?

Observations to be made of anthropogenic activity:
- Level of human activity/infrastructure
  - Houses (number, location, size, material)
  - Roads (sealed, unsealed, eroded)
  - Artificial pollution sources (latrine, agricultural nutrients/waste, vehicles/machinery)

Investigation of Water Sources:
- Investigate activities impacting upon the water sources
  - Directly upstream
  - Downstream
  - Peripheral
- Water Sampling
  - Take water quality samples from each water source x 2 (using DNAS equip)
  - Test for bacteriology, chemical and physical properties. (as per DNAS)

- Water source survey
  - Type of spring (gravity, stream, well, flowing spring)
  - Sketch of spring
    - Rock and soil type
    - Prominent features (trees, rocks etc)
    - Terrain type
  - Determine flow rate, or volume yield of well (seasonal)
  - Determine reliable minimum flow rate, using historical data and discussions with community

<table>
<thead>
<tr>
<th>Water Source</th>
<th>Volume</th>
<th>Time</th>
<th>Flow Rate</th>
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A.2 Summary of Results from Preliminary Physical and Social Survey
Conducted in Aldeia Tangkae, Suco Balibar, Sub-district Cristo Rei, District Dili.
Friday 17th and Monday 20th February 2006

Conducted By:
UNTIL and UWA students with assistance from Domingos de Oliveira, DNAS staff and EWB members Stewart Davies and Natalie Young.

Social Survey

Demographic Information
1. 206 total population
2. 57 families
3. 8-12 people per house
4. Approx. 4 male children and 4 female children, 1 man and 1 woman in each family

Water Use Information
1. 20 – 50 containers
2. 20 – 50 containers
3. Small container 5L, Large container 10L
4. Not directly answered
5. Not directly answered
6. Children collect water in mornings before school. Men and women collect during mid-day and the afternoon
7. Everyone uses the water
8. Water used for cooking, showers, washing and drinking
9. Waste water to water flowers and gardens, Used to wash dirt floors to minimise dust
10. Not directly answered
11. Water is boiled before drinking for a ‘long time’
12. To kill germs and bacteria. This is understood through intuition and is a practice passed on from the ancestors
13. Pipes were built in 1997 and destroyed in 1999
14. Water was still boiled at this time
15. The soil is slippery in the wet season and so the spring is difficult to go down to. Pregnant women cannot go and fetch water because it is dangerous – some women have miscarried due to falls. The water is too heavy to carry that far.

16. The Red Cross in a neighbouring Aldeia had connected pipes from Remisura sub-district which carried water to the other Aldeia. This situation/Aldeia has a tank up the top of the village and the water is distributed down to the other houses. This idea could be used in the Tangkae situation.

**Agricultural Information**

1. Grow vegetables to eat and sell, including maize, tapioca, sweet potato and beans
2. Sow: pineapple, sweet potato and maize  
   Transplant: young coffee trees
3. Prepare for next rain season – clean land, no water is used in the dry season
4. Plants are not watered
5. No chemicals are used
6. Use manure from pigs, goats, buffalo and cows, but not human waste. As this is what the ancestors have always done
7. Pigs, cows, buffalo, horse, dogs, goats and chickens. Some families do own these and some don’t
8. Yes animals are penned (or kept on ropes observation), except chickens are allowed to roam free in the dry season, but it is understood that they can ruin crops in the wet season
9. They graze on grass – sometimes banana plants/leaves are given to cows

**Sanitation Practices**

1. No latrine
2. (it was later discovered (on Monday 20/02/06) that three families have latrines which on inspection (of one) appear to be very clean, with tiled floors and are western style pedestal. These were built because foreigners have come for 3 month home-stays to learn Tetun)
3. There is no designated place to shower/bath. A hole in the ground near the pig pen is used for defecation. The pigs are allowed to eat the waste as there is not enough water to wash waste away
4. Thrown away anywhere – into river. In the dry season the wastes are swept together and burnt.
5. Organic waste is fed to the pigs
6. Mothers and babies shower at home and everyone else does at the spring and soap is used. In the rain season when it is too slippery to go to the spring and there are many leaches and mosquitoes a bamboo gutter on the roof is used as a shower, and rainwater is boiled and used for cooking
7. Clothes are washed at the spring with soap, daily if the children are going to school, clothes don’t 
clean as well if rainwater is used
8. Food is washed with spring water, if it is too dirty it is given to the pigs
9. Not directly answered

