What are the barriers and benefits in developing and transferring new cottage industry papermaking technology using Westerlund's Five Phases of Appropriate Technology Transfer Model.

This Thesis is presented for the Degree of

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by

Leslie Craig Westerlund

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I declare that this thesis is my own account of my research and contains as its main content work which has not previously been submitted for a degree at any tertiary education institution.

……………………………20th October 2014…………………………

Leslie Craig Westerlund

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Abstract

What are the barriers and benefits in developing and transferring new cottage industry papermaking technology using Westerlund's Five Phases of Appropriate Technology Transfer Model.

The best available craft technology is developed, in this case by the author, and a new model applied whereby innovative, appropriate, sustainable technology can be transferred to help under- developed countries. This model applies a 'technical action research' methodology to implement the new Westerlund's Five Phase strategy for the transfer of technology to craft villages in developing countries. This generic new technology transfer model was tested with a controlled pilot plant for highest quality cottage craft technology of papermaking in a remote island village of Wainimakutu, Fiji, where English is a second-third language, by first redesigning and making specialised equipment, teaching the use of the equipment to skilled village artisans, value adding raw recycled paper into photocopy grade paper, then pioneering the production of traditional science based story books. This lifted the combined skill set from craft to a new genre of intensive cottage industry craft. Another pilot plant was trialled in an Australia Lifestyle village.

The 5-phase model is based on a foundation and the following steps. First is the Foundation Phase of getting to know the existing village, their culture, the level of technology, management and craft skills. Phases 1 and 2 introduces safe easy small then bigger steps in hardware and software technology. These involve making some specialised newly co-designed hardware/equipment with the author/scientist/inventor and local industry and university help while trying to source and/or make the standard manufacturing components locally. Phase 3 builds on Phases 1 and 2 and enables more

radical ‘leapfrog’ steps to advanced (western papermaking) technology to gain a competitive quality and or marketing edge (smooth 150 gsm paper).

Phase 4 is the ‘vertical technology transfer’, where value adding takes place, enabling a higher quality raw standard product and a wider range of value added products to be made in the village and or local city. This involved several village, industry and university workshops over a few years of technology transfer. In this case from rough handmade paper (300gsm) into a finer, smooth sided 150 gsm quality paper suitable for printing and photocopiers. Cultural story books were also made.

Phase 5 is the ‘horizontal technology transfer’ where the technology is carried over to the next village using their new skills in papermaking and with the ownership of the new improved intellectual property. In this case local NGO workshops were organised using the upskilled training staff from the pilot village.

This project provides an initial trial and a solid basis for further research into a future Phase 6 on marketing eco-friendly and sustainable products from developing countries in a new world paradigm; and Phase 7 on new management systems.

The study included two case study projects, one Fijian village verses one Australian Lifestyle village, which were evaluated from four main perspectives. Firstly, the first hand designing, making and testing of new improvements in papermaking equipment to make the best quality smooth hand made paper. Secondly, the implementation of the ‘technical action research’ was measured by the quality of the new craft paper produced for the printing industry. Several types of quality books were printed, bound and published as real examples, this included cultural stories from the village made into books for the school. Thirdly, a new modified point system survey was theoretically developed and applied to complement the five phases by rating the making of the equipment and transfer of craft (papermaking) skills; and the vertical and horizontal transfers. Fourthly, the United Nations guidelines were also modified and used to trial the evaluation with a maximum coefficient and rating system to generate optimum values of eco-friendly sustainable transfer of appropriate technologies.

In summary, the developing country setting enabled a successful trial of the new best available design and testing of equipment and the a new generic technology transfer model. They appreciated the advances in hardware and software technology and have upgraded their existing papermaking project to use most of the new technology. The village depend on this project as an employment cornerstone of their remote highland village. The retired tradesmen in the Australian lifestyle village helped the author co-design and test new advances in cottage industry craft papermaking technology and push the quality parameters to new levels, however the life-stylers were more interested in enjoying retiring than taking on a new hobby of papermaking. Some used the paper to complement their other craft activities.

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List of Acronyms:

BAT	**B**est **A**vailable **T**echnology
BWLV	**B**ridge**w**ater **L**ifestyle **V**illage Mandurah
ESTs	**E**nvironmentally **S**ustainable **T**echnologies
DC	**D**eveloped **C**ountry
gsm	**G**rams of paper weight per **S**quare **M**etre of paper
IDCs	**I**ntermediate **D**eveloping **C**ountries
LCM	**L**ife **C**ycle **M**anagement
LDC	**L**ess **D**eveloped **C**ountry
MNCs	**M**ulti-**N**ational **C**ompanies
NLV	**N**ational **L**ifestyle **V**illage
UDC	**U**nderdeveloped **C**ountry
USP	**U**niversity of the **S**outh **P**acific
WPMV	**W**ainimakutu **P**aper **M**aking **V**illage
	Leslie Westerlund's equipment for patent names.
LAM	**L**eslie's **A**luminium **M**ould and Deckle
LHP	**L**eslie's **H**ydro-**P**ulper
LSS	**L**eslie's **S**tack **R**ack
LPP	**L**eslie's **P**apermaking **P**ress
LSS	**L**eslie's **S**uper **S**mooth papermaking technology
LTC	**L**eslie's **T**ransfer **C**urve
MU	**M**urdoch **U**niversity
WES	**W**esterlund **E**co **S**ervices
WHMP	**W**ainimakutu **H**and **M**ade **P**apermaking Village

CHAPTER 1: INTRODUCTION

1.1. Research Question

The research questions addressed in this project are:

What are the barriers and benefits in developing and transferring new cottage industry papermaking technology using Westerlund's Five Phases of Appropriate Technology Transfer Model.

Marjoram (1990) describes technology transfer as a process that "fits the local context and that somebody locally can maintain, repair and preferably understand the technology."

The methodology chosen is the 'action research' process and a 'theoretical survey evaluation system' by which the author, an industry expert in cottage craft papermaking, co-redesigned and constructed the several new pioneering pieces of hardware and demonstrated the range of software skills needed to operate the technology in an existing craft village in the remote highlands of Fiji. English was a communication challenge as it was the second or third language of these villagers. The remote highland Wainimakutu village, within the region of Namosi, is three hours by four wheel drive from Suva city. The Bridgewater lifestyle village for over 45'ers is near Mandurah, south of Perth, Western Australia.

The expected outcomes of the project were:

1. A new 'multi-(5)-(step)-Phase' process of technology transfer from low to medium to high steps of technology, then value adding and horizontal transfer to the next village.

2. Develop and trial a new 'sustainable turnkey approach' to empower developing country villages, local industry and regional universities to redesign and make the equipment for remote village enterprises based on eco-friendly, alternative, appropriate technologies.

3. Trial a 'copy it exactly' approach to existing technology assisted paper making skills as a new advanced trade skill in Fiji.

4. Develop and trial a new objective evaluation system based on 25 points for each of 4 sections of hardware and software skills transfer to yield a 100 point or percentage scale to measure the transfer of technology.

5. Use the paper for as an example of capturing their rich village culture into handmade books for the local school in Fijian and English.

The benefits for a remote rural village would be expected to be more related to creating village based appropriate and sustainable employment. A Fijian village generally has the foundations of food, shelter, sanitation, health and clean water. Their emphasis is now on improving employment and education. In discussion with local villagers, a remote village for instance needs to find a lot more money to send their children off to board in the city for high school and higher education. There is limited employment for isolated villages and transport costs increase exponentially in the rugged mountainous, tropical and cyclonic environment. Each village needs to be more empowered to support the women with creative craft based flexible employment.

The Australian lifestylers would benefit with a new super smooth paper for craft activities, making cards, poems, books and specialty gifts. The Author will also benefit by getting retired tradespersons help to redesign and improve the equipment.

The technology transfer method includes training participants in making a range of new craft equipment from easy; to harder; to radical; and training them with new skills in using equipment and processes. The expected process outcome includes up-skilling in systematic steps that can be monitored and evaluated using standard techniques:

- Adding to the scientific body of knowledge on technology transfer of 'best available technology' from developed to developing countries for social, economic and sustainable development;
- Development of cottage craft industry training and future accreditation;
- Free transfer of the intellectual property of best available technology;
- Training in value adding to create a range of new products from standard production processes;
- Creating a range of skilled village employment and cash flow; and
- Developing a new genre in intensive cottage industry papermaking craft.

Technology transfer (TT) is important to research, investigate and standardise as developed countries (DCs), like Australia, provide help to under-developed countries (UDCs) like the Fiji Islands, to move forward and improve the quality of life of all citizens assessed against the criteria of being economically positive; socially acceptable; and environmentally sustainable. Ultimately it is hoped the participants will embrace the new technology to become cottage industry leaders in using the new papermaking technology, modifying the technology to their own needs, creating many new niche markets; and creating flow on benefits for the whole community. It is hoped that in Australia the retired tradespeople could assist the author in making the hardware-equipment even better and empower the life-stylers to make nice craft paper products.

1.2. Structure of the Thesis

Chapter One introduces the concepts of technology and technology transfer and the importance of the 'scientist' being directly involved in the transfer process. It also presents the critical research questions, "What are the barriers and benefits in developing and transferring new cottage industry papermaking technology using Westerlund's Five Phases of Appropriate Technology Transfer Model.

Chapter Two covers a review of the literature. It provides the background to this study and helps to create a picture of where Fiji and the Pacific fit in as a UDC. These cultural examples provide useful case study settings with which to compare a generic TT project to an Australian lifestyle village and derive useful data for later analysis.

The literature review presents many holistic models of TT, starting with simple models and then building up to complex models. These models include: the 'six phases model'; the 'six dimensions model'; the 'systems model'; the 'seven C's model' and then leading up to a more holistic '3rd dimensions model'. The models provide the foundation for a pilot project model for this study. There was no blueprint for doing this so many ideals were extracted and a new methodology was developed to pioneer this frontier of TT.

Chapter Three develops the new framework model of a multi-phased transfer process as safe, easy, 'small steps' in TT; building on that step with safe 'bigger steps' in TT; experimenting with more radical 'leap-frog steps' in TT, including a new 'sustainable turnkey approach' to TT; and developing skills with the 'copy it exactly' approach. This base of new hardware and software technologies can then help 'vertical' TT. The final step is 'horizontal' TT of their new skills to the next culturally sensitive village with more ownership of the technology and empowerment to modify the technologies and adapt them to their special needs.

Chapter Four develops the methods to field test the above conceptual model.

Chapter Five presents the results of the TT model trial in a remote rural village in the small developing country of Fiji. The village of Wainimakutu, in the Namosi region, in the highlands above Suva provides a unique setting for the project as a base (rough textured paper) papermaking project was already started, and cottage industry papermaking has become a more stable financial backbone of this village over the last decade. This is compared to the results of a parallel TT project to the Bridgewater lifestyle village in Mandurah, Western Australia (full details in a separate report).

Chapter Six discusses the results. Some of the many aspects are craft, employment opportunities, empowering village women, making the equipment, adapting the best appropriate technologies, and creating a entwining new helix of support with industry, NGO's and universities.

Chapter Seven further discusses the results using the experiences of the author both in the 'hands-on' action way of TT and in developing a theoretical way of conducting a survey and then separately doing the survey and presented the results in a separate report on the project.

Chapter Eight provides conclusions on barriers and benefits of TT to developing countries and a guideline for the ideal conceptual model – the Five Phases of Sustainable TT- for future relevant case studies of TT and how positive outcomes can be achieved.

1.3. Limitations of the Research and Site Selection

The research was limited to an example of a developing country (Fiji) and compared with other studies in a developed country (Australia). The Fiji example was an already established basic skilled papermaking village making about 1,000 sheets of A3, rough, heavy (300gsm) handmade papers per week for wrapping paper. To start another project from scratch would have involved many years and hundreds of thousands of dollars in new infrastructure and training; well beyond the limited financial and time limitations of this thesis. For Fiji, the costs of travel, accommodation, and workshops were expensive, with many of the extra funds for visits coming from sponsors and personal funds. The Australian example is a lifestyle (semi-retirement) village with a focus on craft for its clients over 45 years.

The focus is limited to the five phases of TT transfer, providing a foundation for more research into the follow on phases - like marketing or management systems.

The research was focussed on eco-friendly, alternative and appropriate technologies that relate to empowering women and the village cottage industry craft community.

The research is further limited (focussed) to the important area of developing the strategies for empowering people and village enterprises in developing countries to provide a sustainable option for benefiting their village, local skills, resources and culture through the papermaking enterprise with the ongoing involvement of NGOs, industry and governments and improving the process of TT while being culturally sensitive to the setting, needs and limitations of indigenous cultures.

CHAPTER 2: LITERATURE REVIEW

This Chapter will embrace three sections of literature review. Firstly it will examine the literature on technology transfer to Developing Countries. Then it will discuss several models for TT, based on a literature review, looking at several case studies. The models can then be understood and researched in order of complexity and provide a basis for a framework for the new model. As no appropriate model was found for TT a new model was extracted and developed from all the holistic sustainable good frames of reference that were extracted and extrapolated from others.

2.1. Background on Technology Transfer in Developing Countries

2.1.1. Introduction

Technology transfer can be a structured, scientific process for developed countries to work with developing countries to move forward holistically to improve the quality of life of all citizens by adding suitable and sustainable technology to local village craft to attain higher quality or higher volume production or niche market competiveness. The many models of TT need to be reviewed and refocussed as this important paradigm evolves into the new millennium.

By first reviewing the Greek origin of the word ‘technology’: ‘techne’ and ‘logos’ we rediscover the essence of the ‘skill of the hands’ and application of the ‘knowledge and science’(Runes 1942). This re-empowers modern artisans to honour their skills and wisdom as the modern word incorporating tacit skills. The word ‘transfer’ has Latin origins, where ‘trans’ means to move across borders and ‘ferre’ means to personally carry it. This adds new depth and meaning to how important artisans and scientists are

in going to a UDC and carrying their skills with them to share the skills and wisdom in a practical, scientific and personal way.
Marjoram (1990) describes TT as a process that: "fits the local context and that somebody locally can maintain, repair and preferably understand the technology."
Smith (2001) argues it is more than simply giving technology to developing countries, it is about: "the complex process of sharing knowledge and adapting technology to meet local needs. It strengthens human and technological capacity in developing countries. It promotes commercial markets for climate-friendly technology."

Building on that, from another holistic perspective, Agenda 21, defines TT in terms of capacity building for UDCs: "new and efficient technologies will be essential to increase the capacity, in particular, of developing countries, to achieve sustainable development, sustain the world's economy, protect the environment, and alleviate poverty and human suffering. Inherent in these activities is the need to address the improvement of technology currently used and its replacement, when appropriate, with more accessible and more environmentally sound technology" (IETC 2003c).

Another definition that highlights the evolving new paradigms of TT, with an eco-friendly bias is described by Halls (2006) as: "the suite of processes encompassing all dimensions of the origins, flows and uptake of know-how, experience and equipment amongst, across and within countries, stakeholder organisations and institutions".

As there was no suitable existing model to follow, research is needed to review existing models of TT and then develop and pioneer a new model whereby innovative, appropriate, sustainable technology can be transferred to help a less developed country. This model will apply a modified 'technical action research' methodology to implement a new multi-phase model of appropriate ways to transfer the 'Best Available Free Technology'(BAT) to craft villages in UDCs. DCs need generic new TT models that can be tested with a controlled pilot plant for a craft hobby village. This could us understand the barriers and benefits in transferring technology to help them to the next level of a cottage industry.

2.1.2. Evolving Technology Transfer

Technology transfer is important to understand from many levels as the DCs, like Australia, provide help to UDCs like the Fiji Islands, to improve the quality of life of all citizens. TT is founded upon three established cornerstones, in principle, supported by many references:

1. Being economically positive;
2. socially acceptable; and
3. environmentally sustainable.

(Bennett 2002; Hay 2003; Hecht 1999; Keefer 1999; Lindsey 1998; Lipp 2002; Shapira 1996; Strawn 1982).

There are four other important evolving cornerstones:

1. The hands on 'art' or 'artisan' skills are also acknowledged and included as 'tacit skills', and supported by training institutions (Arrow 1962; Colecchia and Papaconstantinou 1996; Redding 1996). It is critical that a artistic-artisan-scientist the author can transfer these practical skills to village artisans.

2. The importance of indigenous technologies is also acknowledged and honoured (Thompson 1999). It is hoped that some wonderful cultural stories can be told and transcribed to a book and printed on the new paper.

3. The use of 'best available technology' should be encouraged. The transfer (free) of the best available technology goes hand in hand with research and control of intellectual property. The author has pioneered new western

papermaking for 3 decades and could be considered and leading in smooth hand made paper technology hardware and software (Westerlund 1998, 2005,2008, 2009, 2011, 2012, 2014).

4. ‘Intellectual Property’ is also becoming recognised as new concepts like the creative commons are explored (Bunt 2007). A new model of TT needs to be developed to transfer and trial this important new paradigm. The author also has his secret formulae to make smooth handmade paper at 150gsm that will be transferred using the creative commons approach.

This research is founded upon these three established cornerstones, and four other important evolving cornerstones.

2.1.3. Developing a Generic Model of Technology Transfer

A general flow chart model for TT that includes several activities is more fully presented in Figure 1 of Al-Ghailani and Moor (1995) and explained below. The model focuses on TT to developing countries at the centre of the model and is circled by the following factors:

1. Forms of TT;
2. Application fields of TT;
3. Types of TT, which include: technology life cycle; the seller and buyer’s needs; and the use of appropriate technology;
4. The channels of TT, which include: direct foreign investment, joint ventures; State owned projects; and the important role of multinational organisations.
5. Factor 5 holds the most importance for this project as it concerns the factors affecting TT to UDCs.

Several key points for which they argue include: the stakeholders; the technology market; the contract; the training of local staff and artisans; the legislation; the recognition of local culture; dealing with IP for a win-win scenario; and national policies.

They developed a good case study of Oman showing how a small country of only 2 million people quickly adopted new technologies over the last two decades. The IP and training of locals were two cornerstones of negotiating a win-win outcome for DCs and UDCs.

2.1.4: Improved Holistic Flow Chart of Technology Transfer

Building on these perspectives, one can revise the flow chart below (Hay 2003) that best depicts the concepts by adding more cornerstones, namely ‘tacit skills’; ‘indigenous technologies’ and ‘Best Availbale Technologies’ to make it more complete (see Fig 2.1.4).

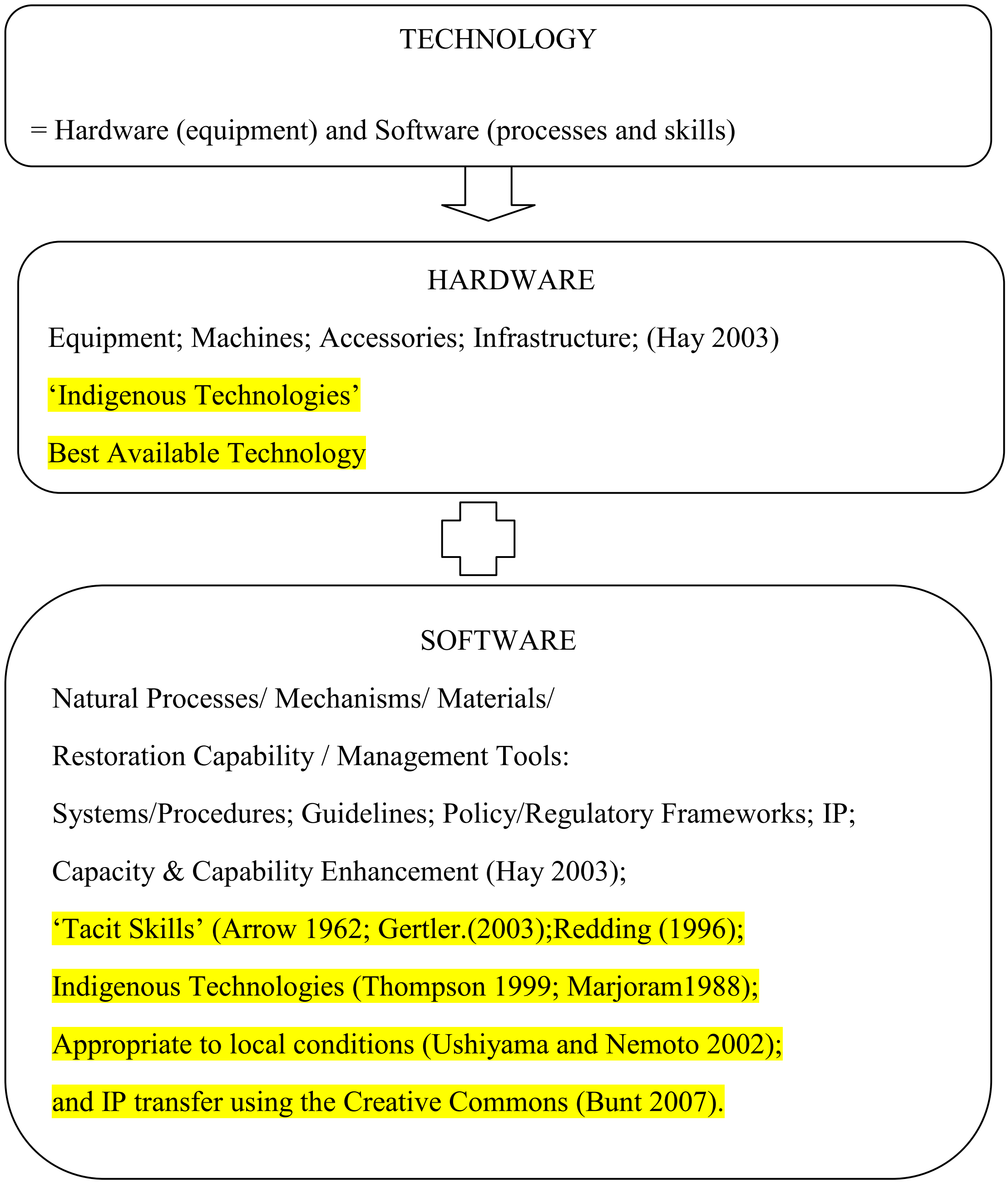


Figure 2.1.4: Revised Holistic Flow Chart of Technology Transfer.

The revised flow chart allows a more structured understanding of the complex nature of the intertwined factors of hardware and software. The ‘hardware’ is considered the range of new innovative technology equipment, machines, accessories and appropriate infrastructure. The ‘software’ is broadly considered the human skills, procedure manuals and management tools. This could include developing an operational procedure manual, or a regulatory framework, or skills training and capacity building of the staff, and now can include the artistic, creative tacit skills and gifts of master craftsmen.

The importance of traditional and cultural skill is important in helping transfer the tacit skills of technology transfer. Gertler (2003) tries to build on the historic research of Michael Polanyi in the 1960's by " using the idea of tacit knowledge to inform their analysis of routines and evolutionary dynamics of technological change". This expands on Polanyi's pioneering work and reaffirms the new importance of valuing tacit skills while acknowledging the importance of traditional skills and the artisan skills.

Under this new paradigm, the indigenous skills and technologies can be included, with training modified to suit local conditions while honouring traditional cultures and protocols. Perhaps to go further and include a separate section to isolate culture would be another challenge (Willoughby 1990). Some books will be written and published to capture some of these cultural stories and given back to the schools as reading books in local dialect and English. The new transfer of IP under creative commons can also be included. This acknowledges the donation of the best available technology to a less developed country (LDC) from a scientist, inventor or research institute (Bunt 2007).

2.1.5. Government Contribution

From another perspective, the governments in developing countries have a lower business capacity to take on and support new technology. The UDC governments lack support training centres like technical schools, universities and research facilities to progressively develop the worker's education and trade skills. From observation of living in Fiji off and on for a decade, the existing indigenous technologies already working in the villages and society are undervalued from a western perspective, yet, there are many shortfalls in modern hardware and software technologies available to city and village people. This complex fusion of hardware and software technologies needs to be objectively evaluated. This can be confronting and transforming as each new step is taken in pioneering this challenging scientific frontier as Godkin (1988) reports.

This is mixed into a generic economic world of maximising profit for investors at the expense of people and the environment. Traditionally it is up to governments to support scientists to pioneer a better way forward to help industry use new and better realms of innovative technology while encouraging industry to make a profit, meanwhile protecting and enhancing the environment. There is also a need for academic analysis of TT to be improved (Debackere and Veugelers 2005).

Kumar (2013) gives a usseful updated analysis of the waste options and scenarios of Fiji in 2013. The Fijian Department of Energy has also produced updated guidelines, with help from the Japan International Cooperation Agency, to the issue of waste hierarchy in Fiji (DOE 2011). In their Figure 1 the concept of the standard 3R theme in a triangle is "Reduce Reuse Recycle Landfill disposal". This helps give a perspective to the paper recycling project. This places emphasis on first reducing the use of paper, reducing imports of paper, reusing waste office paper, using both sides of the paper, reusing A4 waste but cutting into note pads or free children's school art paper, recycling options into other products like toilet tissues or cardboard and lastly, landfill/ burning/ composting. This thesis will elaborate on that and pioneer paradigms to add value to waste paper by converting it into higher quality craft industry smooth paper.

2.1.6. Intellectual Property

There is also a subliminal flow of skills and intellectual property (IP) involved in TT that is hard to acknowledge and quantify, let alone turn into viable enterprises (Moody 2007). While Nieto and Santamaria's (2007) research highlights the diverse collaboration of networks to help innovation and novel products come online. This is easier for DCs but the new innovative equipment and operating procedures are inappropriate or useless without training and operating skills being taught to the relevant operators in a developing country. The skill of the operator is the result of years of training and practice. Time and wisdom are required to effectively transfer this skill. From my drinking water quality treatment industry experience, industry calls it systems, guidelines, procedures, policy and may print out a fancy operating manual in which to hide their IP. This makes bigger companies look bigger/stronger than their business rivals and exert more IP leverage. IP is also seen as part of the contribution from the developed country, although this is being challenged by the 'creative commons' where new and innovative technology can be quickly introduced to any UDC to allow them to freely select from and use a range of good, sustainable and pioneering eco-friendly technology (Bunt 2007). This is complemented by the need to help define commercialisation strategies for entrepreneurs (Gans and Stern 2002).

Liebl (2004) is concerned about " increasing the earnings of poor people in poor countries from their innovation, knowledge, and creative skills". The book calls attention to the unwritten half of the World Trade Organization's Agreement on the

Trade Related Aspects of Intellectual Property (TRIPS). IP is an important cornerstone while multinational companies and markets are needed to connect the cycle in a profitable and sustainable way forward. 2.1.7 Multinational Companies

There is also a complex hidden agenda of multi-national companies (MNCs) in TT. Alkhafaji (1995) introduces an in depth analysis of the four theories of TT.

The first: 'oligopoly/monopoly theory' depicts the MNCs as the owners and controllers of most of the world's technologies.

The second: 'dependency theory' explains how UDCs are dependent on DCs. This is compounded by the negative effects of the multiplier effects that keep helping industrialised countries advance while suppressing local infrastructure in non-industrialised countries.

The third: 'screening approach theory' is supposed to be empowering for developing countries to screen the technologies for positive and negative factors and encourage more suitable transfer of technologies. If the less developed countries and MNCs can negotiate joint ventures or licensing agreements then the positive effects can be maximised over MNCs controlling the IP in wholly owned subsidiaries.

The fourth: 'supplier considerations approach theory' tries to describe the "practical reasons behind the MNCs to transfer technology". Developed countries can change their TT destiny more easily (Chataway 1999; Chico 1981; Craig 2000).

Thus a developing country needs to control its own destiny, understand their own business cycles (Chyi 1998) and somehow negotiate a better deal with MNCs in TT (DeCubus 1974), and more relevant to the Pacific countries (Dubious and Housepian 1997), and compete with DCs (Gao *et al.,* 2007). To do that a UDC must understand its own perspective, and that is radically different to the role of DCs.

2.1.8 Fundamental Differences

There is another fundamental difference between DCs and UDCs. Ming and Xing (1999) have uncovered a fundamentally opposite approach as DCs try to have product cycles that progress from "research to development to design to production", while for UDCs they argue the reverse route of "production to design to development to research".

In the case study of transferring new technology of hand pumps to help supply water to African villages of Swaziland, Baraki and Brent (2013) highlighted that up to 80% of the hand pumps were not working for various reasons. They argued that "Users have little involvement throughout the project life cycle, they do not know where and how to access parts, the majority of the areas do not have trained technicians, and the government does not have a stock of parts."

Barton and Maskus (2004) promoted the access to basic science and technology, to help UDCs start to get important sustainable low level technologies.

The DCs have large numbers of scientists, engineers and technologists and more R&D funding. The UDC route is a "learning and accumulation route, based on transfer and absorption of existing knowledge" Ming and Xing (1999). Some UDCs have many more millions of people, and thus more scientists to help, while small island nations have few scientists and even they are offered better working conditions in DCs. Many small island nations are living on the fringe and need special understanding and support (Halapua 2001; Keefer 199; Keefer and Knack 1997; Kopacek 2001; Mensah *et al.,* 2007).

Makino Beamish and Zhao (2004) highlight the concern that there are significant investment differences between UDC and DCs. They argued that "LDC markets are usually characterised by high potential for economic growth but weaker institutional support such as lower levels of property rights protection and enforcement mechanisms, lack of sophisticated intermediaries, and lower levels of political and financial stability." Thus a "high risk- high return" scenario. Moving forward from this broad base the next sections focus on the project for the Pacific region.

2.1.9 Large To Medium To Small Scale Perspectives

TT can be considered as part of the large to medium to small scale perspectives. From the larger perspective it involves a developing country and its economy, in this case Fiji Islands (Kassim 2002). From a medium perspective, it is a small business in a developing country, like a small engineering company near Suva city, that could also make the papermaking equipment, or the paper manufacturing printing company in Suva that buys in reams of internationally made paper that could also order some raw paper from the village. From a small perspective, it is a craft enterprise in a remote village of a small island state, in the highlands above Suva City.

This starts to focus in on how the many international agencies can help a small island developing country and thus, a remote village with some local small craft businesses to firstly, survive and secondly, pioneer eco-friendly projects in this unique context.

From the larger perspective, and from the perspective of the less developed country's economy, the "Process of globalisation is reducing rather than raising the ability of developing countries to integrate successfully with the World economy" (Lall 2001). In addition, Ees and Bachman (2006) depict transition economies with "rudimentary institutional framework… and weak legal structures" and UDCs as worse off. Furthermore, this is supported by Lall *et al.,* (2002) with case studies in Africa. China is a trying to encourage a range of enterprises in technology transfer (Niosi and Marcotte 2005). As Fiji is only a small island nation, there is limited research on it, so it is good to supplement the knowledge of TT with examples from many other developing countries. The Fiji and small island nations have more extreme conditions than larger developing countries.

From the medium perspective, a business perspective, Sharif (1997) argues that "businesses today have become truly global and … (there is an) increasingly competitive world economy … and developing countries have to use technology as a strategic variable for survival and growth". From a business and research perspective Henrekson and Rosenburg (2001) argue that "science based entrepreneurship" should be encouraged. IETC (2003a) are more concerned with decision-making and analysing how environmentally sound projects can be assessed to help "address environmental problems". While Rothernberg and Zyglidopoulos (2007) take on the printing industry and how environmental innovation can help. Hart and Ahuja (1996) challenge business to be greener and more viable. These example help create a new awareness and mould a better way forward for Fiji and their struggling small businesses. This leads into understanding the smaller scale perspectives.

From an environmentally safer research perspective of papermaking, bio-pulping seems one way for industry to go forward (Messner and Srebotnik 1994). Another way forward is using a species of giant reeds for fibre for sustainable papermaking (Shatalov and Pereira 2006). The Author also looked at many alternative fibre options to make paper in Australia and found it was harder to make a base fibre as a base crop and much easier to use waste fibre from primary crops like wheat and sugarcane (Westerlund 2002). Perhaps Powell (1989) has stimulated some more research into handmade paper and recycling with an education and research perspective. While Rennie and MacLean (1989) argue we need to salvage the future by encouraging waste based recycling.

Focussing on a small scale perspective, the project used as a major case study in this thesis, the transferring of hand-made paper technology from the author to a village in Fiji, can be considered from this perspective and can demonstrate at least seven areas of concern for appropriate waste treatment and recycling options to develop new uses for waste paper.

1. Craft industry papermaking is an example of saving or 'recycling' a waste paper resource: it recycles and saves energy, chemicals, with flow on benefits to reduce air and water pollution and symbolically stop old growth forests from logging.

2. Recycling and papermaking also reduces the use of toxic chemicals in making new paper. All of this is achieved while using modern science and innovation to complement traditional craft skills with the 'best available technologies'.

3. The project also pioneers 'value adding' a waste (paper) into a higher grade product (printer or photocopy paper). In Western Australia, there are 186,000 tonnes of waste paper produced each year and, as 10 percent is writing paper, that means 18,000 tonnes of good quality waste paper could be available (Cardno, B.S.D. 2007). In Fiji, the government printing department were discarding 10's of kg of quality offcuts per week of waste paper, more than enough for this project just from one of many printers in Fiji.

4. The project is a good example of recycling and eco-friendly principles. The Western Australian project could at best use one tonne per year which is 0.005% of the sub-market. Likewise for Fiji, there is excess free waste paper from industry and government departments. This, symbolically, helps a nation contribute research to the search for more eco-friendly technology and pioneer the use of clean development mechanisms.

5. It is a concern to respect cultural and heritage values in supporting traditional villages with appropriate scale craft industries. These combined principles could then be applied to other small scale appropriate technology based industries.

6. It is the new use of IP under the 'creative commons' to empower a remote village with the latest and best available technology and intellectual property from the author to be directly taught as appropriate to their needs and skill levels as required to make a new cottage industry paper product.

The thesis case study also pioneers small scale industry principles, which if done on a bigger cottage industry scale, could be responsible for saving resources and the environment and lead to more discussions in positive outcomes of supporting craft industry employment and sustainable development.

Thus, this research thesis is not just about transferring a fixed set of papermaking technologies to a UDC and expecting them to work, then walk away and leave it. It pioneers a more sustainable and holistic approach, with a strong scientific research base of using the 'best available (craft) technologies' and can be adapted to a village craft environment with local industry and university and government network/helix of intertwined help (Etzkowitz and Leydesdorff 2000; Forest 2006). It also has an important symbolic connection to many international environmental programmes like Agenda 21, the World Bank environmental program, the Kyoto Protocol, the 'Program of Action' and the United Nations Conference on Trade and Development (UNCTAD) (Each referenced later in next section).

2.1.10 International Groups

There are several international agencies that have expressed an interest in improving the opportunities for LDS to improve their standard of living and access international help.