Health Survey
1. Coughing, fever, high temperatures, headache, runny nose and the children get diarrhoea. When the 
children are sick all the time they generally have worms, they eat anything and don’t wash their hands
2. Not directly answered
   Diarrhoea – if still symptoms on day two then they go to a chemist.
   2-3 people in the Aldeia were taught the treatment of worms.
4. There is a high infant mortality rate – generally if a child survives the first year of life then they will 
live to grow up
5. In the last 2 years there have been no infant deaths, but in the last 5 years there were approximately 5 
infant deaths ~ 1/year
**Physical Survey**

**GIS Map:**
See Appendix A6

**Observations made of the physical characteristics and anthropogenic activities:**

<table>
<thead>
<tr>
<th><strong>Water Sources</strong></th>
<th>Three water sources:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Laratema</td>
</tr>
<tr>
<td></td>
<td>- Spring closest to village</td>
</tr>
<tr>
<td></td>
<td>- 500 meters downhill from main community</td>
</tr>
<tr>
<td></td>
<td>- Very steep, narrow and slippery access</td>
</tr>
<tr>
<td></td>
<td>• Fatnamudu</td>
</tr>
<tr>
<td></td>
<td>- Stream</td>
</tr>
<tr>
<td></td>
<td>- Larger flow rates than Laratema</td>
</tr>
<tr>
<td></td>
<td>- 3-4 kilometres from community</td>
</tr>
<tr>
<td></td>
<td>- Originally connected to Aldeia with pipes using gravity (slight altitude difference)</td>
</tr>
<tr>
<td></td>
<td>• Airabat</td>
</tr>
<tr>
<td></td>
<td>- Well</td>
</tr>
<tr>
<td></td>
<td>- Concreted for permanency</td>
</tr>
<tr>
<td></td>
<td>- Approximately 3 kilometres from community</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Anthropogenic Activities</strong></th>
<th>Waste Disposal:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Solid waste is thrown away into the open environment - on the ground or to the stream</td>
</tr>
<tr>
<td></td>
<td>• Many detergent packages were observed around Laratema spring</td>
</tr>
<tr>
<td>Level of human activity:</td>
<td>- Housing is scattered, with two main clusters</td>
</tr>
<tr>
<td></td>
<td>- Buildings constructed primarily of corrugated iron, concrete and wood combinations</td>
</tr>
<tr>
<td></td>
<td>- The main access road to the community centre is unsealed heavily eroded in some parts, allowing access only to 4WD vehicles</td>
</tr>
<tr>
<td></td>
<td>- Access paths to water sources are narrow and steep and also heavily eroded in parts</td>
</tr>
<tr>
<td></td>
<td>- Chickens, goats and pigs were free to roam around village, with several pig enclosures constructed of wood existing.</td>
</tr>
<tr>
<td></td>
<td>- No electricity supply exists</td>
</tr>
<tr>
<td></td>
<td>- Several disused concrete water tanks exist within the village</td>
</tr>
<tr>
<td>Sanitation facilities:</td>
<td>- Three latrines exist, one was observed to be a pour-flush pit design with western pedestal and was also used as a wash house</td>
</tr>
<tr>
<td></td>
<td>- A hole in the pig enclosure also presented as a defecation site</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Physical Characteristics</strong></th>
<th>Generally steep topography</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dense-moderate forest vegetation cover, scattered coffee plantations</td>
</tr>
<tr>
<td>Soils and Geology:</td>
<td>- Observed to be clay-like along path to Laratema as fine and very slippery when wet</td>
</tr>
<tr>
<td></td>
<td>- Hard rock forms the stream bed at Fatnamudu, and richer organic soil top layer along Fatnamudu access path, similarly in region surrounding Ariabat</td>
</tr>
</tbody>
</table>
## A.3 Stakeholders and Organisations Consulted

<table>
<thead>
<tr>
<th>Individuals:</th>
<th>Associated Agency/Role:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kerry McGovern</td>
<td>AusAID asset management advisor</td>
</tr>
<tr>
<td>Natalie Young</td>
<td>EWB Member, Environmental Engineer</td>
</tr>
<tr>
<td>Peter Young</td>
<td>Australian Army, Defence Cooperation Program</td>
</tr>
<tr>
<td>Alan Smith and Michelle Whalen</td>
<td>Community Water Supply &amp; Sanitation Program (CWSSP – AusAID)</td>
</tr>
<tr>
<td>Dean:</td>
<td>National University of Timor Leste (UNTL)</td>
</tr>
<tr>
<td>Lecturer:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Justino Da Costa Soares</td>
</tr>
<tr>
<td>Students:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Adilio Ximenes</td>
</tr>
<tr>
<td></td>
<td>Jacinto da Costa Almeida</td>
</tr>
<tr>
<td></td>
<td>Atibo Tilman</td>
</tr>
<tr>
<td></td>
<td>Martinho dos Santos</td>
</tr>
<tr>
<td></td>
<td>Delfim Gaspar</td>
</tr>
<tr>
<td></td>
<td>Diamantino Soares</td>
</tr>
<tr>
<td>Director:</td>
<td>Department of Natural Resources, Minerals and Energy - Oil Gas and</td>
</tr>
<tr>
<td></td>
<td>Energy Directorate</td>
</tr>
<tr>
<td>Mr Vicente da Costa Pinto</td>
<td></td>
</tr>
<tr>
<td>Geology Student Intern:</td>
<td></td>
</tr>
<tr>
<td>Mateus da Costa</td>
<td></td>
</tr>
<tr>
<td>Antonio Armard</td>
<td>Hamoris Timor Oan (HTO) NGO</td>
</tr>
<tr>
<td>Cedric Breda</td>
<td>Triangles Generation Humanitare (French based NGO)</td>
</tr>
<tr>
<td>Non-Urban Co-ordinator:</td>
<td></td>
</tr>
<tr>
<td>Martinus Nahak</td>
<td></td>
</tr>
<tr>
<td>Technician:</td>
<td></td>
</tr>
<tr>
<td>Ernemagildo</td>
<td></td>
</tr>
<tr>
<td>Isac Fontes</td>
<td></td>
</tr>
<tr>
<td>Driver:</td>
<td></td>
</tr>
<tr>
<td>Amanty</td>
<td></td>
</tr>
<tr>
<td>Domingos de Oliveira</td>
<td>Tetun teacher, translator and interpreter and mentor and cultural advisor</td>
</tr>
<tr>
<td>Daryl Mills</td>
<td>Rotary Australia World Community Service (RAWCS) Liason Officer Dili.</td>
</tr>
</tbody>
</table>
Appendices

A.4 *Research request form for visit to Tangkae planned for April 2006*

The following form is a request from the UWA project team for specific activities and surveys to be undertaken by the UNTL students and Natalie Young (EWB-AUS in-country representative) in a planned trip to Tangkae in April 2006. This field visit was cancelled due to the instabilities arising in Timor-Leste around this time.

*Atividade ho pezkiza sira n’ebé estudante UNTL sira ho Natalie tenke halo bainhira sira bá Tankai iha fulan Abril*

Activities and research the UNTL students and Natalie should do when they go to Tangkae in April

Ita hotu tenke tuir orientasaun husi CAP i ami hanoin katak diak liu, lalika hasoru malu ka ko’alia barak ho ema aldeia sira. Karik bele hili portavós ida ba grupu (kala Martinho fali) atu halo fali apresentasaun i esplika katak ita kontinua nafatin ita nia investigasaun sira, maibé labele promete implementasaun ruma.

It is important that we adhere to CAP guidelines and we think it would be best to keep contact with the village people to a minimum if possible. Perhaps if someone can be designated spokesperson for the group (maybe Martinho again) to make introductions again and explain that we are continuing with our investigations but can not make any promise of implementation.