In article 4.5 of the UNFCCC it states that the more industrialised countries can help "take all practicable steps to promote, facilitate, and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other parties,…developing countries". The World Bank and the 'global environment facility' (GEF) have also expressed a concern to acknowledge and support eco-friendly technology in their portfolios. The Kyoto Protocol is another international agreement within the United Nations (UNFCCC) umbrella to reduce greenhouse gases and support eco-friendly new technology transfers. Part of the enabling environment is to promote 'clean development mechanisms' (CDMs) with companies (Amin 2005). Another is the International Energy Agency's "GREENTIE" program and another is the 'centre for analysis and dissemination of demonstrated energy technologies (CADDET).

Theories and idealistic intentions are a good start, but there needs to be a more concrete plan of action and particularly for the Pacific region a 'program of action' is needed.

The 'Economic and Social Commission for Asia and the Pacific' (ESCAP 2006, 2007) delivered a 'program of action' based on progressing toward the attainment of the 'millennium development goals'. Under Section 3-75 for TT that is "appropriate to the needs and resources of least developed countries". This is hoped to "improve integration of these countries into the global economies and facilitate their overall development". The "transferred technology should be readily accessible, use resources and skills available within the country." This should minimise maintenance costs, be less costly in the long-term perspective, and holistically "be beneficial in all areas".

From this important foundation, in Section 3-76:…the argument of "technical assistance and training opportunities should be available through research institutes attached to regional universities" which it is argued will "lower cost of technology" and is hoped to improve the access and thus expand knowledge significantly in these respective countries. This will be developed in this thesis with help from the engineering department of the local university (USP).

Complementing this support for the artisan's skills, Section 3-77 develops a legal framework that should be established for the "transfer of traditional knowledge as well as indigenous technology" thus honouring the importance of the contribution that indigenous knowledge makes.

Further to this, in Section 3-78 it argues for "regional cooperation and support" and prefers help from the countries of the region that can "help transfer and use of new technologies", especially in relation to the least developed countries. Building on this foundation of producing a high quality products Section 3-79 focuses on marketing with the emphasis on "development of niche markets" that are essential for new and evolving paradigms of exports from these countries. This is already started as Pure Fiji have helped marketed the rough paper as wrapping paper.

Complementing this is the environment section C: 3-82/83 which states that "Measures to protect and conserve the environment must be adopted, promoted and supported". This can be implemented by "effective waste management" and "through the greater use of recycling" and "in line with proper environmental safeguards."

More specifically to the Pacific region, Handani (2004) also referred to disseminating TT to the Pacific islands and encouraging the process. This empowers the project with a framework for a highly structured 'program of action' for the Pacific region.

While the Pacific is important for this project it is still wise to look at how other research helps to integrate international technology into a local UDCs context.

Stewart (1981) suggested three reasons for UDCs to develop local technology capacity: to adapt it so 1. "it becomes more efficient in use"; and 2. "imported technology is often inappropriate to …LDCs… and tends to be capital intensive and large scale and often produces (irrelevant) sophisticated high income products"; and 3. "technological dependence is a major (negative) factor…likely to be perpetuated". This research is complemented by Crane (1977) who suggests to "stimulate the production and diffusion of 'indigenous technology' in LDCs by creating new types of research in the universities and coordinating agencies in government". For example the centre for appropriate technology train young men from each village in new and cultural technologies (Bola 2006).

Theory is good but case studies are also important and Rajan *et al.* (1981) examine several Indian case studies and suggest several practical ways forward. Lastly, all this takes "strategic planning and time" for developing countries as Strelneck and Linquiti (1995) argue for it to be effective and beneficial to all stakeholders. Thus there is a clear new holistic approach to be explored as a more positive and sustainable way forward for Australia's neighbours, the small islands nations of the Pacific.

2.1.11 Measuring Technology Transfer

Henry, Kneller and Milner (2009) used an in depth stochastic frontier analysis to model the production frontier for technology transfer to 57 developing countries for the period 1970–1998. They tried to measure cross-country and temporal differences in efficiency levels and to explain the differences in efficiency levels. As expected, the results indicate significant differences in efficiency levels of technology transfer, but they were focussing on importing capital goods. They concluded that:

Y(output(GDP)) = function of K (the stock of physical capital); H (a measure of the stock of human capital); L (labour supply); RDm (the stock of foreign technical knowledge); T (Time)

This formula acknowledges some important factors. However, it is not relevant to empowering small island nations or developing countries from the ground up at a village level, let alone dealing with craft orientated products that are opposed to their concepts of mass production efficiencies.

Hoekman Maskusk.E and Saggi. (2005) use the concept of International Technology Transfer (ITT) as the new acronym for describing how they discuss and evaluate TT in developing countries. They give a good history and background to the evolution of the modern understanding of TT.

Karakosta, Doukas and Psarras (2010) also promote a simplified 5 stage transfer of technology: 1 Assessment; 2 Agreement; 3 Implementation; 4 Evaluation and Adjustment; 5 Repetition. This really is just a 3 step cycle where 1=4 and the 5th is the cycle. In their Table 1, on p1548, they use a 1-3 plus/minus system of rating the TT pathway with governments, private sector and community levels of analysis. The (1-3 +/-) would be useful to use in this thesis.

Lema and Lema (2013) acknowledge that "fairly little is known about the process of technology transfer in CDMS" and also refer to it as opening the "technology black box". They then use empirical analysis to help them understand the new paradigms in wind power for UDCs. Projects using CDMs can generate tradable carbon credits, used by developed countries to thus comply with the new Kyoto Protocol commitments. They also introduce the concept of 'local technology transfer' that may have originally been international but is now localised and transferrable.

Lulu, Seyoum and Swift (1996) realise the importance of using "objective criteria" supporting high levels of linkages to "maximise societal goals." This decision model approach helps support the approach in this thesis of being objective and evaluating the technology transferred.

2.1.12 Modern Craft Industry Paper-making

Hubbe and Bowden (2009) give a comprehensive account of the history and evolution of modern papermaking and note that "handmade paper has enjoyed a resurgence, both as a traditional craft and as an art-form".

Yang (1997) examine the papermaking traditions of Asia, but this is very different to the western style of papermaking as they use a mucilage to hold the fibres apart during the screening process. Mucilage can be extracted from legumes or seaweed, is a polar glycoprotein and an exopolysaccharide that helps coat fibres until they are dried and pressed. The Nepal artisans use 'lokta' fibre, sustainably harvested for hundreds of years from local forests (Chitrakar and Prescott –Alen 1996).

The author, has pioneered the western way of papermaking. This research started in 1977, and developed into a cottage industry in the 1980s and 90's ,and developed new smooth technology equipment, treatments and processes, that combined, can be used to make a 150 gsm paper for photocopy machines (Longwood-Westerlund 1997). This continued into the 90's with research at the university of Wollongong and Murdoch University (Westerlund 1998). Alternative fibres for the Australia Pulp and Paper Industry were also researched (Westerlund 2002), for example farmers could get a supplementary income by collecting and selling the waste stubble/straw and encouraging a new papermaking industry in major farming areas. Thus a primary crop yields wheat and profit, while the secondary fibre can be used for papermaking. This thesis has allowed ongoing research to trial many of the new hardware and software technologies. Some ongoing marketing trials with 'Jacksons Drawing Supplies'; 'Art Paper and Supplies' in Western Australia by the author has reconfirmed over the years that no other smooth hand made paper is being marketed around the world. The author had ongoing discussions with Kevin Jackson, since 1985, of the prestigious "Jacksons Drawing Supplies" in Western Australia, recent discussion with the new owner / manager confirm that after his recent trips to Europe to source quality papers, that the author is still, after 3 decades, the only smooth photocopy type handmade paper in the world (Boercamp 2014).

2.1.13 Mandate

Thus there are several international guidelines/protocols that support the principles of an eco-friendly pilot project of papermaking in a remote Pacific developing country village. This gives the thesis a mandate and a frame of reference to trial a generic transfer of technology program relevant and culturally sensitive to the needs of a village community in the Pacific region and a parallel pilot plant in a modern Australian lifestyle village.

2.2. Developing a Framework for Understanding Technology Transfer

2.2.1. Introduction

This section will highlight some case studies and women's perspectives relating to TT in the Pacific region. As women make up about 98% of the papermaking workforce in this Fijian village it seems more important to focus on their needs. The aim is to provide a broad perspective of the complex range of issues involved in supporting successful projects over many years of development and implementation, and to examine ongoing improvements until new levels of technology take over and make once pioneering ideas obsolete.

There are many attempts at various levels of TT to Fiji. The following examples give a range of perspectives of the three cornerstones of: financial viability; social acceptability; and environmental sustainability. Some of the more relevant examples are: solar energy for villages; the smokeless cooking stove; the coconut oil / juice extraction; promoting the garment industry; and a background on women supporting TT.

The following Table 2.2.1 shows how the case studies reflect on the major cornerstones, (Bennett 2002; Hay 2003; Hecht 1999; Keefer 1999; Lindsey 1998; Lipp 2002; Shapira 1996; Strawn 1982) as well as the use of the best available technology, the intellectual property protection, and how the technology (hardware and software) can be practically implemented. A 'cross (x)' indicates the project needed a big injection of aid money to help start it or a 'tick (√)' indicates it is financially easy and appropriate to start investing in the project. This Table will be revisited at the end of the chapter as the number of ticks and crosses are refined to indicate the potential good that can come from the project.

Table 2.2.1: Initial guide to show how the case studies reflect on the cornerstones of financial viability, social acceptance and use of best available technology, green and environmental sustainability, intellectual property (IP), hardware (HW) and software (SW) implementation.

	Financially Viable	Socially Acceptable	Best Available Technology	Green and Sustainable	IP	HW	SW
Solar Energy	X	√	√	√	√	√	√
Hydroelectricity Energy	X	√	√	√	√	√	√
Smokeless Stove	√	√	√	√	√	√	√
Coconut Oil	√	√	√	√	√	√	√
Garment Industry	√	√	√	√	√	√	√
Book Making	√	√	√	√	√	√	√
Water Bottling	√	√	√	√	√	√	√
Fish Canning	√	√	√	√	√	√	√
Mat Making	√	√	√	√	√	√	√
Existing Rough Papermaking	X	√	X	√	X	X	√

Karakosta, Doukas and Psarras (2010) in their Table 1, p1548, use a 1-3 plus/minus system of rating the TT pathway. This rating is modified as a guide to start to value and explain the importance of the projects with an environmental and culturally favourable bias.

2.2.2. Energy for Suva City and Some Villages

The Pacific Islands, focusing on Fiji, have an interesting history of energy technology improvements (Bolabola and Lloyd 1991; Lloyd 1991; Thorne 2008). Lefale and Lloyd (1993) conducted some earlier research into the South Pacific region and noted how diesel motor electric systems were being replaced by the photovoltaic systems. As the diesel servicing them had become too expensive, so often the best intentions of transferring the new technology are lost. Likewise the new battery technology for photo-voltaics was also failing and was too costly for an impoverished village to repair. After the World Summit on Sustainable Development, Spalding-Fletcher (2003) suggested capacity building and TT to help overcome these problems. Since then, the Department of Energy (DOE) in Fiji has run a trial project in one village to use solar power to make available one power point and three lights per house, at a cost of $3,000 (Fiji $) per village. The project was expected to help 400 villages (a $1.2 million project), but since the coup of Dec 2007 it has only completed one quarter of that goal and more financial restrictions have been applied as the interim military government seems to have given that project a low priority. The holistic concept is good, to empower each remote village with some reliable free power from the sun and save the use of diesel and generators and thus be more eco-friendly and sustainable (DOE-Fiji, 2008, Figure 2.2.2a) but the implementation has been poor and delayed due to the coup.

With modern advances in solar power, an Australian company has pioneered better and cheaper systems that are now commercially viable in Australia and could rejuvenate this project for the pacific region (Livingston 2008). Other energy research projects are the wind turbines at Sigatoka (Figure 2.2.2b); the geothermal energy research; using free wave power from the ocean currents around islands; using more of the Monosavu dam water for hydropower; and at a village level, using in-line water turbines for fast flowing rivers.

Brent and Rogers (2010) applied a new sustainability assessment methodology to a renewable energy technological system in an African rural village. This project consisted of complementary wind, solar and lead-acid battery energy storage technologies. They were implemented as a pilot mini-hybrid, off-grid electrification system for the village. The results simply indicated that it was still far too costly for villagers to afford on their limited incomes, in fact "the economies of scale for renewable energy supply technologies favour national grids". This could be trialled in Fiji with many remote villages using a complimentary wind-solar-battery energy system.

The Monosavu hydroelectric scheme is another exciting, pioneering example of using international aid money to invest in building a water storage dam in the highlands above Suva for a stable water supply to generate sustainable electricity for Suva city and villages. The project is structurally positive up to the limit of rainfall. Recent changes in the weather patterns have reduced the annual water rainfall whilst increasing population and lifestyle changes have unsustainably increased the demand for energy. The problems are compounded as they run the plant on reduced water levels, resulting in reduced energy conversion efficiency, thereby creating the need to rely on 'diesel turnkey plants' to supplement the energy supply for Suva. While the author was there in December 2006, the dam level was low and power restrictions were implemented, there was talk of more powerful diesel plants being needed, but no guarantee of who was going to fund it. Then the rains came and local flooding filled the dam (Figure 2.2.2cde); truly a region of extreme social and environmental conditions.

Another option of research into sustainable power is to use some of the excess coconut oil as a bio-diesel. Initial research has indicated up to 80% can be safely substituted into existing engines (Raturi 2006). This can be produced locally, saving on international imports and foreign debt, and be sustainable for this remote island nation. This potentially useful holistic project lacked funding and support, so it is still a fringe project.

With the promised return to elections, and stable democracy, Australia and international countries would be more encouraged to help Fiji and the Pacific region. These examples highlights the desire to invest in more sustainable energy options for the future of a small developing country that cannot afford the expense of using fossil fuels, while the negative effects of the greenhouse effect and rising water levels directly impact by flooding some low lying islands in the Pacific. The Pacific region desperately needs alternative sustainable sources of green energy and this highlights the need for TT.

2.2.3. Smokeless Stove Technology Transfers to Fiji

The history of cooking and stove technology in Fiji is a fascinating, great and appropriate example of TT over the decades. Some projects were evaluated in the Pacific Region connected with "improved cooking stoves" (Marjoram 1990). He investigated three approaches: the 'integrated approach'; the 'self help approach'; and the 'dis-integrated approach'. However, the original project to help improve the use of firewood and stoves in Fiji seemed to have originated with the 'National Food and Nutrition Committee' that commissioned Mr Steven Smidtz of New Zealand to help in 1980. They focussed on cooking for boarding schools for frying, boiling water and baking with minimum smoke.

The 'Rural Energy Research Project' then took over the project, under the supervision of the Department of Energy, in 1984. Mr Kurt Conger was a key person who wrote a practical hands-on manual about 'How to Build a Smokeless Stove'. They produced one book of basic designs with technical drawings (DOE-Fiji 1984). Tukana and Deo, in 1983, then improved the design and came up with the “Fiji Institutional Woodstove (model#2)”. Tukan and Goodman (1992) also published a book on the woodstove.

The Foundation of the Peoples of the South Pacific built on this technology. They made over twenty four more stoves for villages and used newer technology smokeless stoves since 1994. They built on the earlier initiatives and focused more on health, nutrition, and environmental impacts (Macgregor 1997). They then produced a high quality book on a construction manual for a $3000 stove.

There was a ‘woodstove working group’ formed about 1989 to help to transfer the technology and “identify appropriate woodstoves for wide scale dissemination in Fiji”. This resulted in a rural survey in 1991 over eight regions. The survey found that the importance of the new ‘smokeless stoves’ was of low priority as good firewood was easy to get in a tropical country and the villagers would not buy the more expensive materials to make the new stoves with the so-called smokeless technology (Tukan and Goodman 1992). This is the opposite conclusion to the Yevich and Logan report, which suggested that firewood and cooking were major issues in developing countries (Yevich and Logan 2003). This, and similar case studies, have proved how local input and support is critical to the success of a project and that international organisations should not impose their perceived values on the Fijian community.

The ‘Tutu Training Section’ was contacted by the author as they were the first to run the woodstove project. Ms Robin (2008) said that many local training workshops were conducted at the school in the 1980’s and she remembered the Smidtz family as important in the transfer process. She noted the importance of good inner design and cementing qualities with some needed changes each year in the hot plate and heating coils. She is only an unqualified cook/ helper and yet was using the design each day for the school. Her valuable first-hand experience of using the technology should be acknowledged and respected.

The next design was the ‘Delainavesi’ Sote House design. The author managed to speak to a former head teacher, Mrs Litia Tukana, now retired in Suva, who was a student and later a teacher at the historic school (Tukana 2007). The author also managed to visit the school, photograph the now derelict stove, and talk to staff. The current cook of the boarding school has used the stove. She showed how she first cooked on the open fire before the new smokeless technology. The next gas type stoves were also rusting in the room and would make a good component in the chronology of the use of these stoves. Figures 2.2.3.a,b,c,d show the Ballentine Memorial School entrance; the smokeless stove; the big pots and handling skills – the use of sticks through the handles to control the emptying of the hot water; the previous metal grates / bars they had to cook on, and the new smokeless stove hotplate.

Mr Smidtz then built several models based on that newer design. This is an example of small steps and leapfrogs in TT. A subsequent DOE (1984) report highlighted a flaw in the design and lack of maintenance, “the clay lining was badly deteriorated and the flue passages were blocked with broken clay debris and creosote. They introduced new research and technology to use ‘firebricks’ to cope with the higher temperature, better flue passages and better hot water drums. This empowered them, with local design and improvements, to create with the best available local technology.

Time moves on, and technology keeps improving in small and large steps as Figure 2.2.3.e shows. The school could partition off the 5x10m area and be encouraged to preserve and display their range of cooking technologies. A modern appropriate village outdoor stove is shown in Figure 2.2.3.f. This is currently used in Wainimakutu Village. They built it as a local empowerment project to help empower villagers to make quality fresh bread and buns in the modernised remote highland village without the need to rely on trucking in expensive supplies from Suva .

In Jan 2007, the author visited a remote village with a house project to learn first hand how to build a modern standard village house with wooden walls and floor, tin roof and louvres for cross ventilation (Figure 2.2.3ghi). The village of Sagani is on the second main island of Vanua Levu near the Natewa Bay, two hours by 4 wheel drive from the main town of Savusavu, The author helped to design and make the kitchen with a modern appropriate cooking stove (Figure 2.2.3.jklm). Using the best available local village technology, the fire stand was raised to about a metre high for easy use, a recycled tin plate was laid on the base, and a covering of local clay and bricks formed a base for the pots. The pots sat on the brick/clay and the sticks were fed in under the pot (Figure 2.2.3.m.). The flue was a tall tin structure with a traditional cross tin on top to draw off the wind and extract the smoke (Figures 2.2.3kl). Louvres were also installed beside the standing zone to help keep the cooking zone clear and create a cross flow if needed (right of Figure 2.2.3m). The 500 litre new plastic tank for drinking water featured a novel improvised cut-in, angled and silicone - overflow from the roof to a new rock frog pond (Figure2.2.3o). The availability of clean water and cooking food are the daily challenges for women in village life. Any project to help empower women at the grassroots level is most important, but that subject is beyond the scope of this thesis.

Discussions were also held with the Director of the Centre of Appropriate Technology and Development (CATD) concerning the stoves they teach the students to make for the villages (Figure 2.2.3pq). The CATD is specially funded to provide young men from many villages with first hand appropriate technology skills to take back to their village (Bola 2006), (Figure 2.2.3r). There is a tremendous opportunity to work with these established organisations to help promote and teach useful technology transfer projects that can be taken back to many villages.

The author has also tried to understand the deeper longer term importance of local skills and technology by observing the history and the making of suitable cooking stoves in Fijian villages. Lipp (2002) explains many mechanisms of TT that relate to this and how the big smokeless stoves have evolved. He discusses some of the many small-big-radical technology issues that were actively tried in Fiji by private and government departments. Now the use of gas stoves and newer leapfrog technology has evolved to replace the smokeless stoves. It is common practice now in Fiji to have 20 kg bottles as the standard affordable gas bottle to use. The author has observed over 10 years of returning to Fiji, the impact of the current economic pressures. Some urban villagers cannot afford the gas, and revert to kerosene stoves and 'lovo' traditional cooking.

These example covers the cornerstones and more as all levels of the helix of support have striven to modify and improve good technology for the local conditions (Etzkowitz and Leydesdorff 2000). This example highlights the importance of government support to complement local training initiatives to make instructional books in local dialects and train local support groups to systematically transfer good technology to the village. This example also highlights the hands on evolution of the best available local technology and adaptations to keep on improving it for local conditions and to make it culturally acceptable. It is a great holistic example of many good principles of appropriate and sustainable TT.

2.2.4. Coconut Oil and Juice Extraction Technology Transfer.

The coconut oil industry is another strategically important analysis as it is the basis of the economy of many villages over many islands. Traditionally many coconut palms were planted to establish the copra-coconut industry. Now the industry is in a lull period and many trees are left unmanaged and plantations are not farmed. There is an opportunity to rejuvenate the industry by introducing new technology to squeeze the white meat to extract the oil and the residue can be used for animal feed. Value adding could include cake making, cosmetics, drinks or energy applications (Figure 2.2.4abc).

One such attempt was with re-designing a new sophisticated coconut oil –cold-press– extraction process to produce quality oil, yet simplified enough to be used by unskilled village men. The modified screw press helped hydraulically press and extract the oil in a 'continuous process' thereby saving time compared to batch processing (Bossley 2006; Bula 2008; Sharma 2006). The Small Industry Business Manager, Mr Sharma discussed with the author, how he was asked to be involved and helped improve the design and build a working model and in reward offered some intangible rights. He thus helped an Australian based group to liaise with the Fijian Coconut Research Department, but nothing initially had come from it. The initial results appeared very positive, innovative, affordable and very suitable for villages to buy and use but delays in time and indecision costs the small business dearly.

Meanwhile he could not make more units and start using the technology due to 'licensing restrictions' and waiting for the Australian based enterprise to get more funding and approvals. Meanwhile other leapfrogging technologies were being developed by other entrepreneurs and one company started on oil extraction with better financiers who were prepared to get on and start a manufacturing base in another town, Savusavu. Mr Sharma's time and resources were potentially lost while the opportunity has gone to others.

Perhaps his business could have had proprietary rights to use the new different–novo–technology within a specified time period and capitalise on his investment, or perhaps he could further modify it by 20% and claim it as his own invention and get on and make some units for sale to villages. It is very hard for small businesses to help in TT without rewarding them with these opportunity costs and rewards.

This leaves the opportunity for a new company to try to secure local supplies of coconuts for their operation, without empowering the villagers to do the oil extraction phase themselves. They have their own company (profit & control) interests at stake and would restrict the availability of the profitable technology to the villages. At least the villages can do three simple processes: collecting coconuts, husking, and bagging for delivery to the central processing facility. For this they will get a minimal return for their labour in the village and finally, and most importantly to the villagers, they won't have to worry about the business side. Perhaps this is a satisfactory compromise - to let the local Fijian villages do what they like best - then let a small entrepreneur in to make a modest profit and encourage the NGOs and government to help at this small enterprise level. A year later, in the review process in January 2008, the Fijian, 'On Time Engineering' business had survived the coup of December 2006 to now have orders for several units of the new machine (Sharma 2008).

Several important lessons were learnt from this one current small industry example. This case study highlights the new cornerstone principle of controlling IP to help empower DCs and villages while being sensitive to their culture, sustainability and economic viability.

2.2.5. Garment Factories in Technology Transfers to Fiji

Fiji has chosen to get behind the new evolving garment making industry. Chand (2001) explores the history and development of the Fijian garment industry and how the government has supported all levels of training and helped with tax free zones. His concluding remarks went beyond such easy to identify factors as cheap labour and tax havens, to acknowledge preferential market access, transportation, communication infrastructure, productive workforce, and location between Asia and USA. They stressed the added benefits of "improved technical and technological competence to be the hallmarks of a good quality labour force" Chand (2001).

This is supported by the experiences of Chico (1981) who suggested that "extension services must be staffed by indigenous engineers or technicians," and thus complement the local traditional environment. Chico examined the Fiji National Training Council (FNTC) and how it actively supported small and medium enterprises in Fiji. Fiji had many choices to make along the way. It could follow Clarke's (2001) rationale, that "enterprise will benefit from adapting, improving technologies to local circumstances" rather than imitating the industry processes (Pack and Todaro 1969). Early research by Crane (1977) also acknowledged the "lack of links between scientific and technological institutions" and their case study has overcome many of those issues in an integrated partnership to help the garment industry. In summary, these case study provides several important lessons on the cornerstone principles and how to successfully network with all stakeholders to create a long term viable craft based industry in Fiji.

2.2.6. Bookmaking Technology Transfers to Fiji

There is very limited research into bookmaking for UDCs. Jenkins (2000) did a project for Papua New Guinea which was one relevant UDC example. Fijian cultural stories seem to be carried over from generation to generation through retelling family stories. They do not seem overly interested in books and recording stories. One Fijian teacher explained to the author that they personally have memories like a photographic record of the story, word for word, so why bother with books (Tukana 2004). A few women tried to change that and record some stories for the education department. In discussions with Mrs Litia Tukana, (2007, 2008, 2009), she enlightened the author about her journey. It started with her being a daughter of a Fijian primary school teacher. Her father's family strongly supported education as a way forward. She became a home education teacher herself and even taught with her father in the same village near Savusavu. In her retirement, she recorded some important cultural stories and wanted to approach the education department to get them published (Figure 2.2.6ab). The Fiji Education Department were half interested and half supporting. The stories were started and drafts made in 2003/4. They were waiting for funding with further delays in 2005/6. More submissions were made and funding re-approved. A final draft was ready in 2006. The Fijian Affairs Department then wanted it re-edited to their new Fijian Dictionary standards (Wara 2006). This waited until the many technical arguments were resolved on how to adopt non-Fijian words into their many dialects and common Bauan national dialect. 2006 went slowly by and the political 'coup' of December 2006 caused more delays, then came the Christmas holidays and more delays. The Ministry of Education was about to hit the print button and then thought about the ISBN number and opened up dialogue with the University of the South Pacific Library, causing more delays until the final publication occurred in 2008.

There is now a national agenda to promote Fijian stories in conversational style books for schools (Drova, 2008). They also depend on international funding to support educational initiatives. The Government Printers Department, near Suva, Fiji, does conduct training for trade skills in bookbinding and produces a range of quality publications. There is a foundation to help develop a sustainable good book making industry in Fiji to meet local demand.

2.2.7. Water Bottling in Fiji

This section will briefly introduce the important role of creating a water bottling industry in Fiji, based on the novel marketing approach of internationally selling Fiji's underground water in the USA as 'Pure Fiji' drinking water. The author inspected the production plant near Nadi in 1998 and followed the evolution of the new industry over a decade. It has grown to be a major source of income for private enterprise, government royalties, and training and employment for the local villages. Other companies have tried to copy the success of the original project but failed for various reasons (Figure 2.2.7). No major scientific references were found on the TT of the project, perhaps the potential profit is too important to protect for the industry. Some reports of water quantity and purity were commissioned by the University of the South Pacific but are not available for public access. In 2008 the government was looking at trying to encourage other industry partners to duplicate the success of the project. Meanwhile the company has been through the courts, internal-fighting to control and protect the valuable IP and market share from its own owner/managers.

This example highlights the many lucrative areas of TT that can really help Fiji progress holistically and sustainably by selling off the underground water to the international market as pure Fijian artesian water. Is it holistic ?, as it seems to create employment from clean water using clean filtration systems and no pollution and exporting it to the western world for profit. Is it sustainable?, as managed correctly it could generate years of ongoing royalties from a deep aquifer but if over drawn the water table may quickly deteriorate and be not sustainable.

The alleged negative perspective is that the local subsidiary company is just making a profit, on the books, allegedly underselling the wholesale product to its American parent company to make more profit. This, it is argued, avoids paying too much tax in Fiji. The government seems to accept this and is happy for a few villagers to be employed in the bottling operation. It subsidised the industry to help it get established. Once established, it is now starting to tax the exported product. This is creating local jobs but generating minimal export income for the Fijian economy.

2.2.8. Women in Technology Transfers to Fiji

This section will briefly introduce the important role of women in Fiji society and how that relates to case studies, the development of better technology to help women in the home and business, and look at examples in the fishing industry, garment industry, tourism industry, an international perspective, and discussion of the cornerstones.

Fiji has a chiefly system that is male dominated and women are more home support for the men and families. They help a lot in the gardens weeding, planting and harvesting, on top of their domestic duties of cooking and firewood gathering. Families are placing more emphasis on their children's education, with some families sacrificing a lot to help their children enter high school, technical and /or university studies. As this case study will be in a remote village, with women making up 80 out of the 83 workers, it is critical to understand the new evolving role of women in the remote village workforce.

The subsistence fishing has also changed, as Kuster *et al,* (2005) argue that the change in technology from "traditional outrigger canoes to outboard powered vessels has caused a dramatic increase in catch rate", and the focus is less on women catching fish each day for subsistence and more on developing employment and sustainable yields for the villages. The fish processing industry has been supported over the last decade and is very dependent on women in the labour force. They seem to be the bread winners and empowering them with money and freedom helps to, change the dynamics of society. Some men are now staying home to mind the children, cook and change roles. This has created some reverse social problems as men have lost their power or control over women and money. A new balance will evolve as the community as a whole benefits from the extra income, impacting on school, housing, food and church. Yes even the church seems to have its hand in any money from villagers as each village chief seems to have a dominant church support. The missionaries seems to historically win a chief and thus village over to their religion.

Near Suva city, the garment industry is dominated by hundreds of women sewing in intensive controlled production warehouses. A lot of Indo–Fijian women find employment, cash-flow and empowerment. The Indo-Fijians have to work to pay the rent and food, while there is less pressure on the indigenous Fijian villages with free tribal land and rent, so they can be subsistence farmers and get along with food on the table and enjoy the tribal life. The Indo-Fijians seem more suited to controlled working conditions and seem to accept them more easily. The Fijian culture obliges women to help in the village in time of community work, funerals, weddings, and church so there appears to be a conflict of cultural issues when women choose to leave the village and work in the city. A funeral may take a week of (free) work for some or all of the village women. The business interests come well behind cultural interests. In time the Fijian culture is adapting to controlled working environments and they will adapt their craft skills to the garment industry.

The tourism industry needs a lot of cleaners, receptionists, sporting attendants, cooks, waiters and guides. This is opening up a better range of quality careers for women. Many resorts are located near villages and have a local employment strategy worked out as part of the goodwill and lease agreements. This improves local employment for the villages and strengthens their financial security, education, arts and crafts, and future jobs for the teenagers. More handicrafts can then be sold to the tourists and the villages are more exposed to a range of international languages and culture. Some relationships have formed with men and women travelling around the world in new marriages.

One valued employment activity seems to be teaching. Many women are now employed as primary and high school teachers. Some schools offer separate home style accommodation while others stay in the village. The average Fijian teacher gets five thousand dollars a year (2006). This creates a stable flow on effect to the village. In meeting some village teachers, one began to see the positive flow on effect to one family in one village. In this case, she married the chief's grandson, which gives them extra honour in the village. They were building a house from chainsaw cut local-bush timber and a tin roof. The husband could now afford a chainsaw and cut their own free timber from tribal land (Pictures 2.2.8a). The wife (teacher) could buy a sewing machine and help the nieces sew clothes. The next combined project was a TV and DVD player so at night they can watch TV from 6-9pm depending on the village diesel power. Their next project was to buy a computer to help with her teaching and secretarial opportunities.

Another prestigious employment activity is seen in nursing, both in the city and at regional nursing stations. The author had the pleasure of meeting Meridani on the first trip to Wainimakutu village and she welcomed me, a foreigner who could not speak Fijian, into her extended family (Figure2.2.8bc). She could speak fluent English and helped me understand the village protocols. The Suva City Hospital employs a number of nurses and cleaners, helping to create a stable employment option for women.

Slowly women are becoming more involved in the police force, but this seems more so near the city. There is a range of professional employment options open now for women with suitable qualifications. They are also expected to donate more to the village, in 'soli'(cash), and the tribal tradition is still strong and evolving.

Another activity for uneducated village women seems to be selling the village produce in the regional Suva markets. They leave the mountain villages above Suva by 3am each morning, squashed in the back of a courier truck with everyone's produce, and arrive in Suva by 8-9am to sort out their produce ready for sale (Figures 2.2.8de). They may spend the morning selling, leaving in the early afternoon for a long bumpy ride home. This can cost 10-20 dollars per day, plus cartage of 50c per bundle for the crop, leaving them little financial return for their efforts. The weekend markets are worse, they have to leave on Friday and sleep over Friday night in the potentially dangerous conditions near the markets, sell on Saturday and maybe get home Sunday ready for church. The roads are narrow, gravel and there are dangerous steep slopes, subject to landslides and flooding (Figures 2.2.8fgh). It is thus more dangerous, with questionable , non existent occupational health and safety standards, and social implications, for village women to work in Suva city. The village women are tough, and need to be in order to adapt to the evolving socio-economic climate in this remote developing country. On the other hand, a village couple from Wainimakutu, Ratu Peceli and Mere, sell their new crop of pineapples, for about a dollar each, in the city near the richer USP clients and make a modest return.

From an international perspective, Della-Guista and Phillips (2006) examine the role of women entrepreneurs in developing countries and “the need to reconcile business with domestic activities”. They assert that women were “overlooked in policies” and thus need much more help and support in many areas to help them succeed. This study is supported by Robbins and Crow (2007) and by Dyah and Dyah (2001), who point to software skills such as ‘know how’ (to use processes, techniques and methods) and ‘know why’ (such as knowledge, skills and experiences). They proposed four criteria for the selection of technology. It should:

- Conform with their own rural village priorities;
- Significantly reduce their burden of daily activities;
- Not create conflict with family responsibilities; and
- Create opportunities to earn income while living in the village.

This is two of a few references that recognises the importance of women, training and adapting technology to village needs.

Perhaps the cosmetics made from the coconut industry offer some hope as the cosmetics industry is starting to grow and expand in Fiji, using women as their base (Frodey and Naidu 2008). This empowers villagers to collect and process coconut in the village; to be employed in processing and value adding in the laboratory in Suva; and to helping in marketing and management of the business.

This research could be applied to re-examine the craft of mat making in the villages (Brigham 1974). The women use sustainable fibre sources from the pandanus tree. They invest their time to plant and tend to the trees near their house for free capital investment to start a craft project. They collect and boil the fibre in big 20 litre pots using easy to get local firewood. They have found ways of not using chemicals to process the fibre for free by boiling the fibre. They have found (free) ways of soaking the fibre in the mangroves to chemically-biologically change the fibre colour to black. They dry the leaves in the sun (for free) and roll them ready for use or sale (Figure 2.2.8ijk). They sit in social groups and weave mats for cultural gifts or for sale at the local markets. This craft project could easily be supported and promoted to create appropriate employment for women in the village, while being very sensitive to the cultural heritage and village lifestyle. The level of hardware technology required is minimal - an aluminium pot to boil the leaves over an open fire, and a knife to cut the leaves to 1-2 cm wide. This illustrates that perhaps western ideas may need to change – we may need to go back to the village artisans and ask the villagers what part of western technology is important to help them. This complements the delicate path forward of this thesis to transfer appropriate sustainable and relevant TT.