*Atividades sira/Activities*

1. *Teste Bee-matan (Airabat) sukat mudansa bee nia nivel.*
   1. Prove Well (Airabat) out – determine water level changes/ recovery rates.
      a. *Etapa 1. Marka bee nia nivel (hodi jis)*
         a. Step 1. Mark current water level (with chalk)
         b. Step 2. Remove 25 litres of water (using buckets?) from well every minute for 1 hour.
         c. Step 3. Every 15 minutes mark water level.
      d. *Etapa 4. Sukat mudansa bee nia nivel (ho régua).*
         d. Step 4. Measure water level change (with ruler).
      e. *Etapa 5. Se bee nia nivel tun liu tiha oras ida, sukat tempu bee-matan lori atu hakonu marka ida uluk liu ba.*
         e. Step 5. If well level has dropped after 1 hour, measure time taken for the well to refill to previous mark.

2. *Haree minutu hira bee matan ida-ida lori atu hakonu balde ida. Kuru amostra bee nian husi bee matan ida-ida (Fatnamudu, Airabat and Laratema)*
   2. Measure flow rates and take samples of water from each spring (Fatnamudu, Airabat and
Laratema)

a. Rai mós amostra udan ben – udan tau iha rai luan ho suli husi kadoras uma tatis (hakerek amostra udan ben ne’e simu husi uma ida ne’ebé ho uma-tatis uma ne’e nian halo ho saida).
    a. Also take samples of rainwater – free falling and from gutter of one of the roofs (note down which house this sample is taken from, and the type of material gutter is made from)

b. Husu ba laboratóriu DNAS se imi bele halo kedas teste iha sira nia laboratoriu bainhira imi fila husi aldeia. Kombina ho Mário oras atu halao teste/análize.
    b. Check with DNAS lab that it’s okay to use their lab directly after field visit. Arrange with Mario time to do testing. May need a few hours as all parameters are required to be tested.

c. Husu saku ho frasku amostra nian ba laboratóriu DNAS (natón ba amostra husi bee-matan tolu ho udan ben rua). Marka amostra sira.
    c. Ask DNAS lab for Request for Water Quality Testing forms.

d. Husu ba laboratóriu DNAS formuláriu Rekizisaun atu halo Teste ba Bee nia Kualidade.
   i. Teste nia paramétru inklui: “ALL Physical, ALL Bacteriological, ALL Chemical”
      i. Parameters to test for include: ALL Physical, ALL Bacteriological, ALL Chemical.
   ii. Husu kópia ida rezultadu sira ne’e (haree keta mákina fotokópia CWSSP bele hasai kópia balu, lae karik bá hasai fotokópia iha loja ruma)
      ii. Ask to get a copy of results (see if CWSSP photocopier is available, otherwise go to copy shop down the road?)

3. Investigate atividade sira iha bee-matan dook liu nia létént (Fatnamudu)
   3. Investigate upstream activities at furthest spring (Fatnamudu)

   a. Observa atividade to’os nian hanesan kolleita ho animál sira ne’ebé la’o iha rai luan.
      a. Observe agricultural activities such as crops and roaming animals.
   b. Observa oinsá aldeia hela besik sira, uma seluk ho ema tur iha liuron besik uza bee-matan.
      b. Observe uses by neighbouring villages, other housing and roads in proximity of spring.
   c. Aspektu ambiental hanesan erozaun ho densidade vejetasaun.
      c. Environmental aspects such as erosion and vegetation density
   d. Deskreve karakterístika elevasaun bee-matan nia leten hanesan railolon, rai aas ho distansia entre bee matan ho buat seluk.
      d. Describe upstream elevation characteristics such as slope, height, and approximate distances between landmarks.
   e. Nat – ita iha karik mákina-retratu digital ida favór bele hasae hela mai ami retratu rumu ne’ebé importante ba projetu?
      e. Nat – if you have a digital camera could you possibly take some photos for us please, of anything relevant?

4. Investigate atividade sira iha bee-matan besik liu( Laratema) nia leten.
   4. Investigate upstream activities of closest spring (Laratema)

   a. Nia mai husi ne’ebé (retratu)?
Appendices

a. Where does it come from (photos)?
b. *Nia ulun liu ne’e oinsá loos?*
c. What does the spring at the original source actually look like?
c. *Diferensa altura fatin ne’ebe bee mosu ho fatin ne’ebe bee sai husi kanu*
d. Height of spring (actual height, not where pipe protrudes)

5. Community map of aldeia, including following features:

   a. *Uma sira* (inkui ema sira nia númeru iha uma ida-ida, estatutu iha aldeia nia laran, ie, Xefe, Funsionário Humnitário*)
   a. Houses (include number of persons per household, status within village ie. Chief, Humanitarian officer)

   b. *Sentina*
   b. Latrines

   c. *Balada luhan*
   c. Animal Pens

   d. *Liuroon*
   d. Roads

   e. *Fatin soe foer*
   e. Waste Disposal

   f. Water sources (Springs including Laratema, Fatnamudu & Airabat, other springs or streams or water sources near aldeia boundaries, used and unused)

   g. *Área ba dezenvolvimentu, hanesan uma foin, aldeia foin, to’os foin, ho buat seluk tan.*
   g. Areas for future village expansion.

   h. *Área ne’ebé maka oras ne’e daudaun ema kaer to’os ka áarea ne’ebé sira sei kaer se iha irrigasaun?*
   h. What areas are currently being used to grow crops on/ what areas would they use if they had irrigation water?

   i. *Se bele hasai retratu barak (uma etc)*
   i. As many photos of the village as possible (houses etc)

6. Presiza husu se karik ema fo bee ba irrigasaun sira kuda saida? (produsaun bele lahanesan sira iha oras ne’e)
6. Need to ask if they have water supplied for irrigation what crops would they grow? (could be different to crops currently grown)

7. Kalendáriu Akontesimentu Sosiál – sá atividade, se mak halo (jéneru espesifiku) ho loroloron sira lori tempu hira. (kalendáriu tinan ida nian)
7. Calender of Social Events – what activities are done by whom (gender specific) and how much daily time they take up. (year long calendar)

Porezemplu
## A.5 Environmental Screening Checklist

**Based on form from:**
Australia-East Timor Community Water Supply and Sanitation Project  
(DNAS 2005b)

### Environmentally Sensitive Areas:

1. Is the Activity in or near sensitive or valuable ecosystems such as beaches, wetlands, coral reefs, mangroves or other protected areas?
   - ☐ Yes  ☐ No  ☐ Unknown
2. Is the Activity in or near sites of archaeological, cultural or historical significance?
   - ☐ Yes  ☐ No  ☐ Unknown

**Notes:**
If either question is answered “yes”, seek advice through CWSD and Directorate of Environmental Services.

**Comments:**

### Other Environmental Information:

1. Will the Activity require clearing of vegetation?
   - ☐ Yes  ☐ No  ☐ Not known
2. What type of vegetation will be cleared for the Activity? (Tick box as appropriate.)
   - □ Forest  □ Gardens  □ Other
   - □ Intake
   - □ Transmission pipeline
   - □ Distribution System
   - □ Reservoir
   - □ Public Standpipe
   - □ Public Toilet/Bathhouse (MCK)
3. Will the activity require excavation in or near water courses?
   - ☐ Yes  ☐ No  ☐ Not known
4. Will the activity require excavation in or near roads?
   - ☐ Yes  ☐ No  ☐ Not known

**Notes:**
Information to inform review by DWSA only.

**Comments:**
A.6 GPS Plots of Tangkae
A.7 *Timor-Leste Trip Plan*

*Drafted 18th October 2006*

**Main Objectives:**

The main objectives for this trip is to complete the preliminary assessment of the water and sanitation situation of Tangkae, refine and evaluate the options proposed as a result of preliminary research, commence community consultation phase and assist initiation of implementation stages.