Another aspect of village life to reconsider is daily food and fishing, whereby women line fish for a few hours to provide precious protein for the family. The donation of a fishing net enabled the husband and wife team to catch a range of fish quickly. This was traditionally shared with the chief, the church minister's family, and thus the community ensured a sustainable way of life, reflecting their culture and existing roles within that community. Fresh fish also has a limited 'shelf life' of a few hours and must be cooked quickly before the heat sets it off (Figure 2.2.8lm).

Boys (2012) developed an interesting case study that could be applied to Fiji. The Fiji eels need to go up and down the Rewa River and tributaries to spawn and complete their ocean life cycles. The competing use of the river and the Monosavu dam impact on this native resource fish (eels) that the women in villages rely on for essential protein and cultural reasons. The research by Boys (2012) (Fig 1p12) could help to design and make new fish traps/bridges to allow the eels and fish to go up and down the river and continue to be a viable part of their food resource and culture.

Another fishing dimension to consider is selling baby tropical fish (Figure 2.2.8m). The author noticed some (unknown locals) catching/stunning the baby fish, bagging them and presumably selling them to international exporters. Perhaps if it was legalised and managed it could be done sustainably by local villagers and legally sold for export.

An under-researched option was the local bivalves. The village ladies trowelled/walked the murky rivers catching the bivalve in their toes. They are sold in the local markets by the small bucket load. The author bought some and tried to keep them alive in the house pond for several months, but they did not grow very fast. Perhaps the large ones could be sold for consumption and the small ones could be bought from the village ladies and grown in commercial ponds.

A backpackers' resort near Suva provides another technology transfer example. The expatriate lady / couple tried to use western waste water treatment and turned the grey water settling pond and organically convert nutrient waste into a eco-friendly lily pond to strip out the nutrients into flowers (Figure 2.2.8o). As an informal group of visiting scientists we could help her discuss and improve her environmentally friendly project.

The women of many villages have married into the Wainimakutu village and are really interested in education for their families (Westerlund 2012). They wanted to build a new library, so the men constructed the building whilst the women collected the traditional reeds for the roof (Figure 2.2.8p).

These studies show the importance of women in the home and workforce. The times are changing with women being empowered to make these changes in the village by part time village employment, supporting their children in education, supporting their church, and their family. Very few business opportunities exist that allow women to stay in the village and generate income. The best examples for Fijian villages would be working as a local school teacher, nurse, mat making or craft activity. This project will hope to address those issues and create a useful range of village employment while reflecting on the cornerstone principles of being economically viable, sustainable and culturally sensitive, plus using their tacit skills with the best available appropriate craft technology.

2.2.9. Case Studies Summary

Table 2.2.9: How the Case Studies Reflect on the Cornerstone Principles; and use of intellectual property; hardware and software (from worst XXX to XX to X to √ to √√ to √√√ best).

	Financially Viable	Socially Acceptable	Best Available Technology	Green and Sustainable	IP	HW	SW	Total √'s
Solar Energy	XXX	√√√	√√√	√√√	√√√	√√√	√	**16**
Hydro-Energy	XXX	√√√	√√√	√√√	√√√	√√√	√	**16**
Smokeless Stove	√√√	√√	√√√	√√√	√√	√√	√√	**18**
Coconut Oil	√√√	√√√	√√√	√√√	√√√	√√√	√√√	**21**
Garment making	√√√	√√√	√√√	√√√	√√	√√	√√√	**19**
Book-making	√	√√√	√√√	√√√	√√	√√√	√√√	**18**
Water Bottling	√√√	√√√	√√√	√√√	√√√	√√√	√√√	**21**
Fish Canning	√	√√√	√√√	√√√	√√√	√√√	√√√	**19**
Mat making	√√√	√√√	√√√	√√√	√√√	√	√√√	**19**
Existing Papermaking	√	√√	√	√	√	√	√√√	**10**
New Papermaking	√√	√√√	√√√	√√√	√√√	√√√	√√√	**20**

The new papermaking project has been deliberately included to gauge some initial – introductory perspective of how it ideally fits in with the other topics.

The Karakosta, Doukas and Psarras (2010) rating system has been modified by the author as a guide to evaluating and explaining the relative importance of the projects with an environmental and culturally favourable bias. The criteria were the cornerstones and aspects of the hardware and software. In summary, there are many good examples of TT in Fiji and the Pacific region that address the major and minor cornerstones.

The government, through the DOE, can support and implement a national energy grid to transfer the energy from wind, geothermal, and new solar energy technologies to many villages. Solar energy may be heavily subsidised (XXX) but it is considered to be the most socially acceptable (√√√'s) while using the best available international technology (√√√'s) (with a total of 16/21 ticks). In time, if they can make simpler solar panels cheaply in Fiji, it could change to 3 tics for both financially viable and use local artisan software skills to make an ideal 21 pt project.

Likewise for hydro-energy, there is a great need for new research into making smaller units that could be used in local rivers to create local turbine power for the village. With a few subsidies it could change from importing high technology, unaffordable turbines (XXX) to a new micro project for a developing country project to be most viable (√√√'s). Plus the SW skills to make it in Fiji would also make it a 21pt or perfect project.

The smokeless stove technology was a great example in the evolution of TT in Fiji with 18 points, but it is now outdated, with gas stoves and gas-energy they cannot afford to buy. The government, through different agencies over a few decades, has helped to bring in new smokeless stove technologies to greatly improve the quality of life for many schools (with 18/21 ticks). This demonstrates the power of the Government and support systems to get behind a good socially acceptable project to benefit the health of school children. The only reason not to give it full ratings was that it was imposed on the villages by the United Nations. Some villages felt that they had easy access to firewood and thus it was not an important issue for them to save energy from wood for Fiji.

Private enterprise and government agencies can pioneer new coconut extraction machines to make more economically appropriate technology for the villages (with 21/21 ticks). This achieved the highest ranking as the project was done locally in Fiji, with help to create the best new appropriate oil extraction technology, at an affordable price for local villages to create and diversify local employment opportunities in an agricultural area of coconut plantations that satisfied their cultural requirements.

The garment industry can prosper through a helix of private enterprise and government, helping to create an internationally acceptable quality range of garments by upskilling the existing sewing skills of the women (with 19/21 ticks). With government tax help, they have focussed on the latent skills of the Indian women and complemented their culture and craft. They do not need the latest technology sewing machines (√√'s), they need the artisans skills. Perhaps this is a weakness of the table, that this project did not get maximum rating. In hindsight, it should be acknowledged as a most appropriate lower technology base for a developing country.

The education department has the initiatives to rejuvenate the Fijian language and stories and are now starting to publish local stories and start the new concept of 'conversational English' (with 18/21 ticks). This is another weakness of the table; that a project of cultural significance does not get maximum rating.

The fish canning operations are a very important example of using the international fishing industry in Fijian waters to develop a small scale processing facility in Fiji. This directly employs many local village men and women and was rated highly at 19/21. A chief can quarantine a fishing zone and let the stocks build up for a future feast. Perhaps fishing should be valued more and reflect more strongly the culture and food and lifestyle in this rating system.

The water bottling enterprise has proved itself a profitable business over the last decade and supports a village with many work opportunities (with 21/21 ticks). It can easily be seen as a shining example of the best in technology, creating local employment, while being sensitive to culture and profitable for everyone. Perhaps this scale rates more highly those businesses that use higher technology and make profits, unlike the following example.

At a village level, the women have already evolved a high craft technology of mat making using sustainable practices, appropriate technology, and free chemical colour technology from soaking pandanus leaves in the mangroves. They use minimum levels of hardware technology yet create a beautiful artistic skilful craft product. Perhaps we need to adjust our focus and put this as the maximum value and give the craft a full rating. Perhaps the village women already have evolved the perfect sustainable formula for technology and so western ways are opposite and inapplicable to them. The women seem to be the gaining a range of employment skills and bringing valuable cash flow into the Indo-Fijian and Fijian villages. The cash value could be $50-100 (Fiji dollars) per mat. This is considered to be a readily available small scale money making venture for any village women with mat making skills. It was given a maximum rating of (√√√'s) for financial viability simply because it can be instantly done now in most villages with little or no access to finance and relies only on their own artisan skills and family /village resources. It uses minimal hardware and some simple better centimetre knives will help to improve the consistent quality of the artisans' skills. Perhaps it should be given maximum overall rating for being the most appropriate technology for the village women. Why do they need imported expensive technology when they can make beautiful products without imposed modern technologies?

The existing Wainimakutu Papermaking village has developed from nothing over several years. This was subsidised to start with as a women's village employment program. International Training Aid was sought from New Zealand. They now make about 1000 sheets of A3 wrapping paper per week. The rough paper is bought by Pure Fiji to wrap a range of locally produced cosmetics made from coconut oil. It is unfortunately only rated low (10/21) as a cottage employment project and uses low technology equipment to produce a low technology product. Perhaps it should be rated higher to show how important basic craft technologies are in creating may village jobs. It is most vulnerable with only one buyer for its product and nearly closed down after each coup. The new papermaking system is rated next to this to give a perspective of the project. It is rated high at 20/21 as a great example of TT yet not financially as profitable as other technologies.

These examples show that in general, Fiji has shown it can help to foster the helix of government and private help with infrastructure, research, university, technical and trade skills, farm training, tourism and craft support. With international help they can build on the concept of the cornerstones and create a better path forward that is economically positive, environmentally friendly and socially acceptable, while using the best available free IP and complementing the local craft skills of the indigenous people.

2.3. Holistic Models of Technology Transfer

2.3.1. The Variety of Models

This section will begin to explore models from a simplistic notion building up to a range of complex ontologies. There are many models and or ontologies to improve knowledge management in TT. An 'ontology' is a "knowledge base that contains the concepts and relationships that define an abstract model of how people think about the world … in some domain … and communicate that understanding to others" Doherty *et al.,* (2005). Doherty examines some models and puts forward an 'environmental expertise knowledge base system' and emphasizes the importance of "making tacit knowledge explicit allowing it to be analysed, criticised, learned, shared and combined." Bozeman (2000) has come up with a model for organizing the vast array of TT literature (see Fig.1 and Table 5 of Bozeman 2000). This section will however focus on TT and UDCs starting from the simpler 3 stage models and building in complexity to the 6 stage models.

There are a few simple three stage models that highlight a potential aspect of a successful TT project for a UDC. The first three stage model is from Kondo (2005), explained as a 'progressive model of technology development' (Figure 6; p170). The flow chart starts with 'acquisition', moves onto 'assimilation and diffusion' then to 'indigenous development'. This is a good basic model for the thesis as it recognises integration into the local indigenous way of doing a craft.

The second 'three stage' or 'dimensional model' from Drejer (2002) looks at 'integration of aspects along the X axis; then 'integration of activities' along the Y axis then 'integration of time horizons' along the Z axis. The concept is further explored in Figure 2, p131 for a product concept development for a business and is a good base generic model. This model could also offer some insight into the critical concept of allowing for time and acquisition of skills and a series of time scales to fully integrate new technologies into the more challenging UDCs.

The third three stage model is from McCarthy (2003) who looks at technology management by 'selection', 'adoption' and 'exploitation'. Figure 1, p732 shows an interesting 'strategy configuration chain' while Figure 9, p741 shows a series of 'S curves' to understand technology strategies. The S curve is also important to give due recognition to reflect the real learning curve of truly understanding and implementing a range of new innovative technologies over a realistic time period. It is ok, to strive forward and then slide back as the new obstacles are discovered, then progress on again and again in 's' waves of applied learning. This is in contrast to the stepwise approach that imposes more distinctive steps and limits to each increment of TT. The stepwise approach fails to recognise the slipping back effect and importance of that in discovering new ways forward. It does allow smaller increments or steps to be made and thus tries to overcontrol it and still go forward without sliding back.

Flowing on from the three stage models is a more holistic model that includes marketing. Xu *et al.* (2007) promotes the 'total innovation management' (TIM) model and explains one of China's key success stories using the 'Haier's internal market chain management' (Fig3.p36) to keep them focussed on innovating and tuning into the market needs. This is also critical to a UDC as they do not have the cultural marketing skills to fully complete a TT project and exploit the best marketing and economic returns. Perhaps the 'push pull' concept needs to apply here, where marketing can help 'pull' the new technology and niche products through (Spann *et al.,*1995).

Building on these simple models is the need to add environmental concerns. Hudnut *et al.*(2006) explore a hybrid business model called 'appropriate organisational design' that allows for the "design, development and dissemination of environmentally friendly technologies into the developing world." The business model even allows 'donations' as part of the model, plus micro-financing and local partnerships. He calls these "orphan" environmental technologies that lack the profit margins for traditional industries but still are worthy of being disseminated into developing countries. His ideals are complemented by Schumacher (1973) where smaller is more beautiful, sustainable and economically justified. This is starting to relate more to the project where a range of eco-friendly technologies is offered to a UDC.

Other models relating to TT include Bozeman (2000); Godin (2003); Madu (1990); Pavitt (1994); Piva (2003) and Strawn (1982). All highlight particular points of the challenges of TT for UDCs. The more relevant complicated models that will be explained next are the 'six phases model'; the 'six dimensions model'; a 'systems approach model'; the 'seven c's'; and the 'third dimension'.

2.3.2. The "Six Phase Model"

The original 'six phase model' was presented by Kearns et al. (2005) and represented one way managers can deal with "maximising the benefits and minimising the costs and risks with …major technology initiatives." Hull *et al.,* (2007) argued it was simplistic and easy to use (Fig1. from Kearns *et al.,* 2005).

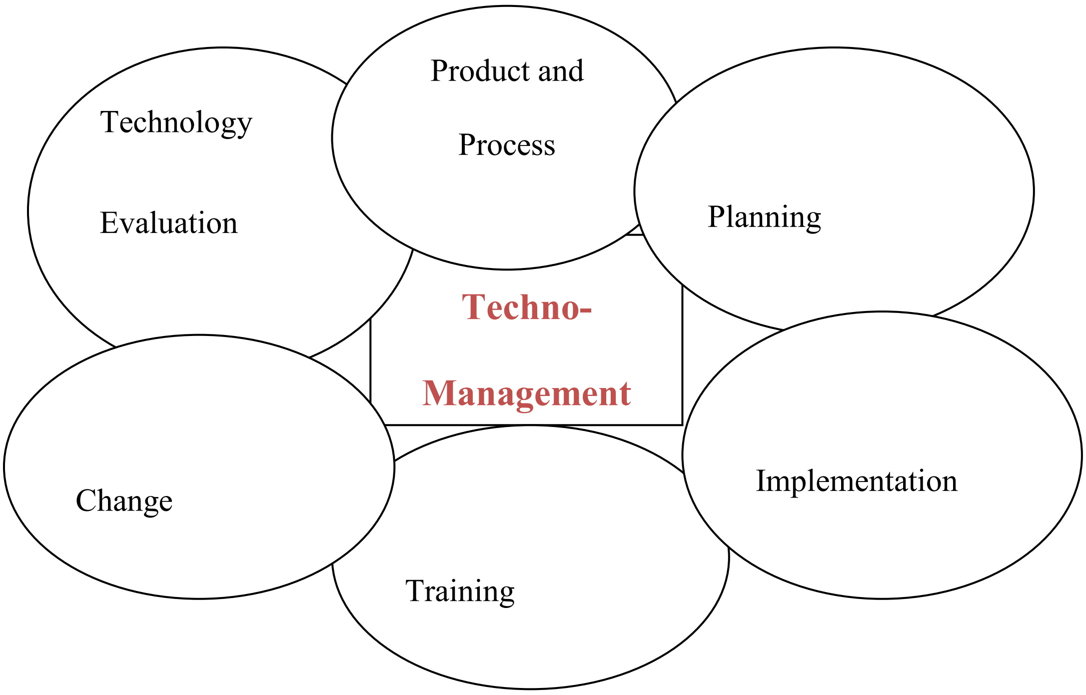


Figure 2.3.2a: The Six Phases of Technology Management (Kearns *et al.,* 2005).

This was a good base from which to start and other layers of understanding were evolving. The 'analytical hierarchic process' (AHP) is now superseded by the 'Modified AHP' (MAHP) because it is "simpler than the original AHP, which makes it easier to use and more smoothly integrated into the six phases approach…yet powerful, approach to the management of new technology" (Hull, Broody and Payne 2007,p59). The Figure 2.4.2b: MAHP decision tree for environmental technologies then becomes important to help put into perspective all the competing influences with culture /heritage / and eco-friendly added to incorporate later ideals (developed from Fig2. Hull, Broody and Payne 2007. p66).

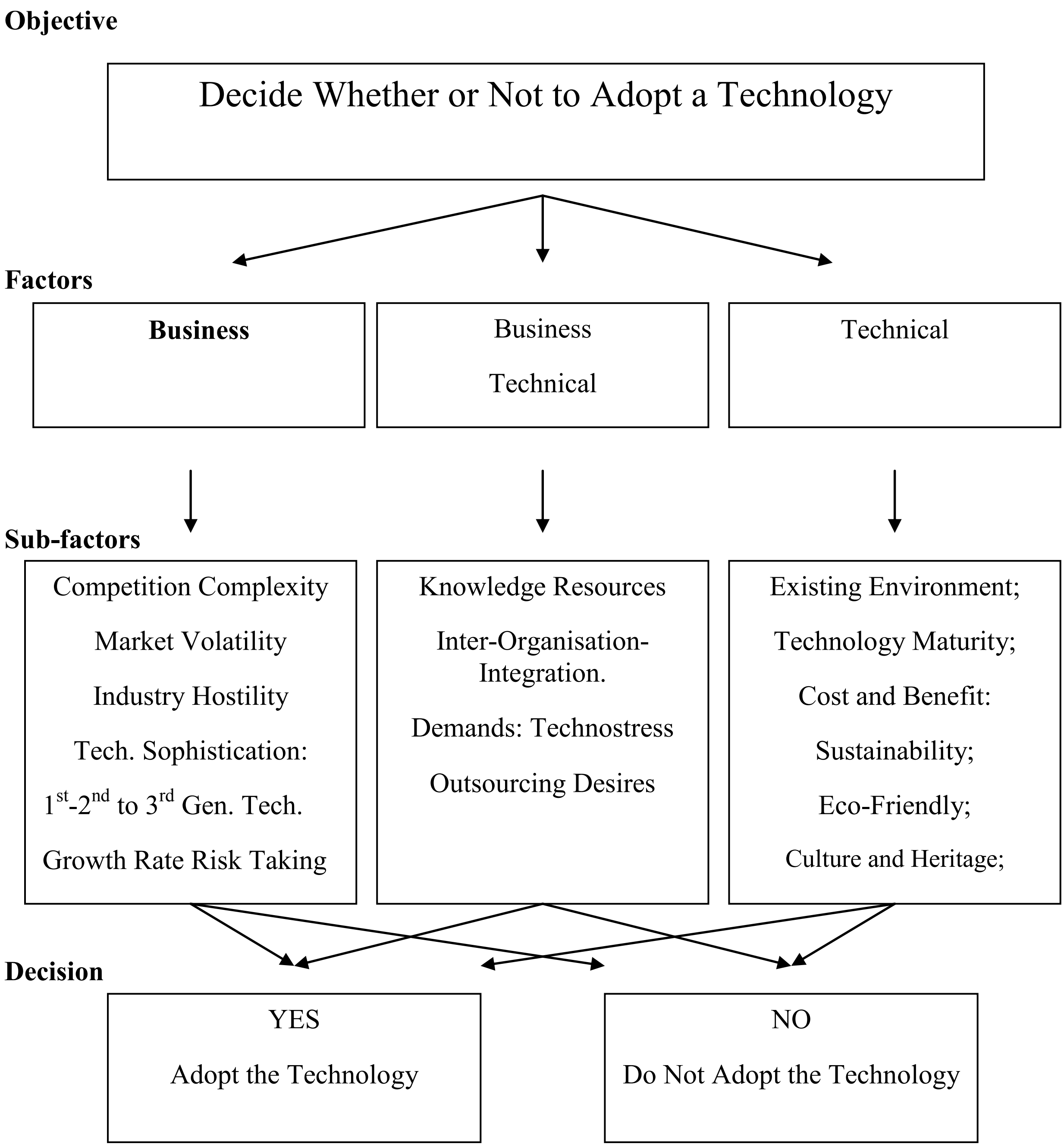


Figure 2.3.2b: Updated MAHP Decision Making Tree for New Technologies

The figure clearly breaks down the objective into three main factors of: business; business-technical; and technical. Within each factor are several sub-factors. What are more relevant to this research are the environmental sub-factors of: existing environment; technology maturity; cost and benefit; the new additions to complete the figure are: culture and heritage and sustainable and eco-friendly. There is no value system to weigh each sub-factor from an economic or environmental rationale so a case by case study is necessary. If the village chief does not like the project then it will not go ahead. Perhaps another sub-factor under culture and heritage is having the chief's blessing. 'Champions' at each level are also needed to ensure the success of a well-intentioned project (Westerlund, Ho and Anda 2009). The decision can then be made to adopt the new technology and a 'time frame' for implementing it needs to be decided on. Time was also included to acknowledge the village 'time' needed to transfer the technology. One safer strategy is to run parallel production lines and maintain current product standards while learning and fine tuning the new technology before full implementation of the new regime. These safeguards are needed in case of unexpected failures or delays in construction of the facilities; unexpected chemical reactions; unknowns of new pressure, temperature, humidity parameters; and /or training of staff in new skills. The villagers need 'time' to slowly understand and work with these foreign, frightening new technologies and adapt them slowly into their cultural ways of doing things.

This decision making model could be developed into a good holistic model for safer more structured ways of improving transfer of eco-friendlier and sustainable technology but business still needs to make a profit.

Research by Kearns, Taylor and Hull (2005) also argues that "change and new technology are essential to the long term survival of businesses in today's competitive landscape" and the use of the 'six phases model' to leverage the best strategies forward. Prakhya and Hull (2006) also look at the "Printing Industry as an example of one of the most technologically advanced" segments to deal with and understand using the 'six phases model'. Messner and Srebotnik (1994) also looked at an environmentally safer biopulping and papermaking option. As the end product of this TT project for the villages is high quality paper, then it must be made to the highest standards using best available technology. Meanwhile Cox et al. (2007) looked at using it to benefit the management system of TT. Perhaps Madu's (1990) 'cognitive mapping' might complement this and prevent another Bhopal, India chemical/ process/ industry disaster. Perhaps Cantwell (1995) is justified in arguing that his third theoretical justification for innovation is a 'demand lead process' from developed countries. At the end of the day, businesses need to be empowered to understand the pollution issues and offered a safer way forward to complement the sustainable environmental pressures and social pressure, while making a profit (Gottinger 1993; Ingebrigtsen and Jakobsen 2006; Kopacek 2001; Lall and Pietrobelli, *et al.,* 2002; Lee and Vivarelli; Lin 2003; Lefebvre 1998; Lindsey 1998; Marinova *et al.,* 2006). Perhaps the idea is not enough, we need more help in turning science and inventions into enterprises (Moody 2007). Then one could question the role of NGOs in technology transfer (Mowles 2007).

The level of sophistication was also expanded to deliberately include the 1st, 2nd and 3rd generation technologies (1st= latest computer software/equipment). This is a real issue as even now, for example, while in Fiji, their reality was using 2nd and 3rd generation computer systems and software. They cannot afford the latest computers and yearly updates. How can they be expected to pioneer better ways forward with antiquated technology (McNamer 2005; Mensah *et al.* 2007).

The MAHP seems simpler than the original AHP, which makes it easier to use and easier to integrate into any standard TT system in DCs. It does not seem directly developed for TT to UDCs and requires modifications so other models need to be researched.

2.3.3. The "Six Dimensions / Phases Models"

This section will explore two six step models. Each is seen from their perspective and their implications for TT.

Kaplinsky (1990) presents a 'six dimensions model' for the process of improving technology. They are: "technology selection; TT; utilizing technology to its desired performance; adapting technology to specific conditions; improving technology beyond its designed performance; and generating new technologies". This complements the themes of this research. New innovative technologies can be selected, trialled and adapted to work in a developing country, or even made in the UDC, where possible. This incorporates the process of adapting to their needs and making new relevant technologies. It could recognise the tacit skills more, but this is implied in some of the goals.

Whereas Bell and Pavitt (1993) develop another 'Six Facets Model' of Technological Learning=> Technological Capability=> Technical Change =>Production Capacity => finally to Industrial Output (Fig.1. p164). Learning is recognised as important, the capacity of the UDC to adopt technology is critical and the ability to change and improve it to their needs is recognised. The production capacity may not be significant by world standards, but to a little UDC it becomes important to their micro economy.

These models show a range of useable concepts and could be improved with a cyclic loop included to encourage ongoing improvement and more adaptation to the needs of UDCs, and the search continues with the 'Systems Models'.

2.3.4. The "Systems Model"

This section will briefly examine how several authors have overlapping views on a 'systems model' of TT.

Fleissner (1983) promotes various systems approaches to appropriate TT . This includes the: "flexible management system" by Rosenbrock (1983); the "integrated system…" by Muzhar (1983); and the Graph (9.3.p18) shows the "main elements and relations between social and political conditions for the application and evolution of technology in developing countries".

From the next perspective: Bobel (1983) uses three flows of technology: 1. the buying in of equipment; 2. exchange of knowledge; and 3. Training. This does not address the need to redesign the equipment to work best in the practical and climatic extremes of UDCs and lake of village skills to use it. This model is quite simplistic and needs a lot of improvement, like the next model.

Benmokhtar (1983) develops a case study using the 'classical procedure of the systems approach' (Diag1. p172). Understanding the problem=> collecting the information =>analysing the information => conceiving possible solutions => evaluating the solution => applying the solutions => testing => modifying if necessary => cycle back to applying and retesting as required. This will be used in the thesis.

The classical approach could be easily adapted to the modern views of more sustainable development, life cycle assessment and including an appreciation of tacit skills and culture. This is similar to the Ushiyama and Nemoto (2002) case study system. Both have a clear path forward to keep adapting and improving technologies to potentially suit UDCs but do not acknowledge culture and other social factors.

More analysis can be extracted from other flow charts, such as Fleissner (1983 Diag. 6-9. p174) which includes more structured analyses including geographical, infrastructure, education, health, human and energy resources, marketing and scientific knowledge while meeting the needs and demands of clients in developing countries. This could start to recognise the importance of this case study, the Fijian culture and their education, their extreme geography and tropical climatic factors.

The validity of science is questioned by Nelson (1974). Nelson analyses UDCs where pressures of low per capita income; high birth and high death rates; low literacy; low skilled manufacturing; low ratio of doctors and educators per population have a larger combined negative economic effect than ‘faith’ in science in restricting development. It is useful to challenge the value of science, adapting the good in science to work for a UDC creating good eco-friendly ranges of product, like paper and books to help educate and empower the village. A ‘systems approach’ is also worthwhile. It can be holistically improved when the village perspective is placed first and the project revolves around them and their culture and traditional skills. This links into the next model that looks at phases by taking a common ‘C’ and being different enough to mould an argument around C’s.

2.3.5. The “Seven C’s Model”

This section will focus on the IETC (2003b) report that developed a set of important guidelines for policy and decision makers for the “successful transfer and uptake of environmentally sound technologies”. It develops the “seven C’s” as a concept of: context; challenges; choices; certainty; communication; capacity and commitment. This is gimmick way of trying to generate a new ‘C’ perspective. To measure its success is to quote from one of its own arguments that: “The end result for the recipient must be the ability to use, replicate, improve and, possibly resell the technology” (piii), which have no ‘Cs’. The other ‘Cs’ they forgot were ‘cash’ or ‘capital’ or ‘credit’ or the perfect ‘crystal ball’ or if it does not work then ‘close’ the project. Most aspects of TT are covered in the C’s and are explained briefly below, as it is an important referenced source of modern models.

The chapters of the IETC report (2003b) provide a holistic reference interconnected base, which must be adapted to a case study. Figures 2-3(p4-5) suitably explain the process of TT. For ‘context’ it paints a broad picture of being “environmentally sound in a given local, culture, economic stage…”. For ‘challenges’ it gives broad generalisations of “barriers along the TT pathway for innovators and developers”. While Yin (1992) notes one “crux of the problem is the inadequate institutional structure and indigenous technical capacity”. For ‘choices’ it implies that UDCs can magically understand and choose from an infinite variety of technologies and be fully implemented and understood for altruistic benefits. This is quite an unrealistic expectation as UDCs do not generally have the skilled people and information to do this. At a practical level, (Fig 4,p14.) it goes through the process with a ‘pre-assessment’ activity of: determining the focus of assessment; identifying technology needs and assessment; assembling information; prioritising; implementing; and then reporting. The useful ‘DICE’ procedure is also introduced: to describe; identify; characterise; and evaluate (Fig.5,p18). For ‘certainty’ it waves a magic wand over “high levels of risk, both real and perceived….to ensuring access to sufficient, verified information… of risk assessment… for financial institutions are of special importance”. There is no magic wand, at some stage a decision has to be made to set up a pilot plant and more effectively gauge the success of the project. The Table 2 (p23) is a good generic guide to environmental criteria as for ‘environmentally sound management of solid wastes’ it suggests: “opportunities for waste minimisation” and more importantly for this research “facilities for waste recycling and reuse plans”. This complements the thesis as it focuses on paper fibres that are reused and recycled. The "opportunities for toxic chemical and hazardous waste minimisation" are also important as the chemicals, calcium carbonates, fillers, colour dyes in the paper are reused in this process, providing a classic example of the tremendous value of the project in pioneering new innovative eco-friendly technologies.

The key summary for information to support TT is presented in Fig. 8 (p29 and Box p.30) for "environmentally sound technologies information systems" (ESTIS) with a mandate to help establish the "Pacific Region Asia-Pacific regional sound technology information systems network" (APREN). For 'communication' they highlight that to "facilitate TT there needs to be an improved alignment between perceived and real risks" (see Fig. 9, p3). For 'capacity' they argue for an "open and competitive market". This is in conflict with other regimes of subsidy, trade protection and enhancement to kick start a vulnerable insecure UDC craft project. This seems different to the point of opposite theory to 'capacity building' from other authors where new industries are protected and helped to become established against foreign businesses. For 'commitment' they expect all levels of help from bottom up to top down. Once again this is unrealistic, MLCs do not want to altruistically help, and small craft artisans are powerless to do valuable projects themselves.

The report acknowledges that there are "shortcomings…absence of criteria, benchmarks and protocols that must be in place before a technology can be classified as environmentally sound." This is again unrealistic as craftsmen and small businesses in UDCs are struggling to survive in producing their craft, let alone understanding and complying with international standards and protocols. This is starting to paint a picture of the complex multi-phased issues that need to be understood and somehow alleviated if environmentally sound and sustainable ventures are to be supported.

The seven Cs are an important reference tool, but MNCs control most technologies. The authors ignore their influence and offer no strategy to overcome this insurmountable hurdle. The MNCs seem to profit from controlling technology and thus exploiting UDCs and keeping them as UDCs. Perhaps the "evaluation and strengthening of policies that influence the enabling environment" is to side step MNCs and transfer technology from IDCs to UDCs or UDCs to UDCs. This is like the COMCON approach of Libik (1983) for "adjusting existing technologies to a local situation." There are a lot of useful issues to be extracted from the report and yet it falls short of UDCs expectations to guide them through the maze of conflicting models and regimes.

Thus the IETC report is a good basis to form idealised perspectives of the many phases required to make TT successful. One obvious drawback is that many arguments are overlapping and restated in a different way to fit a 'C' model. It lacks some real life reality and can cause a project to fail if it expects stakeholders in UDCs to idealistically follow its guidelines. It is still missing a holistic perspective like the next group – the third generation models.

2.3.6. The Holistic- "3rd Dimension Model"

This section will examine papers by Hecht (1999), Musa et al. (2005) and Halls (2006) as they build on many of the foundations of current theories of TT and develop an holistic 3rd generation approach. The United Nations Conference on Environment and Development (UNCED 1992, principle 9) states that "States should cooperate…by enhancing the development, adaptation, diffusion, and transfer of technologies, including new and innovative technologies." Agenda 21 devoted a whole chapter to TT with key resolutions to 'protect the environment' by being less polluting, by using resources wisely, to recycle more wastes and products and finally, to handle wastes better. This is good for the 'end of pipe' technologies and encourages clean-up of bad technologies, but Halls pushes the boundaries to the next threshold.

Musa *et al.,* (2005) argues that UDCs need help - a "technology jumpstart" for basic technologies - first geared toward education, then farming, then health care. Musa explains that "Developing Countries contribute 75% of the world's population and currently share only 16% of the world's products". The Table (p112) relates socioeconomic development, accessibility, and exposure to technology adoption and diffusion. A strategy "should start with reinforcing the positive impact factors while mitigating the negative impact forces". He goes on to explain that "When basic technologies are systematically introduced to solve local problems in the right cultural contexts, meaningful exposure to technology would come about, and more advanced technologies would be embraced and applied". This complements and empowers the thesis to pioneer good scientific technologies in a cultural context.

Halls (2006) goes further than Hecht (1999) and Musa et al. (2005) and sets the foundation of transferring "environmentally sound technologies" based on four principles for the recipients: 1. To understand and take advantage of their benefits; 2. To obtain information, knowledge and tools to assess and decide on the most appropriate TT option for them; 3. To further understand the new technology and the infrastructure to implement and support them; 4. To know how to implement and manage TT successfully. This project will embrace these new environmentally sound technology cornerstones and begin to understand how to implement and manage TT successfully for the benefit of the UDC and village culture.

Halls (2006) puts forward the 3rd generation of environmentally sound and sustainable concepts to be "fully integrated with economic, social and other operational issues so that the system as a whole is sustainable". This may require more innovative approaches to manufacturing, remanufacturing, re-use, recycling to create better products with less (no) waste. This empowers the project to push the scientific boundaries by using waste paper and fibres as the new source for papermaking while reusing the chemicals from the paper to recreate a better quality range of innovative products.

The new TT process is more simply explained in Fig.11.2, p177 (Halls 2006). The 'technology creation' phase has three phases the continuous loops of development, innovation, and design. The 'technology sourcing' stage also has three phases with continuous loops of identification, evaluation and modification. This helps transfer 'knowledge' to the 'enabling environment' and with 'brokering'. Thus allows the process of verification; market testing; decision making; uptake/ application/ and decommissioning to occur. The process complements the thesis as many new pioneering innovations will have to be developed in the UDC. The innovations will need to be redesigned or modified to work using local materials, resources, expertise, conditions then tested, trialled and made to work in the extreme operating conditions of a remote village.