The primary benefit of this trip taking place sooner rather than later is to maintain motivation amongst all stakeholders. Conducting this trip will demonstrate support for the East Timorese community and express the urgency that work should continue towards improving the water and sanitation situation of communities such as Tangkae. Specifically this trip will help to maintain motivation within the UNTL student group to continue to improve their skills and training in the water and sanitation engineering field, to increase knowledge, and to provide opportunities to expand their work experiences. This is important as they are the next generation of local water and sanitation engineers who will be needed to enhance this sector in the future. One of the key objectives of this project is to build the capacity of the UNTL students, and thus it is imperative that they are continually engaged in the project. This is difficult to achieve with increasing time between project field trips. Leaving this trip to a later date could risk loosing the momentum developed during the initial visit. This could increase the difficulties in achieving the optimal project outcomes.
<table>
<thead>
<tr>
<th>Week</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Week 1</strong></td>
<td>Discussions with UNTL, DNAS, Nat &amp; HTO – updates on project proposal, discuss what we have been doing (research, funding etc), what we plan to do while in Timor for Dec/Jan: additional investigations, Community consultation process, begin implementation stage.</td>
</tr>
<tr>
<td><strong>Week 2</strong></td>
<td>Stay in/visit Tangkae for 3-4 days to complete investigations &amp; data collection – observe daily village life and practices (water collection methods, waste disposal, water usage practices). Conduct social &amp; physical surveys (regarding sanitation etc). (improve Tetun) Find local companies that provide supplies for infrastructure, obtain relevant information (costings, availability of resources, labour/personnel).</td>
</tr>
<tr>
<td><strong>Week 3</strong></td>
<td>Discussions with UNTL students, Nat &amp; HTO to plan Community Consultation phase – make educational material to help explain to community various options and issues such as the importance of water quality treatment &amp; maintenance, protection of water sources, hygiene &amp; sanitation.</td>
</tr>
<tr>
<td><strong>Week 4</strong></td>
<td>Begin Community Consultation, including forming Community Water Management Group, discussion and decisions of adoption of specific water and sanitation technologies.</td>
</tr>
<tr>
<td><strong>Week 5, 6 etc…</strong></td>
<td>Begin Implementation Stage – time frame dependant on length of community consultation phase. Hand over of remaining project work to HTO &amp; UNTL students.</td>
</tr>
<tr>
<td><strong>If spare time:</strong></td>
<td>ALGIS – more climatic data if possible. Find out where the data was actually taken and determine in relation to Tangkae. Visit other relevant water &amp; sanitation projects, examine systems used, successes and failures, limitations. Visit Nama-lai village – see if anything is being done… and maybe have a look at their dry season water supply</td>
</tr>
</tbody>
</table>
# Tangkae Surveys

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
</table>
| Physical/Topographical      | ▪ Determine if springs are artesian or gravity  
▪ Determine distances, slopes between springs and houses (Take measuring wheel)  
▪ Find out groundwater table level if possible  
▪ Examine activities upstream & downstream from springs/streams – agricultural, other villages, natural, latrines, sanitation, animal faeces |
| Water Quality               | ▪ Take samples of the 3 springs, 2 from rainwater (1 direct, 1 off roof)  
▪ Check roof & gutter materials.  
▪ Test particulate matter size – to determine type of filtration required.  
▪ Investigate cultural perceptions of rainwater |
| Hygiene practices           | ▪ Survey washing of hands, food, clothes, people.                                                                                           |
| Sanitation Latrine usage    | ▪ Cultural values/attitudes towards open defecation  
▪ Social relevance/status/meaning of owning a latrine  
▪ Cultural practice relating to anal washing or wiping, feelings relating to these  
▪ Are the latrines already in Tangkae actually pit or are they pour-flush systems?!  
▪ Is Tangkae flood prone?  
▪ What are the cultural attitudes towards dry system collection in doors?  
▪ How easily can pits be dug? What are the soil/geological conditions? Are they uniform? |
| Economic & Social           | ▪ Community Map & Calendar  
▪ Determine income for village and individual houses. Think – affordability of solutions, materials.  
▪ Available labour/skills/technical expertise for construction/maintenance within the community |