Building on this, are the important number of key stakeholders and diversity of pathways of TT to understand (Fig 11.3, p178, Halls 2006). The matrix includes the governments, banks, non government organisations (NGOs), IGOs; knowledge institutions and private companies. The thesis will also try to involve the engineers at the university, training providers, NGO's, and industry in the project. The 'barriers' to TT are more positively referred to as the 'challenges to overcome' in developing realistic short and long term strategies. Halls then proposes a standard list of key activities to carry out a 'needs assessment' (in Fig. 11.4, p182). This is based on pre-assessment activities, determining the focus of the assessment and suitable criteria, identifying the technological needs and preferences, assembling information on potential technology options, evaluating and prioritising the best sustainable technology options, and the final report. This approach will guide the project in the first instance, to go to the village and make a trial demonstration of the technology at a simple level to pre-determine the potential challenges of the project.

What is more relevant to this thesis case study and the Pacific Islands and 'small island developing states' (SIDS) is the assessment strategy in Box 11.1, p184 (Halls 2006). These points are more fully elaborated on, because they are the most relevant foundations for the research base of this thesis:

1. Improve operational efficiency and effectiveness;
2. Have social and economic benefits that exceed the collective respective costs;
3. Reduce vulnerabilities and enhance resilience of social, economic and environmental systems;
4. Be environmentally sound and compatible with the local culture, society and environment;
5. Assist people to develop and modernise in less wasteful ways than is the current development paradigm, but without losing the sound social and cultural values and practices that underpin their traditional ways of life;
6. Facilitate compliance with international agreements such as the 'UN Framework Convention on Climate Change' and the 'Convention on Biodiversity';
7. Complement existing technologies and services;
8. Be consistent with current capacities for operation and management;
9. Consult with all stakeholders;
10. Recognise the important roles of traditional knowledge and skills, including indigenous technologies;
11. Make decisions based on comprehensive and creditable performance information; and
12. Implement a tendering process to ensure cost effectiveness: or

12b. Provide full costing of technology projects funded by donors.

This will be used as a template to cover the important phases of the new project in this thesis. The resultant technology pathway and application processes are portrayed (Fig. 11.5. p187, Halls 2006). These are separated into A): 'technology development' and B): 'technology application'. The boxes and lines are structured and easy to interpret intuitively. For development technology it seems to indicate the top start of new design / development / testing, verification of performance, certification, forming an 'information base', cycling to monitoring and evaluation; setting generic guidelines, criteria and benchmarks; and completing the loop back to design. The information base is then linked across to the 'technology application' of technology assessment; followed by selection and uptake of TT (with input from the local criteria); operational experiences; linking back across to the information base or monitoring. In constructive criticism, it could have been better represented in a more modern flow chart or cyclic loops of continual refinement and evolution to adapt the new technology to the needs and wants of the local developing country.

Several initiatives are needed to start to encourage and implement the new foundation of the 3rd generation approach. Progressing on, another way of looking at successful TT is from the summary of the ten steps (IETC 2003b):

1. Context-economically viable; socially acceptable; sustainable-culture;
2. Challenges-supply/ demand/ government orders can create demand;
3. Choice-alternative for a UDC;
4. Certainty – or risk of success/failure;
5. Communication-time-distance-InfoMS-KnowledgeMS;
6. Capacity-innovation-research-technology support;
7. Commitment-catalytic-facilitation;
8. Marketing-value adding;
9. Ongoing training-support-capacity building;
10. Ongoing designs and further TT to next village/region.

2.3.7. Summary

There are many specific steps of technology to be taken and models with common themes and interconnecting phases to holistically blend them into a valid scientific pathway forward. The thesis will embrace as many of these positive principles as possible, trial, evaluate and improve on them in the recommendations. This leads into the next stage of implementing a field trial for the model for the thesis.

2.4. The Methodology Literature Review

The most appropriate literature review for the methodology would focus on an 'action hands on' method of trialling a pilot plant ontology that will be complemented by separate surveys to acknowledge and evaluate the broad range of phases of important TTs (Colombo 2003; Crotty 1998; Grundy 1995; Robson 2002; Tripp 1995).

The principles of survey techniques are well documented in Crotty (1998): the four elements of epistemology; the theoretical perspective; the methodology; the methods. Within methodology there is the experimental research, the survey methods and action research. Within methods we have questionnaires, observation, case study, interviews and several others. This allows a structured approach to guide us in creating a case study and survey in this thesis. More specifically, we have 'technical action research' where an expert in the field of craft papermaking, the author, could transfer those skills to a UDC. This strategy is also supported by (Grundy 1982).

This would involve understanding systematic ways of transferring both hardware and software technology and skills. This should be complemented by surveys to mould together the broad range of phases of TT. With the comparison of building a pilot paper making plant in a developed country versus a developing country, the thesis could actively explore the many phases of issues that arise from the implementation process and networking with each village while being sensitive to their culture and needs.

This could involve the inventor of the technology, in this case the author, being directly involved with transferring the 'best available technology', accessing the 'tacit hands on skills' and the making of the equipment in the village, along with industry and university engineering department stake holders. This approach could be a mixture of standard approaches pioneering the direct involvement of the inventor and assessor in the qualitative and quantitative perspectives (Colombo 2003; Grundy 1995; Robson

2002; Tripp 1995). The risk is that the villagers may reject the good intentions of the benefactors (university and the author's papermaking skills) because of the conditions that the technology imposes on them, or they might change too slowly, and/or adapt it to their needs. This is also a strength of the thesis strategy, to try to reveal the inner workings of the transfer process and discover why so many good TT projects mysteriously fail at the village, industry or community levels during implementation.

Governments and researchers have been "measuring science and technology" for over five decades (Godin 2003). However, "measures of technology transfer effectiveness are neither well defined nor universally accepted" (Spann et al. 1995). Galbraith *et al.* (2007) argue that "experts cannot predict technology success". Yet, Madsen (2007) argues that "technology spill-over" has been measured for 135 years in OECD countries and 'knowledge' is the significant variable.

For this thesis we need to examine a spectrum of other approaches to evaluating the new realm of appropriate TT to UDCs. Several theoretical approaches to evaluating projects could have been partially used that indirectly relate to TT and only some are developed later. These include: the multi criteria approach; the analytical hierarchy approach; the north-south approach; a technology transfer index; the qualitative approach; rating the performance – the critical mass approach; a business approach; the environmental Kuznet's Curve approach; a web based approach; case study surveys; the total design method; the social capital approach; the Delphi method - multi level survey approach; the modelling technology roadmaps; the five phase approach; a rule of thumb approach; the six effectiveness criteria of TT; the push-pull mechanisms; attitudes toward TT; measuring environmental goals; genuine progress indicators; innovation management systems; the Lombardy system; and or the environmentally sound technologies for sustainable development approach.

Harel *et al*.,(2008) presented and demonstrated a "multi-criteria approach for evaluating R&D projects in different stages of their life cycle." Their approach integrated the balanced score card and data envelopment analysis and developed an extended model. Saad *et al.* (2002) attempted to "broaden the analyses of technology transfer phenomena" with a 'performance assessment' of projects. This was based on the 'life cycle model' and opened up a modern way of looking at projects.

Yasmin and Yilddiz (2008) use the 'analytical hierarchy approach' to evaluate TT and factors of success to help decision makers in developing countries. They examine five levels through a flow chart (Figure 1.p163) which includes micro and macro ergonomic considerations. Under macro, they include several cultural factors. These include: the attitude to work; attitude to technology; cognitive complexity; and career concept. This was most significant to acknowledge the importance of women in the village and by being married into a village they introduced many new ideas and expectations. They needed money for the church, the children's education, for their husband's farm, food on the table, dresses and entertainment.

Lundvall et al.,(2002) take a north versus south approach to understanding "national systems of innovation and competence building". Sharif and Ahmed (2006) use 'special technology infrastructure' to analyse Fiji as an example of a underdeveloped country and refer to the 'export processing zone' strategy to overcome their many challenges. This may be good at a national level in the city, but the village is too remote to directly benefit.

Fan and Yu (1983) did earlier research into a 'technology transfer index'. This was based on the "premise that the transferee in the process aims at achieving technology independence through gradual replacement of imported components by indigenous resources". This complements the project and empowers it to adapt the new technology to the village needs.

Cohen (2004), recognises the "importance of the more qualitative aspects of the (TT) process and the difficulties in attempting to quantify them" and acknowledges the importance of each stage from design and development to production, to marketing. This project develops this and tries to implement a trial system of allocating equal points to a process, and justifying this decision. Piva (2003) focus on employment and income distribution in theoretical models. This is too far removed from the village employment situation to be of any use.

Loch and Huberman (1999) take it further, rating the performance of new technology as uncertain and allocating it a value of (E); where (B) is the technology specific externality coefficient; and density to get:

$f_{(E)}(x) = 1/2Be^{-Bx}$ for $X >= 0$

and for $x < 0$; the 'e' to the power of sign is +ve:

They explain it as: "each actor evaluates the technology separately and independently". The equations are further developed as measuring total performance (G_i), as a sum of the basic technology performance (P_i) and so on as:

$G_i = P_i + f_i b_i$ and $G_2 = P_2 + f_2 b_2 + E$

The equations get more complicated when the "critical mass" is reached and the technologies cross over to adopting the new technologies.

Kerret (2008) argues that the ISO 14001 can be used as a tool to understand how business has improved on their 'environmental performance of industrial facilities', but goes further and stresses the importance of an "holistic approach to environmental problems that will include different nations and different actors in society" to help monitor and solve environmental problems and increase 'environmental capacity building.' This could be complemented by Lawn (2006) or Doherty et al. (2005) with the "Environmental Kuznets Curve" that describes the changing relationship between "growth and environmental degradation". This concept is opposite to the thesis. By supporting a project based on using the town's waste office papers in an employment project for a village it creates a new paradigm of the philosophy of converting waste products into a value added new craft product, saving energy, resources and enhancing the environment.

Beak *et al.* (2007) evaluates TT in a web based system before it is transferred. This may prove an interesting exercise that is available on-line with remote access from developing countries. Bhardwaj and Sharma (2005) looked at ways of evaluating the acquisition of technology in small and medium enterprises by the interview process in 22 case studies in India. The case studies were focussed on the automobile industry, so not applicable to the craft industry, and no points system was used. Koberg et al. (2003) used another survey method with a 'total design method' by only surveying the CEOs/Presidents of many companies. This evoked some criticism of their survey technique which was discussed and refuted by some other research papers. This would be irrelevant to a small isolated chiefly village system.

VanHa *et al* ,(2004) examined a 'social capital' value for paper recycling craft villages in Vietnam case studies. They developed a 'reduced form model' of the household production function. They treated social capital like other conventional factors like physical capital, labour and human capital. Their results indicated that this was an important value for a nation trying to grow and use its waste paper resources while protecting its native forests from excessive exploitation. This may be used in the future for a separate study in the capital Suva but is not applicable in a highland village that does not use paper, except for school books and activities, or the odd newspaper that gets read a few days later in the village.

Almabrouk and Soar (2006) use a modified Delphi method: to investigate, identify and understand scientific issues and the intricate nature of TT. They accepted more current scientific evidence; they are more flexible about asking questions in surveys; more empowered to keep clarifying positions; used a second open ended survey; and used a third round of anonymous answers to encourage more interesting answers. Farris (2007) focussed on a 'total innovation management' system'. This is also crucial to the project, to see it as a holistic project. Zurcher (1997) uses 'modelling technology roadmaps' to help identify science, technology gaps and any obstacles to "rapid and low cost technology development". This is crucial as the author has gone into the village with his pre-conceived technology and knowledge of gaps that could be filled with his innovative technology to quickly bring the remote village to lead the world in smooth paper technology.

Landoni and Verganti's (2006) research is more related to universities evaluating their TT. This is important as this university based project tries to pioneer this new form of best available technology in a remote village close to Australia, in the Pacific Region.

Rouach (2003) described technology as five phases and TT as four steps of: show-how; know-how; know-why; and know everything. This could be the best guide on which to develop a survey, as papermaking can follow a similar path of learning. The author will directly show them new skills in smooth papermaking technology and empower them with new wisdom.

In earlier research, Findlay (1978) tried to measure how 'backward' a region was as "an increasing function of the gap between its own level of technology and that of the advanced regions”. In later research, Bell and Pavitt (in Archibugi and Michie 1997) argue that it is too “complex” and “trial, error and experience are therefore central to the improvements in technology” that require “design, construction and testing of prototype and pilot process plants”. In addition they recognise the best experiences in learning are “rule of thumb”, accumulated through years of experiences and un-measurable. Bozeman (2000) also questions why the “analysis assumes multiple, sometimes conflicting definitions of technology transfer effectiveness”. He does however develop a good “contingent effectiveness model of technology transfer” (Figure 1, p636); then develops the 6 criteria (in Table 5), summarized in Bosemans’ Table 2.16, now re-edited as the following Table 2.4.

Table 2.4: Boseman’s Six Transfers of Technology Effectiveness Criteria.

	Effectiveness Criterion	**Key Question**	**Theory Base**
A	“Out the Door”	Was technology transferred?	Theoretical or classical organizational theory
B	Market impact	Did it help the firms sales? Was it profitable?	Microeconomics of the firm
C	Economic development	Did TT help the region?	Regional science and public finance theory
D	Political	Did they politically benefit?	Political exchange theory; Bureaucratic politics model.
E	Opportunity cost	Alternative use of resources?	Cost-benefit analysis
F	Scientific and technical human capital	Improve research?	Social capital theory; Human capital theory

This project cuts across these parameters and could use key points to further discuss important issues. The A: ‘out the door’ criterion is close, as it deals directly with transferring the technology independent of the 'political coups' the country keeps having, or market forces which wildly fluctuate with coups and tourism. Rogers and Takegami *et al,*(2001) also learnt about "effective technology transfer from research on the technology transfer process in New Mexico" over a several year project. For B, the market approach, the project will build on a successful Wainimakutu papermaking village that sells about a thousand sheets of thicker 300gsm, rough textured, arty paper per week and opens the door to build a new product range and expand its market into smooth quality printing paper. For C, there is a great need for appropriate local village economic development that creates sustainable jobs in the village environment (Nieto and Santamaria 2007; Niosi and Marcotte 2005; Pack and Tolardo 1969; Pant 2002). For D, the Pacific region has regular political coups and instability, with a high influx of Indian indentured labourers left in the country demanding their vote (Narayan and Prasad 2007). For E, the opportunity cost is very interesting as the village has already tried several normal development options and is very restricted by its isolation and topography so they welcomed the original papermaking project several years ago to help them and now they welcomed this project to help them to the next level. Perhaps Fiji could look at other sugar cane – bagasse options to go forward (Okano 2006). For F, the project is using scientific advice and networking with key institutions at Murdoch University, a New Zealand University and the local University of the South Pacific, (only 70 km from the project), and will improve research into papermaking over several years.

From another perspective Spann *et al.,*(1995) show how to analyse how developers, sponsors, and adaptors measure TT. In their Table III they summarise technology push and pull mechanisms. For 'push' they include mean and standard deviations of responses for: requests for help; licenses granted; number of sites visited; technical presentations; technical briefs requested; technical papers published; time spent;

transfer budget; and transfer expenditures. For 'pull' they include: the number of jobs created; royalties; success stories published; new business started; technical problems solved; number of new products; user satisfaction; new commercial customers; cost savings; new commercial sales; market share gain; productivity gains; competitive advantage gains; and return on investment. This would be relevant to this project as it has already created a few local news reports, employment project reports, technology evaluation reports and resulted in a few published papers.

The 'attitudes' to TT are also interesting. Au and Enderwich (2000) were concerned with surveying over 3000 companies in Hong Kong, of which about 300 filled out the forms, for their 'attitudes' toward technology adoption. They included questions relating to perceived difficulty, adoptive experiences, suppliers commitment to the firm, perceived benefits, compatibility, and enhanced value. This may be more relevant to larger business projects, not at a village level. In time, bigger business may opt to support small UDC projects in their supply chain.

Porter and Vander-Linde (1999) reflect on the relationship between environmental goals and industrial competitiveness. This study is a small scale example of that, where it is based first on the highest environmental principles and then on an intensive production system, based on the industry experience of the author.

Esty and Porter (2002) evaluated environmental performance on pollution and stewardship of natural resources. The village is the highest in the mountains above Suva, so the principles of a 'clean production system' with no pollution are critical as they are the headwaters for the drinking water of many villages below them. They plant flowers in the village that are for decoration and used in the production process, they plant and harvest a herb that is ground up and used as a natural glue, providing a great example of a sustainable stewardship.

For embryonic technologies, the ‘competitive advantage valuation’ (CAV) method is useful for valuing embryonic technologies and patents. The CAV is generally a well-researched and thorough method of determining the value of technologies before they reach the market and before they generate revenues from licensing. The standard modern methodologies are: cost method, market method, income method, 25% rule, industry standard royalty rates, the Monte-Carlo method, the real options method, the replacement method, the relief from royalty method, and the excess earnings method. There are several additional valuation considerations, these include: citation analysis, enforceability, current impact, claim scope breadth, technology strength, validity confidence, research intensity, litigation avoidance, science strength, partnering licensing potential, innovation cycle time, and technology cogency (Hegelin 2003; Lemley 2005).

There are some international examples of other methods of measuring success. Clarke and Lawn (2007) measure Australia’s “Genuine Progress Indicator” (GPI) as a function of sustainability. This is quite new and pioneering and could be adapted to this project. China is also currently evaluating their ‘innovation management’ systems and may yield future understanding of other real systems (Farris 2007). Some universities are helping socio-economic development and they are using an “evaluation system developed from the Lombardy system” Landoni and Verganti (2006). What is needed is a standard international system that could be adapted to help TT to UDCs.

The IETC (2003c) have developed a set of indicators for ‘environmentally sound technologies (ESTs) for sustainable development’. The list includes technical suitability, compliance with regulations and standards, eco-efficiency, protection of water resources, optimisation of materials and energy use, minimization of toxic materials and waste, protection of terrestrial resources, and finally, protection of the atmosphere. It then goes further with a supplementary check list of selected socio-economic indicators for ESTs. This includes financial viability, operations and maintenance viability, responsiveness to local needs and benefits, and quality of information. These checklists were developed by the Expert Group on Environmentally Sound Technologies in March 2002 as a set of generic guidelines.

From the literature review of methodologies, several environmentally sensitive and important phases could be extracted to complement an integrated approach to proceeding with a pioneering hands on action model of TT involving developing countries and developed countries, helping to understand how to improve the flow of technology.

2.5. The "Life Cycle Analysis"

Whilst it is useful to have the approach to TT in small steps and bigger steps to leapfrog the opposition it should also be considered in relation to 'life cycle management'. A definition will help to start the process, then discussion of the factors. This is followed by three industry examples: a snap shot of the paper industry; an international example in Nepal; and a relevant Pacific Fijian example. Finally, other smaller points are noted to gain a holistic path of understanding to how life cycle analysis could be used to mould and shape a better more holistic, sustainable and profitable project.

Sonnemann and DeLeeuw's (2006) definition of 'life cycle analysis' is:

> "A product's life cycle begins with extracting raw materials from the ground and generating energy. Material and energy are then part of manufacturing, transportation use, and eventually recycling, reuse, or disposal. 'Life cycle' thinking recognises how individual choices influence what happens at each of these points so that trade-offs can be balanced to positively impact the economy, the environment, and society."

The terminology of 'life cycle management' (LCM) system incorporates addressing the three dimensions of sustainability (planet, people and profit) by using the tools of 'life cycle assessment' (LCA), 'life cycle costing' (LCC), an 'integrated product policy' (IPP), and an 'extended product responsibility' (EPR) (Sonnemann and DeLeeuw 2006). Used wisely, this wisdom empowers the many levels of decision makers to avoid decisions that address one phase of environmental challenges but cause other negative phases and thus "help improving entire systems" (Sonnemann and DeLeeuw 2006).

Ruffin and Jones (2007) argue for "who gains and who loses" in TT and draws our attention to both sides of any path taken for one reason, to gain maximum profit, affects others detrimentally. Bellman and Khares (2000) reflect on issues containing the environmental damages for 'end-of-life' products and recycling or reprocessing. With some simple changes in the production system, the end waste could be minimised or changed into another positive raw material and sold on for further value adding.

Sonnemann and DeLeeuw (2007) then argue that LCM should be used as “a starting point for innovation and ‘thinking out of the box’. To develop this for UDCs implies that it focus on ‘clean development centre’; “business can be part of the solution”; “greening the supply chain”; and a strategy for “strengthening the capacity of the weakest economic actors in the global supply chains to tackle environmental requirements”. This thesis will complement this approach. This research is also supported by Porter and Vander Linde (1999); Gardiner and Portney (1994); Hart (1995) and Lindsey (1998).

Meanwhile, Dimirovski *et al.* (2006) look further , and push the boundaries with sustainable development and trends in socio-technical systems. Further to this, Szekely (1995) argues the greener business angle of opportunity. This highlights a range of views to consider and by applying those to this thesis, they will generate new paradigms for TT.

The Papermaking Industry.

Blanco *et al.* (2004) give a good snapshot of the international paper industry for data in 2002. They claim 3.2% of the world’s forests are certified (125 million ha), recovered fibre increased to 160 million tonnes, and the USA invested $10 billion in recycling paper. By 2010 they hope that up to 50 % of fibre can be recycled. From an environmental impact perspective, for every tonne of paper produced, the levels of toxins produced are: SO_2 = 0.45t; NO_x=1.2t; CO_2= 0.36t; BOD 12kg. The toxic gases include: hydrogen sulphide, methyl mercaptan, dimethyl sulphide and volatile organic compounds. The energy used is 10.8GJ of product and 4.5GJ of electric power

(15.3GJ/T). These environmental costs are not mentioned when you buy a sheet of manufactured paper. Perhaps Castrogiovanni's (1991) argument for environmental munificence may come into play as resources get scarcer and the paper industry has to fight harder for forests, energy, water and chemicals. The sustainable handmade cottage industry is opposite to this industry for many reasons.

The Nepal Papermaking Industry.

One international example for cottage industry papermaking comes from Nepal, as it has been sustainable in making paper for over 800 years. They use 'lokta' fibre sustainably harvested from local forests. A case study report by Chitraka and Prescott (1996) showed that a lot of research has gone into allocating the growing of the plants to different community groups and empowering them to sustainably use the 'lokta' resource. The project expanded into 83 towns and three regions employing over 800 families.

From another perspective, Biggs and Messerschmidtz (2005) argue that papermaking could be more sustainable by being socially responsible. They include five principles: traditional commitment to community development; fair trade; corporate social responsibility; industry business service organisation (like the Nepal Handmade Paper Association); and general policy/legal framework.

Life Cycle Analyses of the Fiji Papermaking Industry.

This is supported by another recent example, in Fiji, the Wainimakutu Village grows their own fibre from the drala (*Erythrina variegate*) tree and plant flower species as part of their village garden to create a sustainable source of papermaking fibres and features (Liebregts and Townsend 1998). They also use old masi (*Broussonetia papyrifera*) fibre from traditional bark cloth making and recycle it as an important fibre source.

They also plant a shrub (*Hibiscus species*) that is used to extract a gelatinous liquid for aiding the suspension of the fibres in the vat. The village design is now beautiful, with many rows of garden flowers and plants that can be used in papermaking. They have evolved a range of sustainable and eco-friendly initiatives over the first seven years of the project.

Other Perspectives: From other viewpoints, Cartwell (1995) has researched the importance of which developing country or MNC the technology developers comes from. This could imply that Australia is seen in a better light than Europe or America for transfer of suitable technology to its Pacific neighbours.

Rouach (2003) helps "small and medium enterprises (SMEs) with the right choice of technology, as well as with the strategy, process and management of technology transfer." This is supported and expanded by Leeuw (2006). Perez (2000) takes that further with a focus on sustainable livelihoods, empowerment and poverty alleviation. This is complemented by McNamer (2005) who examined holistic business solutions for rural poverty with "technology in the service of mankind". Further to this, Dasai *et al.* (2005) also argue "for a cleaner future". From another angle, Batabyal (1997) acknowledges the "twin evils of poverty and environmental degradation" as the driving force to help UDCs create effective international environmental agreements. From another perspective, Bonifant and Arnold (1995) argue that "greater flexibility in the structure and focus of environmental regulation is opening up opportunities in business to gain a competitive edge through innovative compliance strategies".

In summary, all life cycle angles are important to gauge a holistic perspective. There are many colourful phases or bases in which to look at more holistic models of successful TT. Next we need to develop a better understanding of the IP involved in TT.

2.6. Intellectual Property and using the Creative Commons

Business and multinational corporations (MNCs) are preoccupied with developing and protecting their intellectual property for their own profit and control of the world markets and less concerned with the real needs and appropriate technology for empowering UDCs (Hoekman *et al.* 2005; Madu 1989). Most IP is held by a few MNCs in developed countries. The historical perspective is briefly given on 'trade related aspects of intellectual property rights' (TRIPS) (UNCTAD 1996); and 'bilateral investment treaties' (BITs) and others but this could be a thesis in itself. The 'creative commons' approach will be explained later and used in this project.

The UN developed a draft 'international code of conduct' on TT but developing countries have not ratified it for several reasons. One major reason, as Davis (2005) strongly argued, is that developing countries felt disadvantaged and disempowered by the process. The other form is BITs, which have been useful for five decades, however the BITs fall down when the UDC has low leverage and a low level of natural resources to exploit and no political strategic values to leverage. The other international way is in the TRIPS, which encourages developing countries to "ensure their domestic laws grant certain minimum levels of protection" to the stakeholders of the IP. This includes copyrights, trademarks, industrial designs, patents, integrated circuit designs, undisclosed information and franchises (Davies 2005). The downside of this is that UDCs cannot afford new first level technologies and in time they acquire the second and third levels of discarded technologies from DCs.

Another way forward is "good will and quasi rent" to acknowledge the trademark owner (Contractor and Sagafi-Nedjad 1981) or another most holistic alternative way forward is analysing the creative commons.

This thesis bypasses the traditional business system of licensing IP for profit and control and wants to encourage the best available craft technology with a sustainable viable technology base for the host UDC. The author desires to selectively offer his twenty years of IP to altruistically help some UDCs. The IP is **not** now **viable**/ valuable to use in Australia due to high labour costs and tax disincentives imposing tax on top of high labour costs and overheads. Several years ago, in Australia, there were tax shelters created to help the newly forming recycled paper industry , in those few years of the 1980's, the author was developing the technology to be viable and had a potential market. Then the Government did a undiscussed reversal of policy and re-taxed recycled paper. This crippled the viability of the venture and it went back into R&D, to be given away, to developing countries, in the hope they can benefit in a holistic way from the pioneering technology. Now international governments want to find ways to also help UDCs to improve their technologies and leave fewer 'footprints' for DCs and UDCs. This may involve licensing IP and subsidising projects to get them accepted and implemented in UDCs. This thesis will indirectly be a case study of that process.

These new craft equipment and principles can be tested and modified in a range of suitable developing countries. If they can work in a remote village of a UDC then they can work anywhere in the world. The papermaking IP is too hard to patent as it is a combination of hardware and many software skills. The secret essence is protected under licensing agreements and goodwill to be given away to developing countries under the 'creative commons' approach.

2.7. Summary

There are many specific steps of technology to be taken and models with common themes and interconnecting phases to holistically blend them into a valid scientific pathway forward for TT. The thesis will embrace these cornerstones and trial them, evaluate them, and then improve on them in the recommendations. This leads onto the next stage, implementing a field trial for the model in this Thesis.

CHAPTER 3: DEVELOPING A NEW FRAMEWORK MODEL FOR TT

3.1. Introduction

A new framework for technology transfer has been developed for this thesis based on the literature review and the author's experiences in technology transfer. This framework and its phases are described in this Chapter and related to how handmade craft paper technology can be transferred.

3.2. Phases (Collective Parts) of the Models

3.2.1. Introduction

Research and development are essential to improve craft enterprise and companies. The current understanding is that there are many levels of increasing risk or innovation to more extreme radical(ness). A 'stepwise approach' from small to larger to radical innovations in technology can be possible. This section will begin with the stepwise approach, by defining small steps of TT, developing the German model (Efstathiades *et al*.,2000), the learning by doing model (Arrow 1962), skills training (Redding 1996) and recognising the tacit skills (Archibugi and Michie 1997) Then future reports could include the business side (Hanvanish *et al*.,2005) and marketing perspectives (Rauch and Watson 2006). The underlying theme is to also develop artisans' skills and recognition of those skills in small steps of improving TT.

The literature review suggests the need for an attempt to define, categorise and start to posit a systematic progressive order of the parts into successive stages of technology transfer.

1. Developing a case for easy and safe to implement 'small steps';
2. Progressing on to safe 'bigger steps';
3. From that solid foundation even bigger, riskier steps, called a 'leapfrog approach', are possible. This includes a standard 'turnkey approach' to turn the

key of new imported high technology equipment to work in the village. Building on the hardware is the need for a 'copy it exactly' approach to improve skills in using new technology to progressively higher and higher levels;

4. Once a standard product is made then a 'vertical approach' of value adding paper into books and printing of traditional stories can be trialled;
5. The village then has a range of skills for a 'horizontal approach' of transferring the technology to the next village. This can be helped with assistance from government training agencies.

This framework will be complemented with the holistic approach of life cycle analysis:

3.2.2. Starting with Small Steps (Phase 1.)

The 'stepwise approach' is based on small incremental improvements in technology (Efstathiades *et al*. 2000). These can be made by the artisan's skills or new innovative technology. A small step approach minimises the many potential risks involved in any implementation of innovation (Archibugi and Michie 1997; Redding 1996). It allows workers and management to more easily understand the innovation and become experts at using and adapting it to their production regime. This is complemented by training a smaller number of people and getting the details right first, before flowing on to the rest of the workforce. An example of this is the 'tipster' program that starts "small and out of the way" to reduce the many levels of risks and compounding flow-on effects of risks and number of participants. It has easier entry options and gently mitigates the perceived negative aspect of failures (Taylor 1996). People and champions are still critical in the process of any of these approaches.

A few enthusiastic, motivated 'champions' along the way will improve the adaptation and assimilation of new technology and thus make small steps more successful (Lindsey 1998; Mital *et al*., 2004; Westerlund *et al*., 2009). The champions need to be at all levels from inventors, the research and development sector, to management, to marketing niche products, to venture capital finance, to the manufacturing floor, and most importantly to the skilful workers accepting the new challenge. The German model has many of these ingredients and focuses on the critical importance of mastering small steps in TT (Harding 2002).

The German industry model has two important factors:

1. "The capacity of the German economy consistently to produce high quality, high technology and highly competitive products"; and
2. The "strength of the German economy in incremental innovations on the basis of existing technologies". This must be implemented with the workers and management support (Harding 2002).

The workers participate and can understand the small steps and are happier with the management. They have less fear of losing their jobs and can help to implement the new changes (Efstathiades *et al*. 2000). The management is more in control and can guarantee small increments of better products, quicker manufacturing, newer chemicals, newer processes, newer hardware and mastering the skills of software. The clients are guaranteed a continuing service and known products with known properties. They may or may not use the 'best available technology' (BAT) but at least they know how to use the smaller increments in new innovative technology, fix them, and modify them for their needs and maintain high production standards. In time they seem to catch up to the BAT and be better at it by taking the smaller steps. The industry clients may also be involved in the process as they need a better product or service for their needs and get the in-line system of incremental innovation to work for them. The German model has a strong 'collaborative approach' from institutions, government, industry and financiers and Efstathiades *et al*. (2000) still argue that it is stronger model with more proven successful history than other models.

This model is appropriate for DCs, where the culture is geared toward improving the quality of products and production with a skilled workforce. For a UDC we need to start to train the workers in new attitudes to work and improve basic skill levels, so we need to acknowledge the wisdom of the German model for DCs and transpose that for UDCs. One way of doing that is by a more hands on approach to learning skills for UDC's.

The 'learning by doing' model is a hands-on approach to teaching, understanding learning and applying new steps in technology (Arrow, 1962). "Learning is a product of experience …and can only take place through an attempt to solve a problem … and the role of insight ...and previous experience". Arrow (1962, p156) also argues that "repetition of essentially the same problem is subject to sharply diminishing returns." There is a mathematical labour model of this:

'learning curve' or 'progress ratio' = N to the power of negative 1/3:($N^{-1/3}$)

The time to make one unit of production is then a "decreasing function of the total number of (units) of the same type previously produced." This model is more relevant to UDCs and starts to acknowledge the artisans' skills and ways of improving them.

To acknowledge and develop skills training more, Redding (1996) acknowledges that an "economy may become trapped in a 'low skill' equilibrium". This is characterised by a poorly trained workforce and inferior quality products. Redding also promotes a way forward to present a "formal model of endogenous growth" in which management encourages workers to invest in human capital or the acquisition of skills. These views are similar to Colecchia and Papaconstantinou (1996) for OECD countries in supporting an evolution in skills training or up-skilling, while Landry *et al.* (2006) look at how university research can help transfer 'knowledge' (instead of technology) as part of the holistic perspective. Thus research is starting to show how all levels of skill development are important in improving TT, including tacit skills.

Kogut and Zander (1992) elucidate the “idea that tacit knowledge has been widely evoked but rarely defined”, whereas Archibugi and Michie (1997) argue that “individuals and firms play a critical role” in developing innovation in a “complex web of interactions” and “individuals imitate and learn” in an informal and voluntary process of technology innovation. Arora (1996) also acknowledges and tries to deduce an economic value from tacit skills as part of the package of TT. The importance of ‘tacit skills’ was acknowledged by Autio and Laamanen (1995, fig. 3) where they put the tacit component in the middle of the components of technology chart, surrounded by ‘humanware’, ‘infoware’, ‘technoware’ and ‘orgaware’. Hands on skills are critical to producing a high quality unique product with higher sales value, but this needs business support, educational recognition, marketing support and a local training or extension officer for UDCs.

The best ongoing support and training in a village can come from projects that have an extension officer. The inventor or transfer agent of technology, in this case study, (like this thesis), the village extension officer, has their ideals, while the villagers change the technology to their particular way of doing things (Khosa *et al.* 2002). This apparent conflict of expectations will be developed later as some projects will fail due to incompatible or unsustainable expectations. An extension officer must ideally have good tacit skills and be a master craftsman in order to be a ‘champion’ of the project and inspire each village into using appropriate higher technology and skills training in small manageable steps. Then a good product needs good business support.

From a business perspective Hanvanish *et al*. (2005) argued that “less codified (more tacit) knowledge resources may be difficult to transfer” and value for TT. Some business people do not (want to) appreciate the advanced skills of artisans and ignore their true worth and pay them less, and exploit their skill to make more profit for themselves. This forces artisans to gain credit for their skills, to get diplomas and degrees and to earn more self-respect and money.

Artisans need professional recognition for their craft. Thompson (1999) looked at the role of French artisan technology to "safeguard the transfer of indigenous knowledge on which it is based" and that "Indigenous knowledge is local knowledge that is unique to a given culture of society" and quality production is "achieved by apparently simple technology and implements … underpinned by a vast repertoire of knowledge and skills". Now, in France, the industry and government have organised authorised training at 'Diploma' level with several months of on the job training as part of the new course. This gives the artisan a creditable trade 'diploma' to be able to say to the world that they are genuine qualified tradespeople with real valuable skills. This is a tremendously important new cornerstone of any emerging craft to gain international credibility. This will become important as this thesis evolves to give due credit to the ancient yet new craft of modern papermaking artisans. Then a good new innovative product or service business needs to be marketed.

From a marketing perspective, Rauch and Watson (2003) argue for "the buyer to start small' and help UDCs to successfully build up to larger orders and maintain quality. This may involve 'substantial investment in training them' and some supervision in production and even to delivery standards. This complements Au and Enderwick (2000) with a cognitive approach to overcoming several factors of resistance to new technology. The six cognitive factors are: compatibility, enhanced value, perceived benefits, adaptive experiences, difficulty and suppliers' commitment. This process has proven to take many years and yet somehow a craftsman must prove to the world instantly how intrinsically great his product is, as well as generate a new standard quality range of products, and be an expert in many areas, and with little or negative government help. There is a negative gap of support from government and business in honouring and marketing craft products and these all take time, time, and more time to understand and implement.

'Time' is the focus of the 'punctuated-equilibrium model of technology diffusion' depending on 'time' for 'rates' of incremental improvements in technology and systems (Loch and Huberman 1999). It is important to appreciate how it takes 'time' for workers and the administration to assimilate new information and skills and integrate them into improving a product. Once the technology ideas are generated they need to be incorporated into policies and programs (Sharpia 1996), which is outside the scope of this thesis, and then complemented by international agreements. The World Trade Organisation for instance, strongly argues that UDCs should be encouraged to trade and develop new technologies and infrastructure to make a range of better products, with eco-friendly labelling (WTO 1998). They gloss over the small and bigger steps and inherent costs involved in developing new innovative technologies, but complement the major theme of this thesis that good appropriate technology can be transferred, learnt, modified and integrated into the future production regime.

Another way of the locals, working in Australia and New Zealand, help to transfer TT to their village is by networking and directing the "diaspora's contribution" to appropriate projects (Belai 2007, Henoch 2006). By contributing money, they can help direct the building of suitable houses, buy tools and empower their families to design and make things better at a smaller scale of operations that complements the village, culture, craft and sustainability. Small village businesses can be supported with small steps in innovation to help use local knowledge and craft skills to achieve better quality products and marketing opportunities.

In summary, there is a new awareness of the tremendous importance of the tacit skills of the artisans in their craft. Thus small steps in training, in skills, and in education complement the small steps in technology development and enhance the overall production output and quality at many levels. A car mechanic has a trade certificate to verify his skills, so too artisans need a certificate, diploma, or degree to verify their tacit skills. Small steps complement and support the major and minor cornerstones, particularly by empowering people at the grass roots level. Only then can an industry try taking bigger steps with more likelihood of successful implementation.

3.2.3. The "Bigger Stepwise Approach" (Phase2)

Small steps are important, but industry needs to make it more profitable for their investors, to make a better cheaper range of products and to make a range of product options more quickly. This requires a more complex production line, using new raw materials and different energy sources, or less of existing materials (or more colourful, or more fashionable) or just different, to be legally different from the many trademarks and copyrights. Whatever the primary reason, craft and company research can then innovate in bigger steps to try new hardware and software TT regimes. Research also indicates that companies need a good research and development department working at the coal face with the workers through to all the intertwining, evolving, growing, helix levels of management, government and financiers for support (Crane 1977; Freeman 1995; Harding 2002; Saad and Zardie 2005; Tierney 2005). This section builds on the smaller steps and will examine the risks and benefits of bigger steps in TT.

The risks and benefits are greater in the short and/or long term arena. Short term positive rewards of taking risks are that they secure an innovative new contract and deliver the same or better product to satisfy the market. The longer term benefits are the development of new software and hardware technologies, new skills of the workers and improved competitive advantage. This is sometimes called the 'spillover' effect. This spillover, for example, can come from pure academic research from universities. Husted and Christenson (1999) described 'market driven' forces that can include universities, suppliers, competitors, conferences and journals. Koberg *et al*. (2003) promoted a 'total design method' and a 'complexity theory' that ranged from small steps to radical steps in TT. The mix of ideals and business becomes more complex and complicated as long term research and benefits are traded against shorter term market needs and perceived wants of consumers or customers.

The concept of steps and taking bigger risks is reflected in the 'global market paradigm' of the 1990's (Harding 2002). The 'Anglo-Saxon approach' has different market and innovation aspirations and gives more rewards to entrepreneurs who take the risk. There is a perceived 20% barrier that new innovative products need to overcome before being accepted into the market. Once the 20% barrier to that new use of the technology is overcome, then the markets accept that as the new norm / standard and thus look to that company as the new market standard or trend setter (Harding 2002). The flow-on benefits also assist them to be automatically considered as the new preferred supplier. This gives craft companies the market edge and due reward for investing in bigger steps of innovation and risk.

From the above general discussion there is a need to find Pacific examples. There are many small projects going on in the Pacific region, and some reports are in many government and NGO archives that are hard to access through normal library and research means. Being in the UDC of Fiji, and networking to meet key personnel, helped the author to track down some local examples of similar TT. Chapter2.2 described some holistic examples of these technologies including a smokeless stove, coconut oil extraction, the sewing industry, the fishing industry and water bottling. These are re-examined here as examples of bigger steps in TT.

The smokeless stove was an historically good example of a project using small and big changes in technology relevant to a UDC.

Another good Pacific example is the sewing machine clothes industry. It seems to be a good intermediate example of using bigger steps in known sewing machine technology that is compatible with local skills and a good project for both the Indo-Fijian/Fijian region. Local women are trained in using higher technology sewing machines to produce a range of higher quality clothing for the international market. In time, the skills will be upgraded to take on new advances in technology and give them a chance to keep competing in the international arena. With tax havens and international training aid, the industry will be in a good position to keep growing and taking bigger steps in technological progress.

The fishing industry uses modern imported turnkey equipment to process locally caught fish into tinned food for the local and international market. The staff are trained to use the higher technology equipment. The manufacturing processes using international standards, are redesigned and modified to suit a small scale manufacturing industry for a small developing country.

The new water bottling industry is a good example of using a natural resource of a UDC and creating a new international business that is eco-friendly and sustainable. The water is the pure underground water from near Nadi to create an impression of a pure-Fiji-ancient water as the marketing edge for the business. The technology is imported, some locals are selected for their higher education and skills, then further trained in small and then bigger steps to help in the production line.

Fiji has potentially viable reserves of copper in the highlands above Suva (Figures 2.3.3 a,b,c). This is only in the first stages of exploration and would be a good future example of the many hardware and software technologies involved in mining a raw material. It would need small and large steps in training of locals to use bigger machines to extract the ore body. It would need new courses in trade skills to up skill the locals as electricians, plumbers, welders, fitters and turners. It would need modified university courses in chemistry, management and environmental science to complement the project. For the project to be viable and sustainable, existing infrastructure and training would require new levels of industry support. Much needs to be learnt from the Bougainville copper mine before the Fiji project can proceed with the blessing of all stakeholders.

With tax havens and incentives, the new industries have been helped to get established and nearly flourish. However, the coup of 2006 has dampened economic activity and Fiji needs to look forward to the hope of more stable government.

In summary, 'bigger steps' are needed in TT in UDCs to help them start to catch up to available intermediate and DC technologies and improve production and quality levels. This may involve using bigger steps in technology to help the village men design and make smokeless stoves for cooking or using local women for cheaper labour to make clothes for a new clothing industry or using cheaper alternative sources of raw materials like fish to start a fish processing industry and using natural resources like underground water to expand the new bottled drinking water export industry. This flows on to more innovative experiments to make each new industry work better and viable. Experiences from UDCs can now be used to see how they approached TT (See Chapter 2). As the main markets become more international there is more pressure to compete and to make a top quality product with guarantees at each stage of production to capitalise on resources, cheaper labour and tax shelters. Thus small and medium sized enterprises need even bigger leaps of technology and skills to leapfrog into the international arena.

3.2.4. The "Leapfrog Approach" (Phase 3)

Small steps in skills and technology are easy and bigger steps are more challenging but to compete in the international market a UDC must make some larger steps –leapfrog steps – in TT to come up close to and or pass intermediate DC and DCs levels of technology, price, and scale of production, which are crucial factors of competitive advantage. These factors, plus tax incentives, and upskilling labour and more investment in industry infrastructure are needed to support this approach. This section will examine notions of radicalness including: leapfrogging straight into clean development mechanisms; building on the important aspect of intellectual property rights; reflecting on the (un)ethical bias of reverse engineering (defined below); and finally summary remarks leading into the next perspective of turnkey approaches.

Dewar and Dutton (1986) define larger steps as "notions of radicalness" that "represent clear departures from existing practice". They include: pushing the limits beyond normal safe operating procedures; using radically new raw materials; using radically different design principles; using highly trained technical tradespersons; using nano-science; using thinner-lighter-stronger-moulded components; and even new radical management systems or financial systems. This is then evaluated as a much bigger "risk" and "managers are likely to differ in their judgment on an innovation based on their level of familiarity and experience". This must be supported by a large research base, larger funding base, funding for innovative pilot projects, and to wisely go forward in a "pre-emptive long range strategy for technological innovation". The entrepreneurs and scientists need the vision and wisdom to see a positive way forward with the financial backing to support that judgement through the many trials and tribulations of implementing a new regime.

Smith (2001) also strongly argued that "developing countries need to 'leapfrog' a technological generation or two….and move direct to environmentally sound technologies". Complementing this research, Perkins (2003) puts the current concept that "developing countries can bypass (the dirty stages of industrial growth) by leapfrogging straight into modern clean technologies as an integral part of capacity addition". This clean development mechanism argument is supported by Amin (2005) and Sharif (1989) for developing countries. Leapfrogging seems to be good and optimistic if clean development mechanisms are encouraged and supported or subsidized by all levels of industry and government. Bennett (2002, p27 Figure 2) uses an interesting flow chart to explain these phenomena. He shows how a village can go up 1 'level of development' then across 2 'routes in technology capacity' to leapfrog but restricts the leapfrogging process to manageable stages and capacity building. This gives balance, limits and perspective to the process. A craft or company can only leapfrog one or two stages at a time and then needs 'time' to consolidate the jump in the learning curve. Given time, training, subsidies and support the craft or company will be ready for the next step or leapfrog into success or bankruptcy.

Another way forward is to acquire the competitor's product and try and leapfrog ahead by stealing their IP. 'Reverse engineering' is another strategy to go forward (improperly or illegally) using others' technology (Bennett 2002). "Reverse engineering has always been considered as a kind of industrial piracy" (Lari and Lair 2005). For industrialised countries it is seen as copying the inventor's ideas and competing in the same market. For less developed countries it is seen as trying to copy and make a lower technology version so they can at least make some basic to intermediate products for their nation and survive. It can be argued that their market does not overlap and the process is somehow acceptable to use. The process then "proceeds in a linear and predictable fashion from research to development, design, production and then to marketing sales and service" (Lari and Lair 2005). By which (lag) time, the original inventor has probably gone on to make newer products. Companies and countries have done it for hundreds of years until they get ahead of the world, claim some higher moral ground and then protect their new IP by legal means themselves. This thesis will not research that approach but the reverse leapfrogging is interesting for any UDC to examine as a way forward if MNCs do not cooperate and willingly help them with the best available technology.

Chen and Puttitanun (2005) examined developing countries' 'intellectual property rights,' how innovations help this process and argue the options of imitating foreign technology or encouraging domestic innovation. Smith (2008) takes it further and challenges industrial designers to think about the other 90% of the world that live on less than a few dollars a day, and by 'reverse leapfrogging' can bring collective ideas into innovative forms.

The "entrepreneur is also a risk taker" and needs support by the community and business venturers Wilkinson (2006). This is a controversial and sensitive area to discuss. Many inventors, scientists and entrepreneurs have committed years of research and are on that leading edge of technology. They are driven by a range of normal and paranormal forces. A scientist can pursue pure research in the protection of some universities. A small business entrepreneur relies on his own experiences, funding and gumption. A company can use those gifted individuals and support them with a team of experts to make the vision into a viable business. A speculative investor wants high profit over a short span and exploits all above. When risk is lowered, a company share investor wants a moderate profit and return on investment (ROI). He can buy and sell shares instantly to profit or sell out quickly. Perhaps Australia needs to look at long term sponsoring of more entrepreneurs and inventors who are the life blood of future speculators and investors.

In summary for this section, this brief historical perspective creates a case to leapfrog into the next generation of better eco-friendly technologies and clean development mechanisms. This is achieved by extreme levels of radicalness. One example of this is leapfrogging straight into clean development mechanisms. This uses leapfrogging for the benefit of the greater community first, and company profits are secondary, as per the cornerstones. This was followed by the important aspect of intellectual property rights and who control what, for what reason. One option was the use or abuse of reverse engineering to acquire technology and advance a UDC.

This lays the foundation leading to the next perspective of ‘turnkey approaches’. ‘Creative commons’ can also be used to distribute and protect some IP. However, UDCs do not have the infrastructure, skill levels and support in place to take advantage of this, so other mechanisms need to be looked at, like buying in new technology or ‘turnkey approaches’.

3.2.5. The “Turnkey Approach” (Phase 3b)

The ‘turnkey approach’ may not be initially considered relevant to UDCs because a village may not have the money or expertise to buy sophisticated hardware equipment and software training for low skilled villagers. There are many obstacles to this idealised process to work in the harsh extreme, remote, humid, mountainous environments of some UDCs with no infrastructure, no regular power and restricted or expensive phone services. Likewise the village has no inventors/technologists to design, make and create it – so there is a level of co-dependence to make the new technology relevant to them, fixable by them, with training to use it safely, and phone support for maintenance advice or breakdown services (Beladi *et al*. 1997; Majit and Mukherjee 1998; Matto and Olarreaga 2001; Pack and Saggi 1997). However, they do this now in Fiji, with diesel powered generators, pre-made and installed in sea containers, coming in and 'turned the key on' to work and provide instant electrical power, at a cost of importing diesel. The old dream of the Monasavu Wailoa hydroelectric dam providing free electricity for Fiji has gone, as 1.5 metres of water is needed per day and in November 2008 the levels were down below critical levels of 6 metres with no rain in sight (Loanakadavu 2008 and Figures 2.2.2cde). By looking at other examples of turnkey approaches a new focus for this thesis will evolve. To be fair, some examples are negative and some positive. A case study will help reveal the many issues. The organisations and governments are also responsible for playing their parts in TT. Successful technologies can then be taken on by the 'copy it exactly' approach in the next section.

On the negative side, Stewart (1987) argues that the "turnkey plants are typically built by engineering firms with no proprietary technology rather than by the innovative firm" compromising the quality and integrity of the holistic system. He becomes disillusioned with the whole incentive system for technology diffusion or transfer and suggests "efforts to promote TT are either useless or counterproductive." Praussello (2005) also expresses concern that "MNCs have a vital interest to protect their proprietor's competitive advantage from imitation." While on the green side, (Walley and Whitebread, 1994), reflect on the difficulties of "being green" in business and the need for "catalysts for constant innovation, new market opportunity and wealth creation". Perhaps a case study will help elucidate some of the many issues to understand TT and the turnkey approach.

One useful model and case study of a Cypriot ‘advanced manufacturing technology’ (AMT) is by Efstathiades, (2000). They argue that it is a good concept to develop the technology and expertise in one city, make units, and then export the finished product to DCs, Intermediate DCs or UDCs. This helps the UDC who may have no or little access to either advanced manufacturing hardware (H/W)- software (S/W). They argue that the ‘turnkey approach’ encourages the “whole implementation process to be entrusted to a single foreign supplier who accepts responsibility to implement the project”…including management, training and operations (Efstathiades *et al*. 2000). The technology can be imported in three different ways: 1) Direct investment; 2) Joint ventures; and 3) State controlled import modes. For ‘joint ventures’ there are three standard types of TT: Foreign firms supply the machine only; Supply of patents, licenses and/or the manufacturing process; and the technical training and or personnel to run it.

The success is then argued to be highly dependent on any of these phases facilitating TT. The ‘organisational structure’ was argued as important by Weill (1991 in Efstathiades *et al.*2000). The ‘ability to deploy’ the new innovative-complex technology was more critical for Bessant (1993 in Efstathiades *et al.*,2000). Bessant also isolates from the H/W-S/W the phases of working practices, skills disposition, inter-functional relationships, planning and control procedures. This may present a weakness in the theory if the process of TT is cut up rather than included under S/W. Whichever way the TT pie is cut, it is still hardware and software. It is more useful to examine the organisational factors.

The organisation is also responsible for helping to transfer the AMT. This may not be possible at a village level and needs the support of industry and services of the regional town or city. This may involve:

1. Understanding the existing available manufacturing processes, technology and skilled staff;
2. Rationalisation of the existing processes and their respective lines of production to understand any 'foul-ups' or 'bottlenecks';
3. Developing an infrastructure future development plan to allow the smooth transition of new technology;
4. Developing human resources with adequate training/ retraining/ up skilling/ industry, technical, research and university programs.

This is compounded by factors such as: the remoteness of some UDCs; the reliance on airplanes and shipping; time delays; phone, fax, internet and communication delays; paying the full price upfront – on order; and no local agents; lack of village finance; venture capital restrictions and higher risk with time delays; humidity and extreme weather conditions; mountainous conditions with bad access on one lane roads; unstable governments and coups; the diverse range of dialects and languages; religious differences between Christians/Hindus/Moslems.

In another case study, Saad *et al.* (2002) developed the 'turnkey approach' further into a 'product in hand' approach where more emphasis was placed on training the recipient country in using the new technology. This was good in theory, but in the case study it took over twelve years to create a new industry based on buying already second generation or out-dated technology. The resultant products became third-fourth generation / out-dated before they were finally made and sold. The low skill level in the UDC proved insurmountable and the project failed for many reasons.

Fuwa (2006) looked at the pathways out of the Philippines rural poverty. Saad and Zardie (2005) developed a "business incubation system as an aspect of the 'triple helix model' of innovation in which universities, industry, government and non-government organizations feature as principal actors in the national innovation system". This 'helix' of intertwined support will be seriously considered as a foundation for this project to help make a better turnkey product (Etzkowitz and Leydesdorff 2000).

From another angle, Sachon and Pate (2002) argue for “advanced safety critical engineering systems” to be more robust and safe and suitable for developing countries which could unfortunately incur significant extra costs. There is a lot of wisdom in these case studies that will be incorporated into the new strategy. Factors such as: using the latest first generation technology; using the helix of support; redesigning the equipment with local help; making equipment more robust and simpler to fix and service in remote areas.

The initial findings suggest that there are too many challenges to the turnkey approach for UDCs. The evolution into the ‘product in hand’ is good but does not go far enough. A new compromise would be to altruistically get the plans of appropriate new sustainable technology and make the hardware component with industry in the nearest city to the project. This would empower TT at the grass roots levels and allow the machines to be made and serviced in a developing country. However, who is going to give away good new up-to-date or (BAT) technology to a UDC? Who will pay for it? Who will teach them? Who will profit? Who will answer their phone calls for help when it breaks down? Who will translate complicated science and engineering to a village unskilled person using the equipment with limited training? While Bagchi-Sen and Ghosh (2005) debate “doing science for profit versus science for social benefit”, Beladi *et al.* (1997) offer advanced technology for sale to help UDCs and go on to argue that to improve its ‘terms of trade’ they could “give away its superior technology”. Then there is also the question of evaluating the new technologies. UDCs are made to feel grateful for any technology while Benjamin (2006) puts it through a four phase decision making framework. This is useful and objective, thus new eco-friendly clean development mechanisms can be planned to be used in a modified turnkey approach.

What is needed is a new paradigm proposed by the author as a ‘sustainable turnkey approach’ using the cornerstones. Where the best available technology and IP is freely given to help a UDC, and a scientist/engineer can help transfer and train the villagers in low levels of sustainable technology. This would build up the infrastructure of the village and local industry, university and government to provide a helix of support. This strategy would need to use the ‘copy it exactly’ system and teach them progressively better skills and technology over a longer sustainable viable business cycle.

3.2.6. The “Copy it Exactly Approach” (Phase3c)

Having established a base operating system, the UDC business must learn higher levels of production quality and skill levels to improve to national and then international standards and only then to push the boundaries to higher standards. Progressing on from Colecchia and Papaconstantinou (1996), research into ‘ up skilling’ allows McDonald (1998) to develop a more structured approach and takes it further with the ‘copy it exactly’ model of TT based on their unique industry perspective. This section will explore a case study and how it seemed to evolve from the ‘make it work’ strategy, to a ‘process output matching’ strategy, to a ‘copy it exactly’ strategy to the final ‘systems synergy’ strategy.

When the Intel Company tried to transfer semi-conductor manufacturing technology to a developing country it came across several issues or phases of quality parameters McDonald (1998). There were several stages to the production and several facets of each stage, resulting in an accumulation of errors. They tried to make a lowest end of technology, a 1.5 micron unit was considered easy to design and make. As they progressed, each step from 1.0 to 0.5 micron seemed a quantum leap in technology, precision and chances of errors. Likewise for the next level of 0.25 micron.

McDonald (1998, p3) developed a "4 level matching system" (from: 'physical inputs'; to 'process equipment'; to 'module'; to 'products'). Each level had checks, limits and parameters to ensure the appropriate standards at each stage. This more structured and controlled system proved to be a valuable way of introducing standard operational procedures and defining specific goals for each quality sub-phase and stage of production. It was counter argued that it was too strict, too precise and perhaps over controlled but the results were excellent in maintaining strict standard operating procedures for a range of high quality products. Manufacturers will try and bend the rules/limits and make the next level of technology cheaper/profitable, but the customer will soon know if the product or service is inferior and needs more maintenance and downtime to fix.

Terwiesch and Xu (2004) expressed some reservations and thought the 'copy it exactly' approach may restrict industry in ramping up its production to cope with ongoing changes. They want to take more risks with less control over the production quality to innovate faster and keep ahead of market demand. Both arguments have value, but in the end one needs to have overly strict control and to understand the process in order to define the limits of the technology at each step of the process. In time, with hindsight, one can go on quicker to higher standard operating procedures, but one first has to learn or stumble through that learning curve and prove to industry/consumers they are up to the task. This thesis could parallel that process. It could be adapted to this new frontier of smooth craft papermaking for the printing industry as it has taken a quantum leap in many small innovations to produce a new regime of smooth craft paper suitable for the printing industry, progressing from rough card paper, to smoother 300 gsm card, to smooth 200 gsm printer paper, to ultra-smooth 150 gsm paper for photocopiers and then colour photocopiers. The market for this would be quality printers paper and book making in the village.

This concept will be adapted for the introduction of the new craft papermaking that turns rough paper into smooth. The Fijian village papermaking skills are understandably low and thus sufficient to make a range of rough handmade papers. However, the Fiji paper is not suitable for printing machines. This thesis offers a range of new training and equipment to Fiji in a systematic approach to empowering the initial structured layers of skill transfer with future accreditation to satisfy all stakeholders.

This new system could also be applied to help the Nepal handmade paper industry that is currently sponsored by UNICEP's Geneva based greetings card operation. Biggs and Messerschmidt (2005) argue it is an excellent example of a socially responsible program while preserving the natural resources of the forest. A new paradigm needs to be trialled and could then challenge the 'aid' regime and become a viable cottage industry using advanced technology in recognition of their artisan skills.

In summary, the 'copy it exactly' approach is very good for systematically forcing structure into the production line and guaranteeing a consistent step-wise range of standard quality consistent products. This would be further complemented if the cornerstones could be idealised in the project. As each new small step is made to get the next quality level it is supported by a quantum leap in technology innovation and skills. This process of continuous stepwise improvements can be now quantified, verified and developed as a 'standard operating procedure'. These processes will be adapted to papermaking to help raise the technology and skill levels from rough to smoother to ultra smooth texture and reduced weight (measured in grams per square metre gsm) in the craft production of handmade paper. This recognises the degrees of difficulty to make a series of higher quality printer paper suitable for the offset, letterpress, photocopier, colour and laser copiers. This also elevates the 'tacit skills' to a new level and justifies why training and diploma level qualifications are progressively needed. It lays the foundation for value adding the raw product in a structured vertical approach.

3.2.7. The "Vertical Approach" (Phase 4)

An international company can network with a local company and bring in new technology to create a range of new products through a modified 'vertical model approach' (Bennett 2002; Goh 2003, 2005; Pack and Saggi 2001). This ensures that the international company has some control of the process, licences or distribution and thus gets a competitive edge over other companies, or it can be for political motives to support one country's development. The normal stakeholders are the MNCs, small businesses, universities and research enterprises. This section introduces the standard approach of multinational investment followed by some empirical evidence and some concern about the motives. Then some Pacific examples are provided in order to lay the foundations for the modified approach to the vertical transfer of technology to a village in a UDC. This will be analysed by using the new cornerstones and that establishes a new basis for the next section on horizontal TT.

Developing skills in a UDC and more so in villages is harder. Chusseau et al. (2008) reviewed the "skill-biased technological change (SBTC) versus North–South trade (NST)" and were concerned with the "widening wage inequality between skilled and unskilled workers". This reinforces the need for trained scientists and technicians to work at a village level to empower the villagers directly with new appropriate software skills to use the new hardware.

Sjoholm (1999) strongly puts the case that "direct foreign investment has been argued to be an important channel for international diffusion of technology". It is supported with comprehensive data from a case study (Table 1, p58) of the "sector wise distribution of Indonesian manufacturing gross output" and further supported by empirical mathematical models. The 'spillovers' were also further assessed in Tables 4, 5, 6 (p66-68) for spill-overs, technology gaps and competition phases. The spill-overs are the silent, extra benefits of transfer of technology. The many flow on benefits help a UDC from a MNC project. Kugler (2006) developed an objective analysis of three phases of spill-over regarding the technical knowledge spill-overs, the linkage externalities, and the positive and negative effects of competition within or between countries. The gap in research appears in how UDCs should try to be empowered to control the positive flow of better technology and better spill-overs to holistically help a UDC improve in the direction it wants to go.

Gorg and Stobl (2002) developed an empirical analysis of the effect that found that "internationals, through the creation of linkages with indigenous suppliers, can exert a positive effect on indigenous firms." The three facets were:

1. competition against local producers;
2. creating additional demand for a range of products and services; and
3. a fall in price with lower input prices.

This is supported by a comprehensive survey from 1974 and every four years thereafter, for a variety of indigenous businesses (Table 3, p1310). For a UDC, the local labour could be cheaper, or more skilled or the local raw materials could be sourced more cheaply. This creates local mining, forestry or agricultural benefits. New technology could use different local raw materials and create a stronger, lighter, cheaper, and a more colourful range of quality products. There are many opportunities for international companies to network with local industries in UDCs and benefit all stakeholders.

There is overwhelming amount of long term research that shows how multinational corporations are crucial to bringing in a large base of technology for IDCs and UDCs, but there is still some controversy. Several authors have expressed concern about the motives, approach, time delays and costings of MNCs and TT. For example, a UDC could invest too much of their limited resources in supporting a MNC in one form of technology to the detriment of other more eco-friendly or sustainable forms of technology. It would take years to then change the investment momentum into a more sustainable eco-friendly technology while still cleaning up the mess from an inappropriate life cycle analysis.

Meanwhile, for a paper industry example, Blanco *et al*. (2004) argue that the challenge is still there for the international paper industry to be more sustainable to overcome social, economic and scientific obstacles affecting its 800,000 members and 11 million families. The MNCs must become more accountable to the whole industry and community and be seen to lead by example. The MNCs are too big, and the small islands states of the Pacific too small, and they must find another path forward.

Meschi and Vivarelli (2009) are concerned that the "skill biased nature of new technologies may be important factors in shaping the distributive effects of trade" and that UDC may end up worse off. While Meschi et al. (2011) show that imports from developed countries imply a transfer of new technologies, in turn leading to a higher demand for skilled labour. This is the skilled-enhanced trade hypothesis

Meena and Singh's (2013) approach is to instil a positive behavioural orientation for UDC projects. They argue that positive behaviour could play an important "role in tackling the issues of rural poverty for improving sustainable livelihood security in eastern India". They stressed the importance of a credit support system, diversification towards high-value enterprises, technological intervention, a media-mix for technology transfer and frequent visits by skilled artisans and teachers. This changes the concept from hoping for some useful 'spill-overs' to a more structured approach of using skills to vertically value add to a raw waste product like paper, converting it into a new, higher quality range of recycled, re-manufactured, reprocessed, re-engineered papers.

To focus on the Pacific region, many technologies are needed at many levels to improve the UDCs and help them compete in the international arena. Papermaking could be used as an example of improving a local craft cottage industry to make a superior paper product for the printing industry. They currently import millions of dollars worth of paper and paper products, books, folders, printers and as the local indigenous people have little money, the focus is on minimal costs. This compounds the problems as cheaper products tend to have a higher environmental cost of production, with fewer safeguards in place, and more exploitation of resources or people. How can UDCs afford the more expensive eco-friendly costs of production and establish new businesses while trying to compete in their own market, let alone the international markets?

Perhaps a “learning alliance” can be encouraged to “fast track effective mechanisms” as proposed by Daghfous (2004). The thesis will also trial this by developing paper for the local printing industry to test for use as niche market products like invitations, weddings, certificates and books. There is already an established private and government printing industry in the capital Suva that could be fast tracked to help. There are many challenges to create new relevant appropriate eco-friendly profitable technology then horizontally transfer it to the next village.

3.2.8. The "Horizontal Approach" (Stage 5)

Once a company has a good standard production base it can expand by setting up more bases and taking over production in many areas or – in the Fijian way– just giving the new technology away to the next town, village, business enterprise and thus empowering them to establish a new business with flow on benefits. This section will start with the traditional MNCs control of TT, by acknowledging how important it is to start networking slowly with the locals; to build on indigenous technologies; and then to adapt them to local culturally sensitive initiatives. This leads into finding some local literature case studies, exploring new options for the IP involving a creative commons, and thus laying a new foundation to understand the horizontal transfer of technology at a UDC or village level before a more holistic life cycle analysis in the next section.

MNCs like to retain control of technologies and distribution channels in DCs but there are many new challenges when working with UDCs. For instance, it is hard for a MNC to give away their latest eco-friendly technology freely to a UDC (Gorg and Strobl 2002; Glass and Saggi 2002; Praussello 2005). They seek to control the IP, to lever the best business advantage over the longest time and to exploit other businesses and countries. Even if the IP and training were provided to one village, then it would be even harder for a UDC to give it away to another UDC. They need time to learn to use new equipment, IP and skills training in order to create a viable business. Even if they have developed new skills and technology, they would still need an injection of finance to re-design, re-adapt, and pay for components to transfer it or give it to the next village (Crane 1977). It is too hard now for a village to acquire the best available technology (BAT), make and modify it to their needs let alone have the extra skills to then transfer it to the next village.

For normal TT from DCs to UDCs, Raunch and Watson (2003) examine how DCs help by slowly networking with UDCs to start with small orders and test their product, support, technology, and commitment before acquiring bigger orders that need a big investment in TT. Raunch and Watson (2003) put forward a model with 4 levels:

1) search for good UDCs and possible suppliers; 2) start small business dealings; and

3) start bigger safer dealings; or 4) if it is too hard or less profitable in a given time frame, an option is to pull out and go with another UDC or supplier. In discussions with a local Australian entrepreneur, he felt that a business must be seen to 'save face' and 'only support successful ventures', or else they will forever fear their clients saying they failed in that project so 'why should we trust you now?' This is an attitude that could cripple a good business due to other factors beyond its control (Well, 2007). That may be good for them, but what about the indigenous people and technologies, how do they still save face and progress?

In regard to the transfer of indigenous technologies, Rajan *et al*. (1981) looked at the "relative magnitude and impact of known factors which promote and/or inhibit TT as well as identify newer factors." He assessed helping the start up, helping with implementation, helping in designs, assisting in complex licensing, networking with a range of investment levels, understanding the complex demand for products and services, operational challenges and future plans. He included case studies from India.

The village still needs technology, either from MNCs, small business or university based research. As most UDCs and village businesses cannot afford the BAT then other sources are needed. The latest forms of copyright were promoted by Prof Stuart Bunt (2007). He explained the realms from 'copyright©' to the 'public domain-pd' and the need for something in the middle. This gap is now semi-filled with the "Creative Commons" a symbol "cc". This can give credit to the person's technology and transfer it with their permission-blessing. This acknowledgement is empowering for all concerned. If the next group wishes to further consult with the original inventor/designer then that can be done in a fair and equitable way. This opens the door for new research into how to transfer the BAT with researches in DCs networking directly with villages in UDCs and further empowering them to keep transferring the next generation of BAT that is already adjusted to the local village conditions.

Limited literature research was found concerning the giving of the technology to one village and expecting them to pass it on to the next village. Oettle and Koelle (2003) explore the concept of " Capitalising on local knowledge" and use it to prepare, implement and evaluate community based learning exchanges.

The water well boring case study in Africa highlighted how the technology transferred better when there was a local business capacity and incentive to dig bore holes and develop water supply systems (Danert 2006). The Fiji example of the Government taking steps to help transfer the smokeless stoves to improve the community health of cooking at boarding schools in Fiji was further developed in Section 2.2.3. This involved developing technology, giving it away, subsidizing the construction and then maintenance of the stoves, training villagers to make and use them, and now with gas stoves and modern cooking the technology has gone in further leaps and jumps away from empowering people to just buying gas and electric appliances. This presents a challenge of how to best understand how to transfer technology from village to village in the modern context. In summary there are too many challenges for a village to understand and they need all of the helix network of business, government and NGOs.

3.2.9. Summary of the Stages of TT

There are several important stages found to be useful in achieving a successful TT, particularly in a developing country village environment. The very first foundation stage is to get to know the culture and what the locals want help with, to work with them and understand their special way of life. Only then should you start to introduce your foreign ideas and ways. The simpler 'small steps' are a preferred safer way to proceed and safely get to each sub-step and acquire the knowledge and experience to make it work without interfering too much with the current working conditions and expectations of existing orders.

However 'bigger steps' are needed to keep ahead of competition. This could be streamlining production to keep costs down. It could involve sourcing new local, cheaper raw ingredients and experiments with government and university research help in modifying them to work. It could involve totally new product ingredients from wood to plastics to fibre glass, to carbon fibre, to metals to recycled variations. It could involve an innovative use of local village heritage craft to suit a niche in international tourist markets. These incur more risks at all levels of concern, yet the risks are still relatively known and manageable. A parallel production zone could be set up to trial the new process and thus maintain current known standards and complete orders to accepted standards. Only then can the new technologies be validated and accepted as the new standard operating procedure.

To be more entrepreneurial involves designing new innovative leapfrog technology and quickly adapting it to work and thus secure a better order, reduce costs, use different ingredients or change parts of the whole production system. The company may need more levels of helix support, and finance from investors to help secure a successful project, while still funding the normal production levels. The 'turnkey approach' may then appeal to an accountant and/or manager to 'buy in' new quantum leaps of proven technology and then get it instantly working and 'producing a positive cash flow'. In principle, new hardware involves learning new software, but it needs to be simplified, teachable, known and proven. A new 'sustainable turnkey approach' is needed to empower a local village to help design and make the best available equipment and develop skills to use it.

The overflow benefits of TT are also potentially good, as local businesses can then see it working and clone it, copy it, and license it to be made locally. The 'copy it exactly' model is then good to build each level of skill up to a standard and improve production like the small and bigger steps but in a more systematic and accredited way forward. This for example could guarantee sales of quality paper for printers or photocopy paper to the international market. This would allay the fears of users with ISO standard quality assured new eco-friendly products.

The 'vertical approach' is useful to introduce a range of new linked technologies to produce higher quality goods for sale to developed countries and the overflow of technology and skills is documented to benefit many in developing countries. The progression from rough paper to smooth paper to books, poems and publications could create many flow on jobs and promote creativity. Many ideas cannot easily be absorbed by villagers but given the next school generation is growing up with these many new ideas they will take them on in their own time and ways.

The 'horizontal approach' is normally licensed out to the next town or city in a DC to financially exploit to the best and longest time but in a UDC there is no financial reward or incentive so it is more altruistic to incur costs and give the technology to the next village and empower them to help themselves more. This can be done with a more holistic ‘life cycle analysis’ and everyone can benefit.

The life cycle analysis opens the new door of opportunity to redesign a craft project from the start to be based on eco-friendly and recycling principles while using the best available technology that another UDC has already used, trialled and tested to be of benefit. In summary, a new 5 stage model of technology transfer will next be developed and trialled in this thesis.

3.3. The Integrated Model Developed for this Thesis

Two styles of flow charts were initially developed to start examining the process of TT.

Figure 3.3a: Flow chart of 5 Phases of Technology Transfer Using Venn Diagrams.

This starts to show a simple development expanding in complexity through each phase or stage.

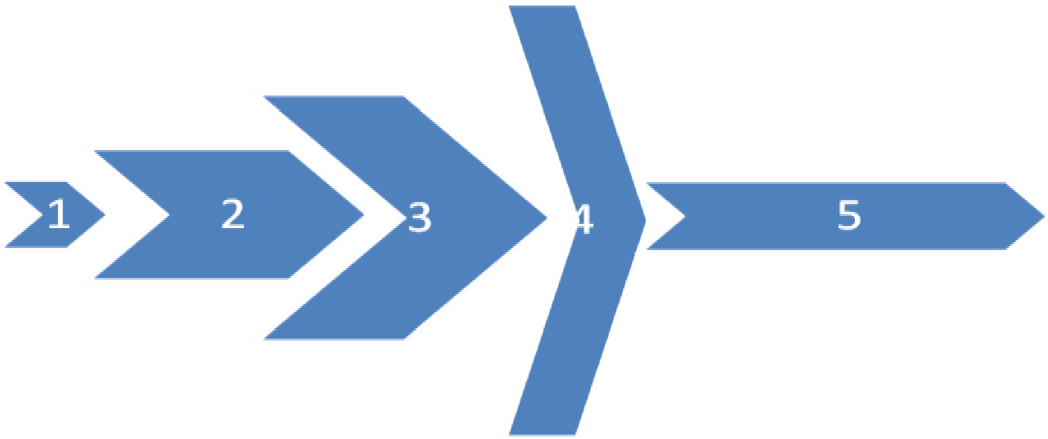


Figure 3.3b: Flow chart of 5 Phases of Technology Transfer: (Using a modified Chevron Approach)

The arrows are deliberately modified, expanded, used to help show the direction from small, increasing in size and complexity to larger (1-2-3) to vertical (4) to horizontal (5).

From the literature review several important phases were extracted to form an integrated holistic model for this thesis. Initially this was based on:

Phase 1: 'Small increments' of easy and/or safe improvements in hardware and software for TT suitable for developing countries level of technology and skills (Harding 2002).

Phase 2: 'Bigger steps' or jumps in TT, with more risk, in order to upgrade the equipment and skills and start competing with better range of products or services (Harting 2002).

Phase 3: Evolving into some 'leapfrog approaches' to be able to adapt big changes in best available TT suitable for and complementary to a developing country village cultural environment (Dewar and Dutton 1986; Perkins 2003; Soete 1985).

Phase 3b: Some more advanced help from developed countries with a modified 'sustainable turnkey approach' to design, modify, and make advanced leapfrog equipment with the helix of inventor, village, industry and university help (Efstathiades 2000).

Phase 3c: To keep improving skills with each phase 1-2-3 but highest skills by the 'copy it exactly' system and creating a new range of standard quality ISO products McDonald (1998).

Phase 4: The improved production base would then be ready for the 'vertical' TT approaches down through a line of business and licences to use IP and make other value added products (Gorg and Stobl 2002; Kugler 2006; Sjoholm 1999).

Phase 5: In time the village would have the skills necessary for the 'horizontal' TT of the new papermaking to the next village (Raunch and Watson 2003; Rajan *et al*. 1981).

Holistic: Incorporating the holistic systems like the six steps (Kearns, Taylor, Hull 2005; Hull *et al*. 2007; Prakhya and Hull 2006) or the 'systems approaches' by Fleissner (1983) or the holistic approach of the third generation of TT (Halls 2007; Hay 2003; Hecht 1999).

Method to include: This would be trialled under the mandate of the ESCAP (2006) 'program of action' and/or a 'action hands on-pilot plant' case study (ESCAP 2006; Findlay 1978; Rajan *et al.* 1981; Spencer and Woroniak 1967) and more specifically 'technical action research' (Grundy 1982) of TT using papermaking as the means to test the model in a least developed country / urban village versus an Australian urban lifestyle village.

This would be implemented by making several components of the equipment in the village, in the small industrial area near the city; or at the engineering department of the university.

1: Stepwise=Small Step Examples: (Phase 1)

Small steps in TT will be small changes in the papermaking equipment and or process or skills. Some equipment can be made in the villages using client's skills and respective levels of tools and technology. The basic designed wooden stacking system of drying frames and a vat are possible examples. Others include:

- Using available free waste industry paper sources of raw material: Networking with local printers and government print departments for access to regular free waste offcuts of assorted quality office/printers waste;
- Making and sewing each cotton transfer sheet with a wooden support rod (LCC); Use the village ladies and their treadle sewing machines to sew a special size and shape cotton clothe into a papermaking clothe (LCC).
- Making a simple wooden stacking bench-trolley for the LCC's; start working with village men and carpenter skills to make wooden equipment.
- Making a more complex wooden aligned stacking system for the couching cottons to be guided onto (LSR);

2: Bigger Step Examples: (Phase 2)

A bigger step in TT would be making better vats, moulds, press and drying technique.

- The vat could be redesigned to use a simple dipping action, with less pulp, controlled pulp concentrations and better drains (LVat).

- The wooden frames could be upgraded to aluminium mould and deckles, thus no warp and better flatter screens, less maintenance; consistent gsm range (LAM);
- The manual screw press could be upgraded to a hydraulic press; to make better paper for photocopiers with better smooth surface transfer technology (LPP);
- The drying creates smoke and thus is bad OHS. The product could be air dried, yielding a quicker and higher volume of continuous production.

3: Leapfrog Examples (Phase 3)

A bigger step again is called 'leapfrog' technology;

Equipment : The new 'couching transfer curve (LTC)' changes and simplifies a section of the process. The 'transfer curve' can miraculously transfer the delicate pulp onto the couching-cotton sheet. This would be made by the craftsmen in the village and this will also empower the women to use the new technology, while saving critical production time. For example: Process: A new smoothing process combines new surface technology plus chemicals plus trade secrets to create a new high quality smooth paper.

3b: Turnkey Examples (Phase 3b)

This would involve designing and making one major piece of new technology hardware in Suva (a developing country) versus Perth (a developed country) with respective local engineering companies. This is a new hydropulper design (LHP), motor, new blades, new bearings, new lovejoy couplings and can be made by special engineers and donated to the project as an example of the 'turnkey approach' to TT. This could process 200 litres of pulp in 30 minutes, a tenfold saving of time and energy. This could also be done as an engineering university student based project to redesign the technology to suit the developing country, the local village and cultural context.

3c: Copy it Exactly (Phase 3c)

The 'copy it exactly' system, McDonald (1998), helps develop the next levels of quality software skills and training parameters plus refining the use of each piece of equipment. It can be applied to the LHMProcess as it is easy to make rougher handmade paper, then progressively harder to make writing paper, then offset and multi-press printers papers, then black and white copy paper, then colour photographic paper.

4: Vertical (Phase 4)

The ‘vertical approach’ will only be started in this thesis and trialled by helping transfer integrated systems of new technology under licence to two different international villages, empowering understanding of each phase of the process. For example this could involve making the paper then value adding for printing, bookbinding, publishing, story-telling, into a finished product like a book of poems from each village.

5: Horizontal (Phase 5)

The ‘Horizontal Approach’ will also only be started in this thesis, and trialled by an independent local training agency in helping each village ‘own’, adapt and transfer the technology to another local village. This will gauge the long term success of the process on how well they independently go on and ‘own’ the new technology and thus, further modify it to their own needs or to help the next village to be successful.

Holistic (within the project)

The holistic and 3rd generation approach, is within the heart of the project and will be trialled indirectly by designing an integrated holistic mode of manufacturing a waste industry paper product into a value added high quality range of paper and products that complement the needs of each village while enhancing the environmental, social and economic indicators. This will empower the villages to use their local resources and talent, and keep their residents interested in staying in the villages.

Another important part of understanding the new 3rd generation approach will be re-represented by Hall (2006 Fig. 11.5, p187). This shows each as a step or hurdles to overcome to develop the information base and to have a filter of the local developing country’s conditions from which to select and adapt the relevant new technologies.

Trial-Pilot Plant

The ESCAP ‘program of action’ or ‘pilot plant’ supports a TT project that is: appropriate; uses local skills; less costly; benefits society at many levels; encourages traditional knowledge; creates new skills and technologies; networks with regional universities; and creates niche markets for products that could be sold internationally.

In this case the LHMP technology and process is done ‘in house’ and can be transferred by the author as part of the project. This will allow an interesting perspective of the whole project from within and analytically external to it. The strength is in the breadth and depth of knowledge from the author and the industry in developing the new technology and in helping to adapt it further for the trials. This will empower decision making within the project without going to many other independent or separate experts in the field. The weakness may be 'marketing' and helping to secure contractual arrangements and as that is …outside the parameters of the thesis…it will be never the less an important process for the developing country to bring in a consultant and secure a good contract to supply a national or international wholesaler with raw A3 or A4 paper for distribution.

The trial plant can also build on the work of others, as the Wainimakutu Papermaking Village operation has been in operation for several years in a remote region in Fiji, with help from a local consultant and a New Zealand papermaking expert. This allows some exciting new technology trials to be tested and investigated in a real functional papermaking craft village.

3.4. Summary

We now have a new refined 5 Phase Model for transferring technology to help generic craft enterprises in developing countries and next we need a new modified standard Methodology to complement this.

CHAPTER 4: METHODOLOGY

(This Chapter is also more fully developed in a separate report: Westerlund, L. C. (2013). *Report on New Model of 5 Facets of Technology Transfer to help Developing Countries*.)

4.1. Introduction

Based on the literature review, the most appropriate methods would include an action hands on method of trialling a pilot plant ontology, complemented by (theoretical / actual) surveys to evaluate the broad range of phases of technology transfers (Colombo 2003; Crotty 1998; Grundy 1995; Robson 2002; Tripp 1995). This is summarised in Table 4.1a. by comparing TT projects in a UDC, Fiji and a DC, Australia.

Table 4.1a: Summary of Methodology Comparing a Papermaking Village in Fiji to a Modern Lifestyle – Retirement Village in Australia.

Knowledge frame	Fiji Papermaking Village	BWLV
ontology	Study of what is real for a remote Fijian village.	Study of what is real for a modern lifestyle village.
epistemology	Way we look at the world: Sustainable eco-friendly, best available technology to support village employment and its cultural heritage.	Way we look at the world: Sustainable eco-friendly, best available technology to make a unique craft activity for a lifestyle village
theoretical perspective	5 phases of transfer as described in the Framework for TT	5 phases of transfer as described in the Framework for TT
methodology	Experimental research Action research Fijian 'turnkey' eg. Theoretical Survey methods	Experimental research Action research Australian "turnkey' eg. Theoretical Survey methods

The significant difference is that in Fiji the whole village depends on part time rotational employment for about 80 ladies and 2 men, while in Australia it is a life-style craft activity.

More specifically, it would involve a 'technical action research' where an expert in the field of the new smooth craft papermaking could transfer those skills to a UDC versus a DC village (Grundy 1982). This is summarised into 6 Parts (A-F) in Table 4.1b. This evolved into 5 phases of TT as the project developed. Two surveys were also conducted to quantitatively appraise the success of the TT.

Table 4.1b: Summary of Methods as they evolved from Parts A-F into phases 1-5.

Parts	**Phases**	Fiji (UDC)	Australia BWLV (DC)
A	**Foundation**	Understand culture/village/ existing papermaking technology	Understand lifestylers' needs, good trade skills, time money, hobbies
B	**1**	Make low technology equipment in villages	Make low technology equipment in villages
C	**2-3**	Make higher technology equipment with industry help in Suva Fiji (UDC): Make Leapfrog steps in TT	Make higher technology equipment with industry help in Rockingham region, Perth (DC). Make Leapfrog steps in TT
D	**2-3**	Transfer software skills of papermaking by the Author	Transfer software skills of papermaking by the Author
E	**4**	Vertical TT of book making and stories of culture	Vertical TT of book making and diversifying craft activities
F	**5**	Horizontal TT of helping the next Fijian village make paper	Horizontal TT of helping the next BWLV village make paper
Survey	**1-2-3**	Questionnaire: Based on a trial of 25 points per 4 parts BCCD =100pts	Questionnaire Based on a trial of 25 points per 4 parts BCCD =100pts
Survey		UNEP criteria Author's assessment.	UNEP criteria Author's assessment.

Note: The part C evolved into a two distinct levels. The evolution from the (1) small step into (2) 'bigger step of TT' and an even bigger step, a (3) 'leapfrog step in TT'. Both still need the software skills of the craftspeople to master the papermaking process.

Part A: would be to gather data on the papermakers: their age, gender, which matagali (clan, family) they come from, levels of technology already used in the village, and existing papermaking skills. This would provide a valuable insight into how village dynamics works. As the chiefly men of the same matagali seemed to dominate in the village it was considered important where or which village the women came from in order to understand whether this contributed to the process of diffusion of TT. The women were dominant in the papermaking project and support of the community. Perhaps they introduced many new skills and attitudes and networking to help the village as a whole. Perhaps their vision was not limited to the local village and they wanted their children to be able to go back to their village or city with pride and new skills. By visiting and living with the Fijians over a few years prior to and including the project the author began to develop a more sensitive appreciation of the deep Fijian culture and ways of working with them to create a new path forward in craft technology.

Part B: would be to make simple level technology in the resource limited environment of the village. This would produce data on the tools they have and need, their level of skills in using tools, and adapting their skills to make new innovative equipment in the limited confines of the village. (This evolved into Phase 1.)

Part C: to make advanced hardware with help from local industry partners in the nearest capital city and the local regional university engineering department. This would gauge the ability of the tradespeople and engineering department to help in the higher level of hardware and software transfer of technology to a remote village craft project. (This evolved into Phase 2-3.)

Part D: to transfer critical new software skills of papermaking to the craftsmen and women of the village with small and large group workshops. Culturally they already made beautiful mats and tapa in a sustainable way and held trade fair days of their craft by visiting other villages. The paper craft was seen as complementing their traditional culture and skills but this still needed to be understood and evaluated by standard qualitative and quantitative methods. This would lift their skill level to the next level of making an internationally recognised premium quality hand-made paper that could be printed on and used as photocopy paper or the highest colour photocopy paper. (This evolved into Phase 2-3.) The 'bigger step' in TT (Phase 2) evolved into another 'leapfrog step' in TT (Phase 3) and was felt very important to create another Phase 2-3.

Part E: 'vertical TT': It was felt they could learn how to make story books with the raw paper they made in the village. As their culture did not traditionally write down stories or use paper, the current young generation would be reading and writing in English as a second language and it was hoped they would appreciate their own stories written on their own beautiful village made smooth paper, then bound with book-covers using their rougher textured flowery paper card.

Part F: The 'horizontal transfer' of papermaking skills to the next village would create an interesting paradigm to understand how they see the importance of the project and how to transfer their adapted technology to pioneer the next level of transfer. This would create a unique research perspective of the village owning the technology and transferring it their way. The other aspects would be 'marketing', which is beyond the scope of the thesis but still critical to the economic success of a science based project. The company Pure Fiji have started the marketing by selecting the village to produce a specific wrapping paper of 1000 sheets per week (before the coup).

The questionnaire **survey** evolved with and followed the structure of the thesis and systematically developed a new standard system to quantify the transfer of technology. This involved allocating the small steps (B); then bigger steps of hardware (C2); then leapfrog hardware (C3): then software skills of the artisan (D2&3): The 4 sections are equally divided into 100 standard units or points; and were allocated a value of 4 x 25 points, and when added together would yield 100 points or 100% equivalent transfer of the author's artisan's skill. The skills were in designing, making, building, modifying, and redesigning the equipment to work in each new environment and the inherent operational skills of each piece of equipment and the artisan's skills of integrating the whole process to create a high quality consistent craft product. This mixed approach was based on forming an objective quantitative value judgement to evaluate the success of the project.

This project was quite complex, multifaceted, multilayered and pioneering. Thus there was a need to use a methodology which seemed to be neutral, impartial and objective when reviewing the emotional, subjective, holistic nature of sustainable-alternative-eco-friendly TT of a cottage-craft industry based papermaking process. The generic '**PIRI**' methodology was chosen (Thrift and Sykes 2012): the '**P**lan' is assessed, then '**I**mplemented', then '**R**eviewed' and finally '**I**mprovements' can be made. This can then be a cyclic process of continual improvement and refinement of ideas, concepts and pathways to pioneer. This acknowledges the room left open for continual improvements and ever-changing paradigms of the new eco-friendly and sustainable regimes.

In summary several theoretical approaches to evaluating projects were reviewed to evaluate the TT. The phases system from Rouach (2003) and Crotty's (1998) standard survey system was used as a base and other aspects drawn from the others and modified to suit. The generic set of criteria for environmentally sound technologies (ESTs) for sustainable development were evaluated for this project IETC (2003c). However, from the literature search, there was no appropriate standard objective procedure to evaluate TT to developing countries for this thesis, so two new ways have been developed. One based on a quantitative survey of the five phases of the process. The other based on the United Nations guidelines for sustainable technologies.

The 'Five Phase Survey' method of evaluating the processes of TT is now under study itself as a new way forward and can thus form an important part of this project's research. It will be developed along the lines of phases or major stages of TT; it will include 5 points per question and 25 points allocated per four sub-parts of a phase. This adds up to 100 points of equivalent transfer which implies 100% equivalent transfer of technology. Each major phase can then be added as a project expands: from making equipment (hardware); to training papermakers (software); to management; marketing; vertical and horizontal transfer; and to future research.

The standard United Nations Environment Program's ESTs for sustainable development were also modified to be more objective and quantitative with a five star rating system (IETC 2003c). This has created a powerful way of extracting the maximum value from the template and magnifying each by a value of up to 5 points yields a comparable aggregated value to compare with other technologies and projects.

The thesis researched and developed and then trialled a 100 point system of valuing and evaluating a rating system of sections of TT hardware and software. For example, for hardware, we selected a representative piece of hardware that was made for the project, and asked 5 key questions about building that piece of hardware giving each question a rating of up to five. This was done for each of the 4 phases of TT, yielding a score out of 100 or a percentage. These scores could be compared for different projects in order to measure their success.

For example, the hydropulper equipment needed a welder to weld the 200L bowl to the frame; the mechanic needed to insert bearings onto a drive shaft and machine the stainless steel shaft to 19.8+-0.2 millimetre to fit; a lathe machinist needed to design and lathe a copper water proof cover to the standard bearing and insert 2 standard rubber seals for extra ruggedness in a remote village so it never needed servicing; and an electrician needed to wire in special safety features to turn the equipment safely on and off in normal use and water/safety emergencies. The concept is to pick a (limited) range of 5 selections of key components to make a level of technology equipment from the many technicians; mechanic; designers; electricians; tradespeople involved. It would be counterproductive to focus only on one skill and is important to include as many specialty unique aspects of skill level as necessary. This also supports the expanding the phases to include (2-3) radical steps in TT. Village tradespeople could help make lower technology equipment while university and industry tradespeople were needed to make advanced equipment. This process honours more people to be involved at many levels for 5 points per contribution.

Summary for Hands On Technology Transfer – the Pilot Plant

The action hands on model of the pilot plant will be used. By actually designing and building a pilot papermaking plant in a developed country versus a developing country the thesis will actively explore the many facets of issues that arise from the implementation process and networking with each village while being sensitive to their culture and needs.

The hardware/equipment would need to be built in the village if possible; then in the nearest town with access to power and engineering skills; then at a close regional university engineering department. This could be done as **Part B**: to make small technology equipment in the village; **Part C**: to make medium/advanced technology with industry and or university projects; **Part D**: to transfer the software skills of making paper by the author to the village via several workshops.

The software/skills; **Part D**: would need to be taught in various structured workshops to first show/demonstrate the new skills and train them in the new technology transferring the skills in the process. Each piece of equipment needs new skills and the overall process needs new skills, understanding and wisdom.

The Fijian village would already have good skills in papermaking as they have been gradually established from nothing several years ago. It would be a process of showing them the more advanced skills and trying to transfer them, and evaluating that process considering the language translation and difficulties.

Given the short time frame and opportunity, the project would only start the next **Part E**: of ‘vertical TT’ (Phase 4) and teach the software skills of value adding paper into books, poetry and publications.

Given a longer time frame and opportunity the project would start the next **Part F**: of ‘horizontal TT’ (Phase 5) to empower a local provider to continue the project. They would use all their acquired skills to start helping the next village to make a paper production plant in controlled workshops near Suva with networking to the villages. This involved using their skills to make the hardware/equipment and teaching. It involved networking with government training agents to facilitate the process.

To help understand the overall perspective, the following Table 3.1c, gives an analysis of the options and pathways. For example: starting with small steps there are the four options. The codes for the equipment are like the ‘couching cottons’=LCC. With a few dollars ($s) it could be made in Fiji. It indicates if it is more hardware (HW) than software (SW). The licence (Lic) to use the new technology was also given freely ($). With any new hardware there is always new degree of software skills to be developed in making it and using it. Each aspect has its own story to build on.

Table 4.1c: Overview of Methodology Versus Equipment and Processes for Fiji and Australian Lifestyle Villages.

Methodology (Survey)	Phase	Equipment/ Process	Code (Ref)	Fiji-Australia	HW/ SW	Village; Industry University
***A	**0**	Assess Technology and Culture in Village				Village
***B Small Steps	**1**					
		Fibre Source		Free		
		Couching Cottons	LCC	$make	HW-SW	
		Stacking	LSR	$make	HW-SW	
		Bench		$make	HW	
***C Bigger Steps	**2**					
		Vat	Vat	$make	HW-SW	
		Alum Mould /D	LAM	$make/T	HW-SW	Industry
		Press	LPP	$make	HW-SW	Industry University
		Drying		change	SW	Village
***C	**3**					
Leapfrog H/w		Transfer Curve	LTC	$make	HW-SW	Village
Leapfrog S/w	**3**	Smoothing	LSS	Free$ +Lic	SW	Village
Sustainable Turnkey	**3**	Hydropulper	LHP	Donated University	HW-SW	Industry University
***D	**1-3**	Papermaking Skills:				
Copy it Exactly		Quality Paper		Tacit	SW	Village
***F						
Vertical	**4**	Value Adding: Publishing Skills:+laptop +printer		$Tacit	SW	Village Industry University
***G	**5**					
Horizontal		TT To Next Village		$MTLD	HW-SW	Village Industry University
H***Other						
7 C's		7Cs	(UNEP)			
Systems		System				
6 Phases		6 facets	(Hull)			
3rdGen		Holistic	(Hall)			

Column 1:
The methodology started with A-G; and evolved over the years into Column 2:

Column 2:

Foundation 0: and 5 Phases of Technology Transfer: 1-2-3-4-5: and options for future #6 and others.

Column 3:
The equipment or process is described

Column 4: (see Chapter 4.5 for explanation of equipment)
The codes relate to the patent ready industry name of the new equipment that Leslie L' has designed and engineered. Eg.
LCC = new L' Couching Cloth instead of felts;
LSR = new L'Stack Rack to guide each LCC onto a board in a new standard parallel stacking system;
LVat = new L'Vat for easy entry of the mould and deckle into the new Vat making a extremely low 0.5% pulp solution.
LAM = new L' Aluminium Mould and Deckle to make each sheet of paper in the vat;
LPP = new L' Paper Press for parallel pressing of 50-200 sheets of paper at 100 tonnes per square metre;
LTC = new L' Transfer Curve that scientifically uses physical angular transfer of a parallel surface interface to almost miraculously transfer the newly formed delicate-wet-paper over and upside down to another flexible clothe medium, without breaking the continuum of fibres.
LSS = new L' Smoothing Sheet technology that helps create a superior premium smooth surface with controllable sizing characteristics.
LHP = new L' Hydropulper that uses water-hydro and pulping in a big 200 litre blender to create pulp from waste fibre of less than 1mm in length.

Column 5:
Fiji =Wainimakutu Hand Made Papermaking Village (WHMP):
Australia = Bridgewater Lifestyle Village Mandurah, WA. (BWLV)
$ =input money to buy components and or save by making it;
M =**M**ake= make it in village or industry or university;
T =**T**acit knowledge/skills;
Lic =**Lic**ense to use the new smooth papermaking technology from the author;
D =**D**esign skills;

Column 6:
HW = **H**ard**w**are = equipment;
SW =**S**oft**w**are = skills to make paper or use equipment;

Column 7:
The ideal is to do as much as possible in the Village and as noted with Industry or University help to co-design and make the equipment.

4.2. Methodology of the Survey

An evaluation survey was developed from research in the literature review and fine tuning of the field experience on the Fijian site complementing the technology of production and transfer of skills to villagers. The rationale was to try and first develop a working model that would compare the real life situation of the pilot plants, TT, and developing countries: eg. Fiji, then adjust it to the Australian case study. Both surveys evolved and reflected changes to cater for their respective situations. After much consultation with key indigenous stakeholders the final Fijian structure was agreed upon with a locally qualified translator present. The BWLV survey was then developed to mirror the Fijian survey. This proved a challenge as papermaking was just a craft to them rather than a potential economic enterprise but in other ways it was easier, as no translators were needed.

The project pioneered a modified use of the survey technique to try and quantify the TT process relevant to the village environment. The data focussed on

A: background of the technology and skills of the villagers;
B: small steps in hardware TT (Phase 1);
C: larger steps in hardware TT (Phase 2-3);
D: process or software TT (Phase 2-3).
From this data base and the Author's knowledge of the life stylers involved, the data was extrapolated to form the idealised potential of

E: vertical TT (Phase 4),
F: horizontal TT (Phase 5),
G: acknowledging the marketing Phase of projects.

Based on their existing skill and understanding of TT they would thus have some skills to transfer to the next village to ensure the potential ownership of the technology and ability to pass the skills based knowledge on to the next village.

The data was separated on the 'Excel' program into the two realms and summarised and calculated as subtotals and combined totals and percentages. They were then combined into a master summary and analysed for percentages of the ideal total.

4.3. The "Pilot Project Model"

A theoretical approach or survey could have been used for the thesis but the hands on pilot project approach was preferred to trial the many parts and challenges of technology transfer in a real life situation of a developing country that desperately needs help at many levels and to further understand better ways of implementing TT while being sensitive to their cultural needs (Daghfous 2004). This section will briefly explore this interesting, challenging, confronting, pioneering, scientific - hands on approach to TT. It will give some useful background; examine a case study; include a cultural bias and sensitivity analysis; examine the need for laboratory support; and present another case study, before leading into the model for this thesis.

Spencer and Woroniak (1967) developed many arguments in their pioneering book on "Technology Transfer to Developing Countries". Firstly Murphy examines the 'retrospective view'; secondly Kmenta explores the 'technology gap' and in Figure 1, p41 they measure "not only the size of the technological gap but also the 'bias' of the technological superiority". Thirdly, Salin's critiques of the 'Schumpeter models' of "distinctions between statics or circular flow and dynamics" implied it is "irrelevant to (modern) technology transfer". This evolves into the one major supporting argument for this thesis that "for efficient application of technology (transfer to developing countries), a wide range of know how must be added, and the technology must be transferred easily by personal contact, demonstration and training… by a team of specialists … complementary knowledge and skills… participating in actual operations … called a pilot project" (Spencer and Woroniak 1967, p181). Later they argue that scientists have two major roles in UDCs: in "choice of technology … and science is essential to the receptive technology of the donee / recipient country." This will challenge the science of the project and provide a framework to understand the myriad of issues and introduce relevant technology into a case study of a pilot plant.

The 'Gesalk' versus 'transfer' views were also examined to note that "technology must be adapted to indigenous culture;…and…culture must adapt to the foreign technology… or be destructive to indigenous culture"(Spencer and Woroniak 1967, p197). This complements the thesis and supports the underlying theme of making a craft paper product and value adding into a cultural book of poems and stories relevant to the primary school curriculum. Then the ESCAP 'program of action' or 'pilot plant' supports a TT project that is appropriate, uses local skills, is less costly, benefits society at many levels, encourages traditional knowledge, creates new skills and technologies, networks with regional universities, and creates niche markets for products that could be sold internationally (ESCAP 2006-7). This empowers the project to step out and pioneer these important principles.

Rajan *et al*. (1981) proposes "innovating laboratories" to be "directly responsible with operational problems concerned with 'commercialising' reproducibility of technology at the factory floor …and feedback from clients and follow up actions." This supports the desire to network with the engineering department of a local UDC university to redesign and make advanced equipment for the project. Also, Findlay (1978) argues that "new technology generally requires demonstration in the context of the local environment before it can be transferred effectively". A good case study is from Danert (2006) where empowering the hand drilling operators of water in Niger over thirty years puts the technology now in the hands of the locals. This also guides the thesis project to work first with the villages, then local industry, then a local university to transfer the technology and ownership to them.

This section strongly concludes that a pilot plant that is sensitive to the needs of the local indigenous people is important foundational research for TT to a UDC using skilled personnel and time for hands on training. A number of theories, models, methods, approaches, concepts are available from which to pick the best parts for a hands-on project to form a model for this thesis.

4.4. Methodology of the New Papermaking Process

A simplified order of the new papermaking regime is in the following Table 4.4

Table 4.4: Order of standard WHMP / LHMP production process.

1:	selection of paper and fibre sources;
2:	pulping by the Hollander / hydropulper;
3:	use of moulds and deckles: wood / aluminium
4:	use of cotton - couching cloths
5:	use of the couching or transferring process
6:	stacking the layers ready for pressing
7:	pressing with screw press / hydraulic press
8:	drying with fire / lofts.
9:	grading and sorting of larger A3 plus into cut A3 into two A4 papers.

4.5. The Technology to be Transferred

The new smooth papermaking process is a combination of three decades of ongoing private, business and academic research to perfect the science and art of a new highest level of hand made recycled A3plus paper that can be cut into 1 x A3 and 2 x A4 standard sheets, now being trialled for higher grade printer paper.

The new mould and deckle is made from moulded aluminium (so it does not warp or rust or mould) and inserted with a high strength mesh (to make a level layer of pulp). It is called Leslie's Aluminium Mould (LAM).

The new vat has special angles of entry to ensure a novice can make a perfect sheet of pulpy-paper the first time. (L Vat), and control the pulp volume and concentration. For example, a refill of 2000ml will make a 200gsm paper.

The new L'Hydro-Pulper (LHP) is a 200 litre recycled drum with a special L'Pulping Blade (LPB) and water seal and standard bearings, on a 20mm stainless steel special threaded shaft, and safety electrical switches and designed to chop paper into 1-2mm pulp.

The new L'Pulping Blade (LPB) is a marine grade 6, stainless steel blade with a reverse design and special cut angle to slice through the toughest pulp.

The new L'Couching Cloths (LCC) are made from cotton with a special insert of 10mm dowel, and sewn to a special size (650x450mm) for the stacking system +- 5mm.

The new L'Stacking Rack system (LSR) is a guided stack rack, for 5 LCSs; with 600x400mm boards for easy removal and entry into the press.

The new L'Paper Press (LPP) is a modified bench press with a 600x400mm thick base plate for transferring 100 tonnes per square metre of critically even pressure over the newly forming pulp into paper. It is stacked with layers of the 1 board and 5 LCCs and 5 LSS and up to 20 sets =100 sheets of A3 paper.

The L' Super Smoothee (LSS) technology is a specially coated film that is inserted into the pressing process to create a unique smooth side to one side of the paper under controlled temperature, pressure and drying time conditions.

The software skills are firstly the tradespeople's skills in making the equipment; an artisan's skills in papermaking; and the scientific skills to improve the process; and the design engineering skills to improve the equipment; the chemistry skills of controlling the papermaking; the physics skills of pressing the paper; and the evolving cyclic process of refining technology to keep testing and improving each aspect over time and decades.

4.6. Summary

We now have a new Best Available Technology for the design of the equipment and a Method and Methodology for transferring new eco friendly craft and technologies to help developing countries in a culturally sensitive and sustainable way forward.

CHAPTER 5: RESULTS FOR A PILOT PLANT TECHNOLOGY TRANSFER TO A FIJI VILLAGE

5.1. Introduction

This chapter describes the results of the application of the innovative new model of the 'Five Phases of sustainable technology transfer' (5PSTT). The demonstration project was a case study of a village in Fiji and compared to a duplicate case study at Bridgewater National Lifestlye Village in the town of Mandurah, Western Australia. This was conducted by reviewing the background on the village, infrastructure, marketing, culture, skills, needs, wants and existing papermaking technologies; while indirectly incorporating the several 'C's' (IETC 2003b). This chapter concludes with the author's reflections on this ambitious project over several years.

5.2. Improving Existing Technology: (Foundation).

5.2.1. Introduction:

Before a TT Agent can transfer a new technology, a suitable village must be chosen. This could be considered a phase in itself, but in this case study it was considered a foundation. If you already have a foundation, then you would proceed to transfer the technologies by Phases 1 through to 5.

5.2.1.1. Selecting Guidelines for a Preferred Developing Country:

The village within a developing country project was examined before applying the 5 important phases of TT: the 'Foundation' consists of:

- deciding on a suitable developing country, location and village;
- reviewing their papermaking options;
- assessing their papermaking 'life cycle management';

The latter includes:

- some holistic perspectives (Halls 2006);
- some of seven C's (IETC 2003b);
- how sustainable they are (Ghina 2003);
- how some machines can be made locally (Sharif 1989; Sharma 2007);
- how green the technologies are (Gupta 2007; Walley 1994);and
- if they can follow codes of conduct of technology (Guadamuz 2005).

5.2.1.2. Choosing a Suitable Village and Developing Country:

The PIRI methodology was used as a guide: the first 'plan' was adapted to choose a suitable developing country close to Australia. Several countries including Samoa, New Guinea, Solomon Islands, Tonga, Fiji and even New Zealand were examined as examples of a DC. Handani (2004) referred to disseminating TT to islands and encouraging the process.

Several regional areas were evaluated. Tome (1994) had some basic background on the Solomon Islands to indicate it had a low level of papermaking craft established. New Zealand has some craft established and would be easy with English language but too developed for this pilot project. A Tongan delegate was interviewed and we reasoned it would be a good 2nd stage base to trial the project but the focus kept coming back to

Fiji. More background on Fiji and the Pacific region was found, in particular: "The composite vulnerability index (CVI) results by region and geographical vulnerability (GV) thresholds" were assessed (Turvey, 2007, Table 4, p257). This relates to four factors: of coastal index, peripheral index, urbanisation indicators, and natural disasters. In the Pacific: Tonga, Kiribati and Vanuatu had high GV's (0-0.6); Fiji, Solomon Islands and Samoa had medium GV's (0.6-0.8); Papua New Guinea had a low GV (0.8-1.0). From the countries surveyed, Tonga, Kiribati and Vanuatu were the most vulnerable. Fiji, at the time, seemed to be the most stable country in the Pacific region, which could ensure a stronger base for any project and especially a new innovative TT like this project.

Other research was needed before focussing in on Fiji. The WTO (2005) report indicated the "least-developed country WTO members continue to face serious economic, financial and administrative constraints as well as a need for flexibility to create a viable technology base" and "if past trends persist, the least developed countries are likely to become the major locus of extreme poverty in the world economy by 2015".

Kassim (2002) did a comprehensive study on "transfer and utilization of technology ...for Fiji". He examined the economy of Fiji, the human resource potential, the technology capacity and policies, and found many inadequacies. He strongly suggested "technology is a crucial component of this process (industrialisation), enabling greater productivity and the sharpening of industrial competitiveness. Active promotion of technological activities will help lay the foundation for leap-frogging towards …domestic technological activities". Further to this, some discussions were held by the author with the Austrade delegate in Suva, Fiji (Bray 2002). He supported the concept and helped with contacts, but was unable to help with money.

The UNDP office was also approached for guidance (Bossley 2002). The University of the South Pacific was approached and Dr Koshy (2006) was most helpful in networking and sourcing information (Koshy et al 2006). Thus Fiji, at this time, without knowing they were going to have a coup, seemed to be the most stable in the Pacific region and provided a strong base for any potential project to help display and model innovative technologies, with a second base at Dr Koshy's USP facilities.

There were more reasons to decide on Fiji as it uses English as a second language and is among many 'least developing countries' and 'small island developing states'(SIDS) of the Pacific and is the centre of the Pacific region as far as the 'University of the South Pacific'(USP) is concerned. This allowed the project to be more easily implemented, evaluated, and supported with more chance of success. Australia also had an embassy in Suva and Austrade support for some projects. Fiji was thus chosen as the preferred area, in the centre of the greater Pacific region, for an example of a TT project.

For general background on Fiji, there is the Fiji National home page on the world wide web, that gives a good account of the chiefly structure, government and policies. The mandate for TT to Fiji (Kasim 1992) and background on the Wainimakutu papermaking village (Liebregts1998; Liebregts and Townsend 1998; McDiarmid 2006). The essence would be to acknowledge the great importance of the chiefly structure in Fijian islands. Each village has a chief and each region or 'matingali' has an appointed bigger chief. There are several regions or States or groups that form the great council of chiefs. The former indentured Indian labourers are now assimilated into the population(45-50%) and are seeking equal political rights. This is creating great divisions within the community as evident with the last two political coups, which dis-empowered Indian led governments and reinstated Fijian led political parties. It is beyond the scope of this thesis to comment on this and it may jeopardise the project if any more is said about the political situation in the country and the present military led government. Thus at a generic village level they need a lot of help to scientifically understand, evaluate and accept new technologies and somehow integrate them into their traditional culture and lifestyle.

The transfer of papermaking technology project was ‘implemented’ by going to Fiji in 2003,2004, 2005 and 2006 to establish links with the community, government agencies, NGOs, and business leaders. The UNDP representative at the time was Mr Malcolm Bossley (Bossley 2002). He advised the Author that there were only two papermaking operations in the Pacific Region, both in Fiji, and he was helping one project. Mr Beddoes of Earth Links was contacted by phone and background information was sought (Beddoes 2003). The other was a remote Wainimakutu Village making wrapping paper for a Suva business. The other was a private Fijian couple who wanted to start a papermaking craft venture.

Based on the initial findings, a few options were looked at in Fiji. These include:

1. starting a new project with a non-papermaking village;
2. extending the small family run papermaking enterprise: ‘Earthlinks’−Beddoes operation in Lautoka (or a
3. helping an already establishing papermaking craft village.

Option #1: to start a new project. The Author met Mr Ratukalou (2000) informally at a Murdoch University environmental conference in January, 1997 and re-met in Fiji in 2000. He said he was an engineer with the Suva City Council ; and that his family / matingali were happy to look at starting a small business that was craft orientated and good for their village. In further discussions in Fiji it was felt that this would involve a many year project, massive injection of capital, expertise and training beyond the scope of this project.

Option #2 might have worked, dealing with a small family enterprise. The business ‘Earthlink’ was found to be a small family concern, with limited technology and some international marketing (Beddoes, 2003). The Author managed to visit their craft cottage industry in Oct 2006 and met some family still doing the craft. It was felt they were not committed to papermaking and developing new technology. The offer to help was left with them if the situation changed.

Option #3: the Wainimakutu Village papermaking (WVPM) project was contacted via the local company, Pure Fiji in 2004, then by emails in 2005 and 2006 then serious negotiations in Oct 2006. Pure Fiji had helped sponsor the project and spent several years supporting and establishing a village based operation. They felt the village now needed help to further improve the technology; equipment; processes and training (Austin 2006). The WVPM headman was consulted by the company and protocols followed with permission to visit the village in Nov 2006. Further to this there were already professional reports on the TT to establish the operation by a company called ’Eco -consult’ (Liebregts 1998; Liebregts and Townsend 1998) and Ms. Prue Townsend of New Zealand was also previously involved in mentoring the project (Townsend 2007). Since then a more recent report gave a current view of the ‘Pure Fiji’ company profile and how they value the rich culture of Fiji and working with over 200 village women for craft products (Frodey and Naidu 2008).

A tremendous amount of background research has to do to ensure a good foundation is made for any new project and of course, starting a network with as many agencies as possible over as many years as possible.

5.2.1.3. Choosing and Reviewing a Suitable Village and Developing Country:

Wainimakutu village is in the province of Namosi, in the highlands above Suva city on the main island of Viti Levu. The village consists of about 100 families who rely on subsistence agriculture, crop rotations, dalo, cassava, a few community cows, eggs from chickens, and a few horses to help with work. Some sell pineapples as the best cash crop, otherwise it is a typical remote village, like many along the mountain road to this village. They have one primary school and have started a high school. The cost of transporting their crops to town, cripples the viability of many households, a three hour drive down a treacherous mountainside to Suva is too costly. They need to look at other avenues to seek local employment opportunities.

The WVPM was more deeply 'reviewed' to determine the history, what they were already doing, the production system, technology, expertise, cultural factors and the economic base. As the village is remote, with a limited satellite working phone, no secretary, no office in the city, no email, no web page, it was decided to visit the village for a few days. A 4WD could have been hired but part of the TT experience was to appreciate the local ways. This involved a journey/expedition to the village in the local carrier truck that departed Suva city at 1pm, 5 days a week.

The author joined the locals and travelled for three hours squashed in the back of the truck up rough winding hills to a remote inland village (Figures 5.2.1.3abc). In the truck, the author informally met some village men, the regional nurse, her uncle Timothy, a school teacher and started to gain some invaluable background information. The author was duly welcomed into the village and escorted to his accommodation where Mere Naivacakuca made traditional meals and became a champion of the project (Figure 55.2.1.3c).

5.2.1.4. Meeting the Chief and Reviewing a Suitable Village and Developing Country

The formal part was to present a traditional 'yaqona' to the chief (turanga levu) and the headman and seek their blessing to be in the village (Figure 5.2.1.4abc). The author met some key people, papermakers and chiefly delegates. The initial review process involved seeing the equipment, the staff, and method of operation. By making paper with them - using their technology and expertise, the author could better experience things from their perspective, and build up understanding and trust. The 'Headman', Ratu Kiniviliame Taukeinikoro (2005) was also a politician, a Senator before the coup (Figure 5.2.1.4a). He discussed much about the important history of getting the papermaking to their village. He indicated that it was an ideal project for them at that time, as they could make the paper in the village and easily take a lot of dry weight A3 paper to Suva by the local carrier truck. The project complemented their village ways, provided some income to the women and flow on benefits to the community, school and church. The flow-on benefits were also important to create jobs in the village, supporting local education and helping to keep the precious community together. For example, to fundraise, to send high school students to the city, with food and accommodation, was an enormous drain on their resources. Now they have a local high school and the plans to keep extending it to full courses are very exciting for them.

It was very strategic to get the Chief's wife involved early in the trial project and actively making the new paper with the new technology (Figure 5.2.1.4d). Without the blessing and support of the women of the village any project would not proceed.

5.2.1.5. Meeting the University and Reviewing a Suitable Village and Developing Country

It was also important to facilitate the meeting of the village delegates with the local university USP, with support from Dr Koshy (Figure 5.2.1.5a). Behind the scenes it was also important to informally network with the past and present interim governments (Figure 5.2.1.5bc).

5.2.1.6. Meeting the Villagers and Reviewing a Suitable Village and Developing Country

From an informal inspection of the village papermaking studio, the 'hardware' involved a modified Hollander beater, a wooden vat, wooden mould and deckles with dented mesh screens, couching boards, a screw press, and tin−wood−fired−drying. The 'software' involved the skill of choosing plants, making the pulp, adding chemicals, the screening technique, the couching technique, the pressing rates, drying-painting the paper on the heated metal drying sheets, drying times and then quality sorting (see Figures in next section).

5.2.1.7. Life Cycle and Reviewing a Suitable Village and Developing Country

The 'life cycle management' was based on using locally grown feature fibres and flowers that could be sustained and buying in some refined white-paper pulp that compromised the eco-ideals of the operation (Figures 5.2.1.7abcd). They used a clean production system, community business initiatives, and green supply chain (Sonnemann and DeLeeuw 2006).

5.2.1.8. Hardware and Software and Reviewing a Suitable Village and Developing Country

The initial conclusion of this review showed that hardware and software improvements could potentially be made in the village and or in Suva with industry or university engineering department help, and could be successfully trialled with their help and support, while improving the 'life cycle management' by substituting free post-industry waste paper into the raw materials.

In the fourth subsection of this PIRI process, 'Improvements', it was considered important to pre-trial or demonstrate a simplified new appropriate papermaking technology and try to evaluate if they appreciated it, wanted it, or if in fact it actually helped them (Findlay 1978). Some basic hardware was shown and pre-trialled with the TT author's software skills to introduce the new smooth, easy to make paper (Figure 5.2.1.3d). This gave the author a solid scientific base and many important analytical first impressions that project phases 2-3-4 would be warmly welcomed and appreciated in the village.

5.2.1.9. Summary to Selecting Fiji

In summary: the selection process enabled the following criteria to be addressed:

- from the greater Pacific region;
- as an example for villages in regional UDCs;
- a small island developing state (SIDS);
- English as a second or third language; and
- the TT project needs to be 'needs based' for that village.

Fiji was chosen as the best place to launch the project, with the University of the South Pacific as a base, the City of Suva and the highland region of Namosi. Wainimakutu Village met most of the criteria for the best place to trial the TT process to ensure the best chance of success for the papermaking project. They had started basic papermaking and relied on international expertise to get them started and were now ready to go to the next level of better equipment, better production base, bigger studio, and more diversification of products. The traditional protocols were followed and the project had the blessing of the Headman and the Chief.

5.2.2 Foundation Phase of Village Based Technology

5.2.2.1. Introduction

The simplified 'plan' (PIRI) of the foundation phase was to assess, understand, work with and endeavour to systematically and strategically improve the existing technology, from small to large steps, in the chosen papermaking villages. This involved both H/W and S/W examples of technology while also acknowledging appropriate tacit skills and being very sensitive to their culture and needs.

This was 'implemented' (PIRI) by

- going to the village and working with the local craftsmen;
- taking some basic H/W and demonstrating the S/W concepts;
- organising to make the H/W - equipment over several workshops;
- progressively training and teaching improved S/W skills;
- making a better quality rough paper into smooth paper;
- value adding smooth paper into some local cultural school books;
- helping facilitate the further transfer of H/W and S/W to another potential papermaking Village;
- training manuals were published separately as reports and books as a extension of the project.

The 'review' (PIRI) of each phase of understanding and improving TT will be discussed under the 5FSTT. More emphasis was given to certain aspects to highlight TT issues. Further to this, some equipment was pre-made in Australia; some new equipment was to be made in Suva with local engineers; and as much as possible was to be made and/or assembled in the village with the assistance of un/semi-skilled villagers.

5.2.2.2. Assessing Village Based Technology: the First Workshop

This section assessed the village and then began understanding the small steps in TT.

The first **Part A**: was to assess and work with the existing WHMP village:

The second **Part B**: was selecting four examples of ‘small steps’ in TT are:

- ‘fibre source’;
- ‘transfer couching cottons’;
- making a ‘stacking system’;
- making a special ‘couching stacking bench’;

The third **Part C:** was selecting and introducing ‘bigger steps’ of TT: for example

- the new ‘vat’;
- new ‘aluminium moulds and deckles’;
- new 100 tonne/square metre flat ‘press’;
- improving the drying regime;
- trying to re-design and make a hydropulper with industry and university help.

Part A: (Foundation). Assessing WHM-Papermaking process (WHMP)

The WHMP process consisted of a lot of work in preparing the virgin fibre from the Drala tree (***Erythrina variegata***), preparing local flowers as decorative additions for the paper and cooking the inner bark of the drala tree before papermaking (Figure 5.2.2ab. A Hollander beater was used to help grind the long thick fibre into shorter finer fibre (Figure 5.2.2cde). They used a wooden/mesh A3 mould and deckle in a wooden vat (Figure 5.2.2f). The wet paper /pulp was transferred onto a flat couching base (Figure 5.2.2g). The pile of sheets was pressed in a simple screw press to extract some water. (Figure 5.2.2h). Each sheet was peeled off the stack and brushed onto a metal sheet for the drying operation (Figure 5.2.2ijkl). Free firewood was used to control the drying temperature of the metal plates. The dried paper was removed from the metal plate and checked for quality control (Figure 5.2.2mn). A thousand sheets per week was delivered to a business called ‘Pure Fiji’ in Suva for use as wrapping paper for cosmetics (Figure 5.2.2o). The cosmetic opposition company tried to copy the success of the wrapping paper and use it for their products (Figure 5.5.2p).

The WHMP system has evolved over several years to produce a good rough wrapping paper with flowers and fibre features suitable for a specific wrapping market niche. The weakness is in being limited to one market of Pure Fiji and now after the coup, in January 2007, the market has decreased by 75% and is likely to remain depressed until the economy recovers.

Workshop on Making the First Pulp from the Waste Paper:

Hydropulping a brew of paper was one of the first challenges. It was decided to use their system of first boiling the waste paper in water to help soften it. The boiling of the fibres is also known to sterilise the paper; making it more suitable for international sales. This seemed to be a good example of local knowledge, initiative and international consultation, as they employed their traditional skills of using wood fires under 20 litre pots. As the project had not yet made a hydropulper in Fiji it was decided to first try their Hollander beater. The ¼ hp motor took a long time to break down a small amount of paper (500g dry). A half hour later the first part batch was ready. We decided to then use both beaters as the generator was needed for one, so why not two. After some minor fixing we had both going. After an hour we had enough pulp to start a batch of paper. This equates to 2 Hollanders for 2 hours versus one LHP (hydropulper) making 200 litres of pulp in 15 minutes (2x2x4=16 times better). For more detailed information and pictures, see "How to Make a Hydropulper" (Westerlund 2007a). The use of clean post industry free waste from Suva seemed logical and important for this project. The initial pre-trial success helped create a good understanding of the transfer of suitable technology for the project.

5.2.3. Part B: Small Steps in Technology Transfer: (Phase 1).

Small steps can be made in improving the use of fibres and in work skills for technology hardware and software (Phase 1: Table 4.1b). Examples include 5 parts:

1. improving raw paper fibre sources;
2. making the transfer couching-cotton sheets;
3. making the rods that go in them;
4. making a work bench to hang the special couching cottons;
5. making a wooden stacking-guiding system.

5.2.3.1. Small Steps: Fibre Source

The WHMP use a variety of fibre sources. They need to grow some plants for the fibre and flowers as features in the paper. Over several years they have developed a stable sustainable production base and have their systems in place. They also bleach the fibres to get them whiter to appeal to the market demands of their regular outlet. They also buy some white tissue paper and add that as a supplement to the paper to make it cheaper, quicker and whiter. The wild ginger (cevuga) stalks are beaten by mallet/stick/rock on the river side to break down a 2-3cm stem into a fibre source then boiled (Figures 5.2.2abcde). The soda ash is used to help create a caustic chemical environment to help cook the fibres. The soft inner bark of the drala is scaped off the stick and boiled in soda ash. Another fibre is 'masi' from recycled masi mats that were ripped apart; cooked in soda ash; and re-beaten into fibre by the 'Hollander beater'. This turned out a rich brown textured paper.

The new system can use free waste coloured and white paper from post-industry Suva City government and private industry. Samples were couriered up to the village and trialled with great success. The government printing department was chosen as the main waste paper supplier as they were also helping in binding the books and value adding to the final product. It took a few years of background networking to establish the links, ease of access and networking. One concern is that the 'coup' of 2007, has changed the economy and opportunities beyond the bounds of this project that may even affect the source of free waste paper from a once buoyant industry.

The unique marketing of local fibre featured in the paper was important to the on selling of the Fiji paper in the Pure Fiji company product range to an international audience. The local fibre was greyish and needed to be bleached whiter to help the marketing image. This paradox and compromise was necessary to sell the illusion of a purer, whiter, product in a fierce market dominated by image and cost parameters first, with some eco-values secondary (Figures 5.2.1.7d; 5.2.2op). To totally source the traditional grey fibre by growing the fibre in the village would prove too costly and financially cripple the project. It is more viable to use the traditional bark as the feature and substitute purer refined fibres from post industry waste streams.

In summary, a new white fibre source, and pure coloured paper source, could be obtained free from government printers waste off-cuts and the local fibre used more as a special feature in the paper. This would save paper, energy, time, money and resources by:

- recycling a free post-industry waste product;
- saving money spent in buying tissue paper;
- saving time by reconstituting waste paper versus raw processing of local fibres;
- saving energy and time to process the waste paper in the hydropulper;
- saving water by using the hydropulper and recycling the water many times;
- reusing the chemicals, carbonates, whiteners, and fillers of commercial papers;
- creating a better quality paper that could be used in photocopiers and printers;
- from a marketing perspective - creating a cheaper base A3 and A4 product;
- providing more profit for the many women in the villages.

5.2.3.2. Small Steps : Transfer Couching Cottons

Use of Cotton Couching Clothes: Workshop on Making LCS:

A few of the new cotton transfer sheets were pre-made for an introductory trial in the village. Before the project can make paper using the new technology it needs many more than the 5 sheets that were brought over for the demonstration, 50 -100 would be needed for a good trial, then 500-1000 for the next level, then 1000-5000 for a serious operation. There were several challenges in making the special cotton couching sheets that are used to roll the newly formed paper-pulp onto before pressing with the 20 tonne press. This involved sourcing suitable material, measuring, cutting, yielding to the unexpected local needs of the trainees, sewing, and making the inner rods.

Fifty metres of couching cloth material were sourced from a Suva fabric shop to help start to make the LCSs. The widths of the rolls were measured and the differing rolls noted and the optimal cut out patterns calculated. This took more time as 5 metres of material was laid across the large community village hall (Figure 5.2.3.2a) then marked out two rows aside and one row down the middle. This yielded about 5 LCSs per square metre with a 5 cm leftover strip (that was made into head bands for the kids). Another leftover of about 1000 sq cm was quickly put aside by a mother and made into a pair of shorts for her child. It was then decided to cut the next lengths differently and easier (for the author). By simply cutting one lengthwise along each side (i.e. cut 450mm strips from the 1.5 m roll, then into 2 x 650mm, left a 450 by 300 centre off-cut). These were happily collected to be made into 150 pairs of knickers and shorts for the kids. This seemed more important to the women and provided a reward for helping.

The next example explains how the needs of the local village ladies seemed to again interfere with the project. The next roll was a trial of a smooth polyester/cotton material. It was a high gloss white quality material. The women were wrapping the white material around themselves and happily chatting in Fijian. When asked what all the excitement was for, it became known they wanted it to make their undergarments/sulus. What was best thing to do, give them 20 m of the valuable papermaking cloth, or keep going with cutting it up for papermaking couching cloth. After about 12 metres a decision was made to ‘happily give up’ and we joyously presented them with several metres of nice high quality glossy white cloth for their own personal use.

The technology of the village sewing machines was another important perspective. They said they had sewing machines, so the author assumed they had semi-modern ones. They come out with 2 old treadle sewing machines (very appropriate for a remote village with no power) (Figure 4.2.3.2bc). This was adequate to over-lock the sides and only do the top straight stitch. The author accepted this and after a few failures, it was decided to only straight sew the top edge, but there were no needles or bobbins and a ‘door knock’ was soon organised to find them. A half hour later they were started as the author had brought 4 rolls of cotton, but did not think that they would also need needles. During our lunch break a teenager was trying to sew and broke a needle so another search and ‘doorknock’ was undertaken for another needle. The afternoon progressed better with 150 cottons being sewn for the day (Figures 5.2.3.2bc).

On reflection the villagers need a modern sewing machine and an over-locking sewing machine for the village use and for the making of hundreds more couching cottons for papermaking. This would mutually benefit the project and the community. They need a basic local shop with supplies of cotton, spare needles, threads, and machine oil without having to make a shopping trip to Suva City. The women need a reward that was relevant to them and their village lifestyle.

5.2.3.3. Small Steps : Support Rods for the Couching Cottons

A simple sub-project to make a piece of low technology equipment, a wooden dowel insert, turned out to be a larger issue than necessary in the context of TT to Fiji. The couching cotton rods were rough-industry machine-made in Suva from 1.8m lengths of 10mm dowel. They would normally be cut in a bundle of fifty with the fine-tooth saw, but these were cut in the village individually with a (borrowed) hand ripsaw. They would normally be quickly smoothed over the cut end with a bench grinder to grind each end safe and smooth to handle, but in the village we had only sand paper, and one carpenter, 'Fiji time' and 2 helpful volunteers (Figure 5.2.3.3ab). The varnishing was done by laying them out in rows, varnishing and rolling along a bundle of 20 dowels. This should have been satisfactory; to complete a straightforward component of the equipment making but when checked later they were only ¾ varnished around the diameter. With time constraints and patience exhausted it was decided to get on and use them, so once again the project was compromised and standards reduced to get the job done that day.

The next batch of 50 lengths was cut in Suva with a good hand saw, in bundles of 3x50, bagged and taken to the village for finishing. Extra sheets of sand paper were supplied to hand sand-paper and smooth the ends. The children were once again milling around and eager to watch the parents and uncles sanding properly. The wooden dowels could then be inserted into the hole, in the cloth, that had been sewed, to hang the couching cotton square. This helped to make the paper more professionally and was a critical new increment of technology for the guided staking system.

5.2.3.4. Small Steps: Trolley for Stacking the Couching Cottons.

Workshop on Making the First Papermaking Trolley for the Transfer Curve

The next example of a simple sub-project to make a piece of low technology equipment proved challenging. Stepping back in time, a day before making the rods, the making of the first bench to hang the new cottons on was the first challenging experience with getting the men villagers to help. They said they had a carpenter, who turned up to help make some equipment. The village had no instant access to quality wood (no local hardware, only the forest), a door knock proved futile so we begged and borrowed and finally bought a length of rough 4x2" from the church for $20. The carpenter had no saw, so one was borrowed from the expatriate's house (a tradesman with no tools). We did some basic measurements and got started. Just in case, some bolts and nuts had been pre-bought to help make it, but the carpenter also had no hand drill. It was decided to improvise and use a hammer to help hit the screws in. Somehow one rough frame was made to mount the transfer curve and stack rack on (Figures 5.2.3.4a). Another cotton stacking system was made with the L Stack Rack (LSR). The author learnt from this and brought his tools and wood to make the equipment more professionally (Figures 5.2.3.4bc).

The lessons learnt were to expect a simple job to be difficult, time consuming and almost impossible, and one needs to bring all basic and advanced tools and accessories, without going back to Suva for something you forgot. A short list of tools could include: saws; hack-saw; hammers; drills; screwdrivers; spanners; pliers; wood and metal; screws; tecs; brackets, hinges, bolts; tape measure; level; pencils; marker; straightedge; and 240V power supply-generator (and fuel); a multi-metre and a small set of 'Allen keys'. Anything forgotten requires another trip to Suva and subsequent delays. Another book is being compiled and edited on "How to Make Papermaking Stacking

System" (Westerlund 2014). With more networking and local knowledge we would have found another carpenter and tradesmen in the village but they seem reluctant to initially come forward and volunteer to help or use their tools. Local 'champions' of the cause need to be found to empower the project to succeed.

5.2.3.5. Small Steps : Staking System for Couching Cotton; Pressing

The next facet of making and using an L Stacking Rack (LSR) for the 'pulp' onto 'cloth' transfer is critical. This is more complex yet simpler than their traditional technique. The Wainimakutu papermaking artisans stack and rock (flat couching) to transfer on top of each to form a vertical pile of 5 sheets/pulp (Figure 5.2.3.5a). The artisans soon learnt how to lift and flick the cotton onto the new guided stack rack system (LSR). The sheet then needed to be further aligned by tensioning the sides but with tacit training skills and understanding they quickly picked this up (Figure 5.2.3.5b).

The stacking system is also where the two systems are very different. The artisans press the couching cloth/pulp and repeats of 50-150 per batch (Figure 5.2.3.5c). The initial trial used both technologies to allow them to understand the differences in press quality and ease of use. The next trial was using the new 20 tonne press (Figure 5.2.3.5d). The LHMP system separates each with a special smooth surface plastic film. If they used the new technology to further improve their system, then they could use the plastic and do the LHMP system of 5 per board. This will keep their paper aligned and pressed better. This would make them buy and make and use more boards per batch. Fifty boards versus two, but the technology-biased author feels the results are worth it. It is an up front investment that will be used over and over again.

It was noticed that their boards were already in need of replacement. They had been dented and water rotted away on the surface and edges. They would be no good in the new super-smooth system. The initial impression was that they have no maintenance programme, let things get damaged and rot until they were no good for use, then keep using them because they do not understand the need to maintain quality parameters. This was confirmed in personal discussions with Ms Townsend (2008). Some press boards were made, sand-papered and varnished with help in the villagers (Figures 5.2.3.5ef).

A workshop was organised to redesign and make a double stack rack system (LSR) (Figure 5.2.3.4bc). From the small one that the author had pre-made for the demo we up-scaled to two systems and not three (like the Australian design) for space limitations. From lessons learnt from making the first bench, the second was made a lot easier and better by bringing in a selection of the author's power tools, plus quality wood, screws etc to make it with them in the village. They enjoyed using and playing with the tools and the men seemed happy to be involved. This will evolve into another supporting manual/book to be finished in published on "How to Make a Stack Rack " (Westerlund 2014).

5.2.3.6. Small Steps: Summary

Several important small steps were made in improving the existing technology while encouraging and embracing the tacit skills and network system of the village.

By keeping the designs simple, easy to understand and duplicate, then the local village men and women can understand the way you do it.

They can pick up the tacit skills along the way with much demonstrating, some translating, and fun.

They have hidden skills that you will also learn from: their skilful techniques, their strength, their capacity to fix things without our standard tools we take for granted.

They are in Fiji-time, you have to accept their worldly priorities first.

Do not expect any tools to be available in the village: bring your own tools, materials, spare parts, power generator and petrol or diesel.

Bring your own cooking, camping, gas, mosquito repellents, torches, batteries, matches, and personal things.

Expect that when you leave, you leave whatever tools you bought with them, and start and finish the job with a blessing or prayer and a smile.

5.2.4. Part C: Bigger Steps in Technology Transfer (Phase 2)

There are four examples of 'bigger steps' in TT (Phase 2: Table 4.1b): These 4 parts are:

1. designing and making a vat from local wood;
2. assembling aluminium standard components into moulds and deckles;
3. designing and making a hydraulic paper-press from local materials;
4. changing and trialling the paper-drying system.

Each example of a sub-part of H/W or S/W is specially chosen to highlight many aspects of overcoming local limitations of the UDC, changing the design, using raw materials and components to make an equivalent local piece of equipment.

5.2.4.1. Bigger Steps: Making a VAT

WHMP village has a excessively large wooden tub as a vat. It seems useful for their style of papermaking using excess pulp and flower features and dipping into the pulp solution. However, it seemed to fall apart and was water-rotten from the lack of yearly / monthly maintenance, no varnishing, and gouges out of the side from the frame hitting the edges (Figure 5.2.4.1a).

In noting these issues it was decided it would be easier for the author to use this as an important new design opportunity. To start making a vat from his base house in Suva using his access to modern tools. A new design was used which had a pull–toward–yourself type of mould, then up and back to the drainage parallel rack. It also had protection guide rails on the sides and base to protect the walls from being hit-scratched by the frame and thus less susceptible to water rot damage. It also was reduced in size (to just fit the screen) to theoretically help control the pulp concentration parameters and finally to conserve materials and costs as it could be made from one sheet of 8'x4' marine ply. It even had 2 roller wheels to lift one end and move it around. It was stylish and professionally finished with the fresh varnish (Figure 5.2.4.1b).

The newly designed and made vat was enthusiastically received in the village and the women could also use it easily (Figure 5.2.4.1cde). In use it started leaking and needed some ongoing repairs to the silicone seal and a re-varnish of the joints (3 coats). It was found that by diluting the varnish with 5% turpentine it helped to paint on the thinner varnish and settle into the wood grains for sealing the fibres against future moisture.

This resulted in another reference book on “How to Make a Papermaking Vat” (Westerlund 2007e). More lessons were learned from this. The author could not get volunteers to help make it in Suva, it was easier to make the vat himself using quality tools, technology and 240V power. This compromised the ideals of TT but the reality of the project and time constraints left the author unable to invest another week.

Interestingly, the villagers could then see, feel and use the new technology and get excited about it. They then wanted the author to help them to make their design of a ‘vat’. The author redesigned it with small changes to their measurements and, managed to include some buffer designs, and a reinforcing system to make it of lighter weight wood. It was cheaper and quicker to make from only 2 sheets of 10mm marine ply (8x4) instead of 3 sheets of 16mm ply (saving $80). They liked the author’s system but wanted their larger vat and system. They were happy that the author could improvise and in only one day build it with their help. The author amazingly had three men helping that day for something they actually wanted to make happen (Figure 5.2.4.1f). This is a critical lesson, that they wanted to help after they felt comfortable with the author and could see the results of proven, familiar, understood, local and relevant technology.

Also, it is important to note that the committee decided on this new vat, discussed their ideas with the author, authorised the $100 to be spent, ordered and delivered the wood in a few days. They allocated 3 men to help me enthusiastically build it. They can be empowered to own their project and implement small and important changes.

5.2.4.2. Bigger Steps: Making Moulds and Deckles (LAM)

Workshop on Using the New Moulds and Deckles (L Aluminium Mould):

The author first donated a pre-made mould to get the project started then tried assembling some in the village using locally sourced parts.

The author donated the first aluminium (not-wooden framed) mould and deckle (LAM), which was made in Australia. The A3+ size is designed to make one clean cut sheet of A3 (Figure 5.2.4.2a). This fitted into a suitcase on the plane to Fiji. The artisans soon appreciated the concept and were happy to make a slightly bigger sheet of paper with an aluminium screen. Their screen is a fly-wire mesh over a wooden frame. They seemed happy with the new screen but needed to be shown ‘tacit skills’ and how to use it without clogging it with fibre by going the wrong way (Figure 5.2.4.2b). The use of standard aluminium moulding, a very important simple new design feature, meant it was straight and rigid and not subject to warping and twisting. The high strength new technology screen surface proved most appropriate to increase the quality and consistency of pulp-fibre distribution over the whole surface area of the screen (Figure 5.2.4.2c). Workshops on making and fixing the screens are now needed.

The second part was to try and source local components and assemble a mould and deckle in the village. The following week the author improvised and brought the components to the village for assembling (Figure 5.2.4.2de). This involved an electric drill, drill bits, pop rivets, pop rivet gun, square and some fizzy drinks to reward the men with. This resulted in another support book on "How to Make Papermaking Aluminium Moulds and Deckles", (Westerlund 2007c).

The lessons learnt were that Fiji gets its aluminium mouldings from New Zealand and they are the same profile but a few millimetres different (in business intellectual property) and thus most frustrating as all the standard Australian measurements were now out by a few millimetres and the designs, where some critical measurements were either inside or outside of the frame, and it would not match both.

The two right and wrong answers would be to use either locally available components and get them made and assembled in Fiji to new measurements or send over kits from Australia and keep control over the international use of standard parts. It is the 'right way' to empower them to make it locally. It is the 'right way' to have a consistent International standard design to facilitate interchangeability of parts and Standard Operating Procedures. It is a good strategic business decision to overcontrol the design and function of equipment but (ethically/practically) wrong to control it all in Australia and expect or force UDCs to order parts from Australia and incur extra expenses and time delays as well as losing control of making and repairing the equipment in their own country using local materials.

5.2.4.3. Bigger Steps: Making a Papermaking Press

The WHMP press was designed and made in Suva for the original project. It was made as a simple mechanical screw type press to be used in the village (Figure 5.2.4.3a). It seemed to make acceptable rough-surface paper. From previous research (Longwood 1997) the press would not be suitable for the new papermaking needs. It took several years of progressive press research to come up with the LHMP standard 20 tonne press (LPP) over the A3+ surface area, equivalent to producing a minimum smooth standard paper modified from an industry standard bench press (Figure 5.2.4.3b). Further to this, the LPP press handles 100−200 sheets/press so up to 80 press boards are needed per batch. Furthermore, to keep the process going another 80 boards are needed to fill the next press while the first is pressing (for 1−2 hours). The author would suggest looking at making 160 press boards for a continuous system to work. Their system presses for up to ½ hour to help press the rough paper with no apparent standard operating procedure time setting parameters. The LHMP system takes 1−4 hours to press properly to different, higher standards, with a big 20 tonne modified bench press. This equated to 100 tonnes per square metre of paper pressure. This is a good example of a bigger jump in technology, and quality of papermaking. This resulted in another book on "How to Make a Papermaking Press" (Westerlund 2007d).

There were many lessons learnt from this workshop. Some local Suva businesses gave some off-cuts of metal for the press to help a community project (Figures 5.2.4.3cd). One village man, Ratu Autiko Naivakaucu helped the author with his good welding tacit skills and welded the metal into a press using a small welder the author brought in for the project (Figures 5.2.4.3ef). (The welder was bought in Australia on special, and brought into Fiji on one of the trips to help out). On shopping around Suva, using local knowledge, and time, the author managed to buy a good quality 20 tonne hydraulic jack at a very good price ($80) and save more money ($60). The village courier driver, whom the author got to know well after a few drives up and down the mountain, was happy to detour and pick it up from the Suva base. Suva's hot weather is good to sometimes rub down the metal, then paint, dry and set the paint before rust sets in with the humidity.

Fijian men seem to like heavy metal things that are easy to weld and hard to lift and thus test their strength. The men have a patience about them to do what others would consider too time consuming, yet in Fiji–time, the job is magically done and celebrated with a bowl of ceremonial 'kava–yogona' (local plant extract with sedative affects), or cup of 'lemon grass tea' for the Seventh Day Adventists.

5.2.4.4. Bigger Steps: Improving the Drying Process

The 'loft air drying system' versus the 'open fire' – metal plate drying process is very different. The WHMP peel off each sheet after pressing onto the metal plate (8x4 foot sheet, staked 2 aside like a triangle) this allows even heat distribution over a period of several minutes to dry the paper. It is carefully placed on the metal plate and then the damp paper is painted out to the edges to allow even spreading, then tended to, until dry (Figure 5.2.4.4a). The fires are carefully controlled to just give a consistent heat on the metal (Figure 5.2.4.4b). There is a lot of smoke and the dusty-ash environment means any dropped sheets get contaminated and are thus useless for sale. Several women, including the Chief's wife, indicated their disapproval of the fire, the smoke and the dirt for health and paper quality reasons. They have justifiable concerns to avoid breathing in the noxious fumes. The floor was always sooty, any dropped sheets were thus compromised and caused a serious drop in the quantity of output. As well as a being a different process, time was also important for economic reasons of unit production costs. The time required for each process is tabulated in Table 5.2.4.4.

Table 5.2.4.4. Time for stages of the WHMP vs LHMP paper drying processes

Phase	WHMP Time (Sec)	LHMP Time (Sec)
To peel off the pulp pile of cottons	5−10	5
To walk to each metal drying surface	5−10	1 (using a trolley along rows)
To paint on with paint brush/hang??	10−15	5 (pegged on parallel line)
To tend to	35−60	1
To peel off each dry piece of paper	5−10	5−7
Sub total	**60−105 seconds**	**17−20 seconds**

From Table 5.2.4.4, a significant amount of villager's time, one-two minutes, is invested in each sheet to facilitate drying. The system was co-designed by New Zealand consultant to cope with the extra rain and humidity of a tropical country. They considered loft drying, but the paper did not dry, and thus researched an alternative metal surface drying system (Townsend 2006). (Mrs Prue Townsend help consult with the original craft project and TT).

In observing the success of the technology, the author argued that the chemistry of their paper is improved by the heat reaction and hydrogen bonding of the forced drying conditions compared to the LHMP process. The forced drying dries the paper past the air-loft drying of 5% moisture level down to 1% and helps force a better chemical based reaction of hydrogen bonding to occur. They also add a mucilage, extracted from natural plants, which helps with fibre dispersal in the vat rather than providing a 'glue' (Hubbe and Bowden 2009; Townsend 2006). This may also increase the bonding and moisture sealing of the final paper. Further studies are needed in this area.

The new drying system was tested out to trial a saving of 80 percent in time for this phase of the integrated production system. This involved setting up the drying lines, hanging the paper, peeling and drying time parameters. This was only suitable for fine dry weather. This might cripple the project and consideration is needed of a full scale operation to be established on the hotter, dryer, northern side of the main island.

For the new drying lines, 5 small rolls of rope were bought to start installing a loft concept in their existing drying (outside) room. In the picture, Ratu (the grandfather) contribute in the TT process and asked the young adults to help him (Figure 5.2.4.4c). The rows were measured and marked at 10cm intervals along the underside of the roof wood. They followed the pencil marks and hammered the 'U-nails' in. Some had better hammer skills than others but they were all happy to hammer. It was interesting as each lad brought one from their homes, some were old, some were dented-twisted, some had broken handles, and all had a story to tell. After some OHS safety on hitting in nails so they don't fly out into your eyes they were hammering more safely. The roll of rope is easy to unravel if you start from the centre, thus they learnt the hard way and started unravelling from the outside. This soon tangled and they got more frustrated and more tangled. They learned from one another and soon tied each line up. The method had left the U-nails with some gaps to let the rope be retightened later, but when the author was not there for a minute, they nailed them all in against the rope. It was not appropriate to get angry, as they seemed too enthusiastic to help and use their initiative, so it was put down to learning that the instructor must be aware and in complete control of each level of activity to avoid further incidents. In hindsight it might help to save the rope from being cut and used for other purposes like tying dalo bundles together or tethering goats and cows in the paddock or tying tarpaulins down at impromptu markets.

The hanging should be easy, but special pegs were not brought from Australia and the author forgot to try to buy some locally (Figure 5.2.4.4d). Once again a house knock soon produced an ice-cream container of unsuitable pegs. A simple thing like pegs could prove frustrating. The local village pegs are inappropriate, cheap and plastic and have no grips to hold the paper/plastic onto the cloth. The 'V' shaped pegs just compressed on and dented the plastic and wedged onto the line. The wind loosened this in time and they fell off. The floor is contaminated with the fire soot and some sheets and plastics were soon contaminated. The plastics are $1-3 each so it can be expensive to destroy a plastic when they fall and people walk on them against a rough cement floor. It was decided to transfer the next batch to the safety and shelter of the expatriates 'bure' house veranda, where they could be checked as they dried over the day/night, and any fallen ones would be safe to fall onto the (hand woven) traditional 'voivoi' mat surface. That helps to inspire those that look at the mats and sit on the mats while working. (Spicer and Me 2004). This complements the holistic nature of making a lovely craft product.

Mere and friends waited and tended to the new sheets drying, like they would to their own babies (Naivakauca and Naivakauca 2007) (Figure 5.2.4.4ef). They needed to be peeled at 7-10 % moisture level to ensure the best sheet formation. They were delighted with each new sheet that dried and carefully stacked them. After a few thousand peelings, an unemotional, detached, 'peeling' experienced person just leaves them longer to dry and peel off a batch of 1,000 at a time. Paper peelers spend the minimum, less than 10 seconds per sheet time to critically peel and stack each sheet in an intensive system with a trolley going along rows of hanging papers.

Several lessons were learnt. From helping to improve their OHS and change the process to "no fires-no smoke– no OHS issues" to a simpler system that involves a simple peg and hanging system in a protected area (from wind). The grandad and his young adults were great and enthusiastic to work with and hammers can tell you a lot from whence they come. The ladies loved the special super smooth paper and tending to it, and thus helped to create better quality smoothest paper. This newer version of the old traditional loft drying would save from 50-80% of the time involved by simply letting it air dry for a day, letting nature, the sun, radiant heat and time do the drying. The village papermakers seem not worried about time and efficiency parameters. They accepted things and just did it to make it work in their situation. The author was personally happy that they love the qualities of the new smooth paper and treat it as special.

5.2.5. Bigger Steps: Summary of Phase 2

Several important lessons were learned from the hands-on approach of meeting villagers. Firstly, by working with them in their system of production, working with their dextrous skills to help improve the hardware and software technologies in many small safe ways of TT while advancing to bigger steps.

1: Making better ‘moulds and deckles’;

- Aluminium components can be used to make a better, stronger, straighter piece of ‘mould and deckle’ equipment.
- Components can be sourced locally but were made to different international standards and shapes. This forces unnecessary changes to the design parameters that need to be understood.
- Adapting to new technology can quickly keep you pioneering the best available technology that can be adapted to the village environment;
- Adapting the new screen technology can establish new important bigger steps in industry production quality and capacity;
- New handle designs can complement the intensive use of the equipment and keep pushing the boundaries of best available technology.

2: Making a new papermaking ‘press’ with local industry help:

- A blend of village and industry help can make new hardware;
- The village was able to offer the help of a welder;
- The industry offered free offcuts of metal to the community project;
- The author offered to help design and weld the unit in Suva;
- The hardware can now be made in Fiji using industry and village help;
- The local university can also make the press as a student project.

3: Improving the drying process:

- The new technology and process needed a new drying system;
- This is based on the old drying-loft system;
- This was re-invented and adapted for the new smooth papermaking technology;
- This was still limited to dry days and not suitable for many rainy and humid days;
- This needs more research or must be moved to a dryer region, like the Nadi side of the Fiji Islands.

Cumulatively, the advances in small steps of hardware and software enabled the Wainimakutu Village to be a (Pacific) first – for smoother hand-made paper in a remote developing country village. This laid the foundation to start even bigger steps in TT where more radical ideas in production equipment and operating skills are required to produce even smoother better quality paper, faster and cheaper.

5.3. Part C: More Radical Hardware and Software Technology: (Phase 3)

5.3.1. Introduction

Several lessons were learnt from first working with the villagers and improving the system in small and then bigger steps. Now the author had the confidence in himself, the network in the village, the helix of industry and university expertise, some government departments, and the understanding to work with them in some even bigger, more radical leaps in technology.

From the methodology Table 4.1b, this is an example of Part C and D: Phase 3: for 'leapfrog technology':

1. The making and using the 'transfer curve';
2. The new 'smoothing technology';
3. The 'turnkey approach' of making and using a new hydropulper.

5.3.2. An Example of Leapfrog Technology Transfer

In this case study, the leapfrog examples can be new equipment, like the new roll over transfer couching curve, or the new process using the 'super smooth technology' to create higher quality handmade printers' paper.

5.3.2.1. Leapfrog: Making and Using a Transfer Curve

Workshop on Making the New Transfer Pulp-to-Cotton Curve (LTC)

The workshop on making the LTC was easier from the experience gained while working with the village men. The components were bought and tools ready for the making in the village. Two men and 3 youths helped learn to make the new transfer curves (Figure 5.3.2.1abc). The experiences reflect those previously discussed and there is no need to reiterate the lessons. The process was more streamlined and successful with the experiences learnt from the previous lessons.

Workshop on Using the New Transfer Pulp-to-Cotton Curve

It was personally felt that the next phase was the empowering part for the artisans. To use the new technology and tacit skills of the LTC transfer curve was extraordinary. The thin layer of 2mm pulp, on the screen, easily transferred over onto the cotton in one continuous process. The village men and women were getting excited by the easy use of new radical technology and processes. Once they were shown the simple roll-over technique, starting from aligning the base of the screen on the dowel on the cloth (Figure 5.3.2.1defg), then firmly and continuously rolling over (Figure 5.3.2.1hijkl), then exiting − without dripping onto the delicate new layer of pulp on cotton. They were happy to have fun making it the new scientific way. Several pictures show the range of men and women learning this critical new part of the TT process.

Several points were noted: The smaller (height) people could be helped by one person standing aside from the LTC to help the final critical roll over process (Figure 5.3.2.1l). The stand could be redesigned with a variable height system to suit all artisans individual needs in using the equipment. This highlights the ongoing cyclic process of improving technology. The inner sponge helps by removing a lot of water in the new rollover technique (Figure 5.3.2.1b). Stronger persons will make a better transfer but this seems not critical as the press will remove the remaining water (Figure 5.3.2.1e). A minimum pressure is still needed for an effective transfer. There seems no maximum pressure as this is limited to (below) the strength of people and their arms in the process. This force has not been quantitatively measured but if /when the design is taken to automation then it could be measured and critical parameters ascertained.

There are several dextrous skills involved in getting the transfer process correct. It is hard to describe the tacit skills in limited words, one has to try and do it for 5 critical seconds and actually learn the intricate tacit skills by actually doing it (Figures 5.2.4.1cde; Figures 5.3.2.1d-n).

1. The holding of the mould and deckle together, then removing the deckle before transferring is important so as not to drip onto the mould/screen (Figure 5.2.4.2b).
2. The handles (on the back of the screen) make it easier to hold and control the screen (Figure 5.2.4.2a).
3. The wrists need to be strong and roll the screen over in a strong continuous technique (Figure 5.3.2.1d-n).
4. Your back is stretched over the transfer curve to fully extend the motion under pressure from the arms (Figure 5.3.2.1n).
5. The finishing technique is also critical to exit the screen sideways without dripping water onto the sheet and destroying the delicate thin pulp (Figure 5.3.2.1k-n).
6. The joining of the deckle back to the mould can be quick as they slide together and the wrists then hold them tight (Figure 5.2.4.1d).
7. The mould and deckle are then ready for the next dip into the vat.

The young man who is doing this in their system already has a good strong technique to produce consistently good paper (Figure 5.3.2.1e). He has what could be described as a traditional kava-serving type technique, (as if he was in a Fijian traditional ceremony presenting kava to the chief). (note: The author has had any bowls of kava, in many types of ceremonial, religious and social events and first hand seen the tremendous importance put on this process). This gives the technique honour, dignity and respect for a young man to do while working with women in the village. His strength and honour is at stake here, and it seems very important that he asserts this and remains in traditionally distinctively different roles from the women.

Several more lessons were learnt. This resulted in another resource book being written on “How to Make a Papermaking Couching Transfer Curve” (Westerlund 2007b). As the project went on the author had more offers of help from the men to make the equipment and use the power tools and have serious (fun) learning TT activity. The author had paid for some of the materials in Suva, and even brought a section of damaged/recycled trampoline mat from Australia (saved $100), plus wood from Suva to make the special new transfer curve work using ‘best available technology’ in the village (Figure 5.3.2.1a). This was part of the heart and soul of the new process. To share its secrets in making it in the village was special. The author had gone to the extra length of making a pre-made single demo unit, but the double unit for the village was re-designed to suit the size of the studio and medium capacity of production (Figure 5.3.2.1bc). We communicated once again by showing, holding, measuring, cutting, sharing, drilling , holding, screwing, checking, unscrewing, re-screwing, rechecking, laughing along until it was agreed that it was suitable and scientifically professionally made.

5.3.2.2. Leapfrog: New Process of Smoothing Technology

The smoothing process is akin to the heart and soul of the trade secret of making LHM smooth paper. To be able to share an advanced papermaking technology, after over 20 years of secret research, for the first time with a remote developing country village of papermakers is ultimately special. It is a process, a combination of secrets, experience, feel and love for papermaking that makes it so special. The Fijian women (and some men) are–tacit−hands on artisans who love to create by doing, by making precious sheets of paper. For the author to see their love and passion of papermaking come out as the smooth paper process was gently shown to them was a beautiful experience (Figure 5.3.2.2a).

At a science level, the principles of chemistry and physics are used: Chemically, the special plastic surface has been chemically treated under licence to work for this form of papermaking (Longwood 1997). With physics, the pressure distribution of 100 tonnes per square metre over the whole surface area of the delicate formed sheets of paper is critical in many sub stages. At a nano level, the fibre length ratio in the range 50-150 length to width and fibrillation of the fibres into hundreds of nano fibres allows maximum cross linking and hydrogen bonding.

For the village artisan, the blank board is aligned into the stack rack; then a couching-cotton sheet is aligned on top using the 2 guiding hook system (Figure 5.3.2.2b). The film is layered over the thin pulp, on the flat couching cotton, on the stacking rack system (LSR). This is carefully aligned to squarely cover in a set system of alignment. On the base board: five layers of cotton, pulp, plastic are stacked on the critically designed LSR, then one protective layer of blank cotton is placed as the 6th sheet to protect the top film from damage. This is called a ‘sandwichee’ with plus and minus

5mm in tolerance. It is a new word for the many layers that look like a sandwich with two boards and 5 sets of cotton/pulp in-between that can be used in legal terminology for patenting the process. This is now ready to be easily, quickly, safely lifted up, with the baseboard, up and over to the pressing system. The sandwichee is slid in over the protective board and squarely aligned to the press, then another protective board placed on top. The board also starts the gentle pressure on the top layer of the sandwichees and gently prepares it for the weight of the next sandwichee. The thin pulp layers are still very delicate and need to be gently pressured flat to start the process.

A pressure gradient system was developed and researched by the author, (Longwood 1997). Once the stack of 100-200 sheets or 20-40 sandwichees has filled the press the next pressing part can start. First the rod ends are double checked that they are offside of the board line, then the alignment left/right is rechecked and/or gently pushed/ twisted to align, then 3-5 boards placed on top of the pile, then a heavier board, then an aluminium plate (light weight and strong/flat plate with reinforcement support), then packers to fill the gap to the shaft of the hydraulic press.

The pressperson then starts slowly pressing the pile of sandwichees. By showing and demonstrating to them each facet of the process, they were able to understand:

- how to generally do the new process;
- how critically slowly to do the new pressing technique;
- how to check for the dripping rate of excess water;
- how to build up the pressure over several minutes to maximum;
- then leave and repress; and
- leave and repress over half an hour.

Trials were first done blending the old and new press technologies (Figure 5.3.2.2c). The next year, in January 2008, trials were done with the first new press (Figure

5.3.2.2d). The pressure is built up to 100 tonnes per square metre over one hour. A pressure gauge can be used or a long enough handle to exert maximum pressure until a person's limit is reached and this can be calibrated. The USP made press was trialled in January 2009 (Figure 5.3.2.2e). It lasted one day before being stretched too much. It needed drastic structural reinforcement. It was designed by the students but was not strong enough for the paper pressing features of technology.

The fibres and water are loosely bonded together, by pressing, the hydraulic pressure of the water can go through the pulp/cotton interface and into the porous 3D−cotton and by osmosis/ escape out the sides of the pile. By showing them a sample of dried paper that was pressed too quickly they could begin to see the escape lines of water damage that look like branches of a river, where the water goes if it breaks/goes through the pulp. The pressing first sets the pulp onto the cotton, and then onto the film, and then slowly the water can be encouraged to escape out through the porous cotton layer.

For quality control, by holding a dry sheet up to the bright light they can understand the damage radiating out from the middle of the paper when pressed too quickly or too thick a layer. The light shows clearly an even light distribution for a perfect sheet of the new paper. Another test is to place some colours/dyes dropped onto one sheet of paper before the film layer. This makes streaks of colour along the pressure lines, radiating from the centre, if they aligned it right, and makes an artistic effect on the paper.

After pressing, the damp layers are hung out to dry in a traditional loft enclosure. However, special clamps/pegs were used to hold each sheet on to the horizontal clothes line (Figure 5.2.4.4cde). The line was designed to use standard rope/ 3mm−5mm diameter and special larger, more gripping, pegs. The paper could then air dry through the cotton side of the sheets. The drying conditions had to be controlled:

- If the cotton is dried too quickly, the outside dries first and the centre is damp and the paper buckles in radiating folds from the centre.
- If it dries too slowly the same occurs;

If not done correctly, it also wastes time and it is important to reuse the cotton and plastics in the production system. Having 1000 sheets drying, it can be reused each second day, implying 2000 sheets are needed for a continuous production base of 1000/day.

The papermaking industry generically uses rollers to gradually press out the water and create 'nip pressure' as it is momentarily squeezed through the continuous system. This LHMP system is simply a flat feed batch process of 200 sheets in a one metre high standard bench press, of 500 mm internal width that has been modified for a paper press to create a potentially even pressure over all the flat surface area. The equivalent pressure gradient of 100 tonnes per square metre is gradually built up to 20 tonnes of pressure over the A3+ sheet. This is calculated by:

Calculations to convert pressure per piece of paper to pressure per square metre: Each A3 oversized sheet of hand made paper is = 38cm x 48cm = 1824sqcm. => 20 tonne = 20,000 kg / 1824 sqcm or A3 sheet of paper => 11kg/1sqcm of paper being pressed: or => 11kg x100cm x100cm kg / 1sqm.= 110,000 kg/sqm : or = 110 tonnes/square metre of paper being pressed = 1 079 000 N/ m^2 Note: 1kg/sqm=9.807 newton per square meter (N/m^2)

The sheets are then ready to hang dry and then the peeling takes place:

- The film is carefully peeled off at a diagonal angle;
- The left and right edges of the paper are shown to be teased loose; and
- Then the paper is pulled from the diagonal across the paper; (Figure 5.3.2.2g).

It sounds easy and it is easy to a master with tacit skills. Some people cannot do the peeling process and destroy the sheets with creases or rip marks. The LHMP system takes an experienced person (author) on average 6 seconds/ sheet to hang or peel:

Many subtle and yet important lessons were learned from teaching this new smoothing technology to the village artisans.

1. They already had used a screw press and they could start to understand the smoothing process with the new technology.

2. They were not frightened by it; they have seen and used smaller car jacks and 1−2 tonne hydraulic presses. Some of the men would have used hydraulic jacks in their work.

3. Once they are shown they seem to talk with each other in their dialect and reshow – explain it to each other.

4. One lady was used to flicking the cottons before laying it flat for use. She tried the same technique to the plastic, The author advised her and indicated not to do it that way … as it would damage and crease the plastic, then put creases in the paper, and this was 'no good' => ' saga vinaka.' It is important for the transferrer of technology to have basic word and number skills in the local (Fijian) dialect.

5. It is appropriate for the transferrer of technology, (and clients), to deliberately make mistakes in a group setting so others can learn from this experience. Mistakes should be openly discussed as a positive learning experience.

6. After the challenging process to teach them most of the tricks and then see their eyes light up with delight as they peeled off each finished sheet was 'beyond' words =>'Sa-ya-wa'.

7. This phrase sounds so inspiring, 'sayawa', that the Marketing lecturer at Murdoch University asked the author to help in his 'marketing student project' and he took on the phrase as an important part of their course work project (Figure 5.3.2.2hi). The students learnt about papermaking and presented an enthusiastic presentation as part of their 3rd year marketing project. This opened the door to some unexpected marketing opportunities. This became part of the future marketing chapter of the ongoing research.

If a scientist is open to experiences on the holistic journey then greater good can flow from the first hand sharing of beautiful papermaking with lovely people, rich in culture and tradition (Figure 5.3.2.2j).

5.3.3. Turnkey: Donating Finished New Equipment

5.3.3.1. Turnkey: Introduction

The normal business ‘turnkey approach’ is an example of introducing a ready made part of the production system to the village community. Normally, the new high technology equipment is made in a developed country and exported to a UDC to ‘turn the key’ on and use. This may have worked elsewhere, but it was not possible to find the ten thousand dollars for an Australian made hydropulper to be made, exported, plus import taxes, and given to the village. The village may have benefited, but who will be able to fix it in Fiji or in remote UDC villages. A greater sustainable and holistic challenge would be to help empower the village to build one in a city nearest to them.

The first aims were to empower the WHMP villagers as much as possible, so the author decided to make one in Suva for them with their help. However the reality of being in a remote developing country, with time lines and pressure to get the project transferred, created many challenges along the way.

This became more about a story of overcoming local infrastructure, manufacturing, cultural and personnel issues that indirectly and directly affected the project being implemented.

In the end, a hydropulper was made in Suva with industry engineering help and then later, one was made at the University, with engineering help, as a Masters project by two students.

5.3.3.2. Turnkey: Making a Hydropulper with Village Help

The initial ‘plan’ was to use a volunteer from the village to make a LHP in a home workshop in Suva, with local engineering help, and thus empower some local villagers in helping and making a LHP. Ratu Autiko Naivakaucu was the village delegate who helped design and make the new hydropulper. It was felt that the author could build one in Suva for a few hundred dollars, using locally available recycled parts, motors, pulleys, drums, metal and wood. Welding, electrical, carpentry, designing and engineering skills would be tested to the limit under UDC conditions if it was made locally.

TRAVEL NOTES

With the volunteer from the village, we got up early Friday @ 3am to have the best chance of leaving the village @ 3.30am with the courier to Suva. We met the driver on the road near his house and got to sit in the front of the cab. This was important as the bumpy 4 hour ride is hell on your back and body in the back of the truck. It took an hour for the 3 local villagers to get on and overfill the truck with people and food for the markets. The wondrous trip through the morning sunrise and rugged hillside of Namosi made up for it, as the mist in the hills and valleys evaporated, as smiling faces of many villagers along the way waved us by, as the truck overheated and stopped dangerously by the roadside, as boys soon disappeared into the thick bush to reappear with containers of water for the radiator, as we waved back to the military and police at the ‘coup’ roadblocks, as we somehow got to Suva by 9am. A taxi was easy to find to take us to my place in the suburbs. After a traditional breakfast we discussed the materials that were already bought for the hydropulper and the options going forward.

The village delegate, Ratu Autiko was shown the facilities we could use to help build it or go to the engineering company. He was happy with the electric motor and could suggest ways to secure it safely to a bracket and further mountings for the pulley system. As money was limited, we decided to try doing it ourselves as much as possible. The ‘implementation’ phase stopped when he received a phone message and other commitments became more important. The author was again left to do it himself.

5.3.3.3. Turnkey: Making a Hydropulper with Cottage Industry Help.

This time the new 'plan' was to seek the help of a small manufacturing company that had previously helped an international TT project to design and make a coconut oil extraction machine. As they were based near Suva city it became a chance to deal with local Suva industry as an example of developing 'turnkey technology' transfer.

The plan was discussed with the manager of 'On Time Engineering' and set in place, with a hand shake and a bowl of grog, to make the LHP at their small engineering company and to redesign it using locally available material and tradespeople (Sharma, 2006) (Figure 4.3.3.3ab). The plan was 'implemented' and resulted in a report for the thesis and/or book being published on "How to Make a Hydropulper" (Westerlund 2007a). There were once again, many more lessons learnt from this. The village could not be relied upon to help and it was up to an Indo-Fijian owned small engineering company to come to the rescue of this native Fijian village project. The author did invite two other delegates from the village (Ratu Peceli and Maria) to the workshop to at least be there a few hours each day and see how much work was involved in making the hydropulper (Figure 5.3.3.3cd). They were able to see how a simple thing like a pulley belt could prove difficult. The author had bought a pulley belt from a business across town, but when the support bracket was made, that pulley belt did not fit. Another local supplier was only 200 metres away, and offered a range of sizes. The first chosen still did not fit, so the belt was returned, refunded and the right size purchased. The two village representatives were thus involved in the process of understanding the sizes, shapes and sources for replacement belts. If or when there is a problem in the village, then they can at least courier the unit back to Suva and get it re-engineered locally. This was one major positive outcome from the change of strategy in the project - to try to empower a local engineering company to co-design and build the hydropulper. A photo of the group was taken while working in the engineering business (Figure 5.3.3.3e) - special thanks to the manager (Figure 5.3.3.3f). There was only so much the author could do with the engineering company and the author completed the rest at his Suva home base.

The author needed to carry out a series of trials before going to the village to find problems he could not fix in the village. The first test was the blade. The engine was not strong enough at 1:1 ratio to drive the 5 inch blade. A smaller blade was bought and the 5 inch blade was given to a carpenter for his blunt circular saw in return for his help. The next test was to run the engine over a longer period than needed to check the motor did not get too hot. The motor needed slight realignment and an on/off switch mounted. It was now working but had no protective cover from hands and splashing of water. This could be an OHS issue and needed a cover. A sheet of ply and screws were bought to be loaded onto the courier by the Monday morning deadline. Against the odds the author made the hydropulper in one week (+weekend + early Monday morning), ready for the Monday morning courier to be in the village for the start of the workshop that week. The project could have collapsed at any time during the week with pressures from many angles, but the hope of greater good for the Village provided the incentive to get through. The final tests were in the village. A wood/ply cover was cut and made to shape in the Village (Figure 5.3.3.3g). This was done more easily as the author had bought all his electric tools and extra diesel (for the portable generator), just in case. The magic moment came to start the generator and 'christen' the new motor-hydropulper … and… it 'did not work'! After all the pre-planning and testing, it did not work! The village generator was not powerful enough to start the motor. We had overlooked that issue, of extra current needed at the critical starting phase. The author is not an electrician and did not fully appreciate using non standard 240 volt systems. The pulley had to be literally kicked to make it move and help start the motor. The ‘kick-starting’ was accepted as ‘normal’ by the village men, and an interim measure in the village. The motor seemed suitable then to run off the village generator. The village men were amused by a small 3inch circular saw blade chopping up 180 litres of paper into pulp. Going at 2800 rpm it was quite powerful. It could have been geared slower with more torque but this was a good trial of new process technology adapted to the situation in a developing country.

It took up some space in the production room and needed a close water supply. The author had also bought some standard lengths of white PVC pipe, elbow and joiners to extend the water hose to near the hydropulper. These little extras provided by the author are necessary to ensure the success of the project. They could see the value in the pipe idea and were soon happy to help. Several volunteers dug a new trench to lay the pipe to the other line. A new tap and ‘snap-lock’ fittings were bought to make it work better than their standard cheap tap fittings. There were a few unexpected challenges to mount the brackets and pipes on the concrete block walls, but these were overcome. The author used up the extra fittings – elbows and joiners he had bought and then had to undo a few joints using local skills to reuse a few joiners to finish the project. A $1.50 joiner to the author is cheap, but to a villager, it is an hour’s work so they were happy to unglue the bonded fitting and reuse any joints and save precious money.

The motor was making some noises and the author asked if there was an electrician in the village…there were two. The hydropulper motor was stripped down and realigned to work better (Figure 5.3.3.3h). They also fixed the switches better onto the mounting plate. This was good to help empower them to own and fix the hydropulper in the village. They also explained in Fijian and English why the 3kVA generator did not have enough initial current to start the motor but was suitable to keep it going.

5.3.3.4. Turnkey: Making a Hydropulper with University Help

The ‘review’ was done at the University of the South Pacific – Fiji because they decided to take on the project and remake another LHP and LPP with their students as a 2007 engineering student design project. Ongoing communication involved the design and many strategies to make a better one as a template for more papermaking projects (Kumar 2006-7; Omwubolu 2006-7; Koshy 2005-7; Wood 2006-7).

The ‘improvements’ were co-designed with the Engineering Department of USP (Wood 2006,7) as his students made one to our guidelines. The project design started in first semester 2007 then continued into second semester, then was planned to be built in a second semester project in 2007 (Figure 5.3.3.4a). This was ready for when the author returned in January 2008, with some help by engineering support staff (Figure 5.3.3.4b). A few modifications were done on the lathe, blade and motor and the LPP was taken to the village for trials

Dr Danial Wood from Engineering USP emailed to say the student project for making the hydropulper was finished and ready for delivery in Feb 2008. This is after donating the drum and design concepts in Jan 2007, and follow up emails. On inspection the project was good and functional but on testing under pulping conditions on 5 Feb 2008 in the USP Engineering workshop the author noted some areas for improvements (Figure 5.3.3.4b**cd**).

1. no spring washers in the bolts securing the motor and pulleys.
2. the motor rpm was too slow at 1480 and 6” to 2” =>3:1 =>500 rpm.
3. the safety cut off switch was not safely mounted and open to water splashing.
4. the drive belt had no cover plate.
5. could it start using a village 3kVA generator?
6. the unit was wide and may not fit through the door.
7. the motor seemed to get hot in use as it had no vents on the cover.

In discussions of the issues with Dr Wood it was noted that his expertise was in aircraft design and to minimise wind friction and turbulence, while the blade needed turbulence to stir up the pulp and create a circulation motion. Several options were discussed, considering the author's experience of making 3 other hydropulpers of different designs:

1. buy and install some spring washers to stabilise motor vibration.
2. increase blade size from 8" to 10" =>20% speed =>600rpm ($50).
3. increase pulley from 2" to 3" => 740 rpm ($50).
4. change blade design - with wings … to create flow.
5. cover and remount the safety switch.
6. make cover plate for pulley.
7. test starting conditions using the USP student research generator.
8. may have to disassemble the unit to fit through the door. The village workshop door should have been designed for industry use and made bigger like a garage door access.
9. the cover to the motor could be re-bolted with bigger bolts and locked in, with a nut as a simple, cheap, effective spacer to provide a ventilation gap.

The most important pulley option was agreed upon (3). The author arranged to help modify the hydropulper with some help from the head technician (Lal Radesh) and staff of engineering This took two days, involving buying a new 3" pulley ($40); taxis ($20); pulley belts ($10); taxis ($10); spring washers ($10); taxis ($10), (Total $100): The machinist did a good job of machining a 20mm bore hole and cutting a pin slot using a file (Figures 5.3.3.4b**e**). The workshop and access to tools allowed easier modifications to the hydropulper. It could not have been done in the village.

The student generator was used to test the unit (5). It was modified with many electronic controls to test remote power starting conditions (Figure 5.3.3.4**f)**. It seemed to start with no obvious problem. It was over 4kVA while the village generator was smaller at about 3 kVA. Would it still work in the village?

The next week was organised to take the LHP to the village and test it. The Author took a box of tools (as insurance policy) to fix any more problems in the village (Figure 5.3.3.3a). It was thought that there might be problems getting the unit through the door. On Monday the courier driver and the Author met Dr Wood and collected the new hydropulping unit. The out of pocket costs kept accumulating to ensure the success of the project (taxis $5; courier $20; accommodation $100; village food donation $40; time- four days; soli $35;Total $200 plus university costs of $400 =$600).

After arriving late in the village, at 7pm, four lads were asked to help lift the heavy unit into the paper shed. They lifted it out of the truck and through the creek to the shed. The truck headlights were shone on the door and it was soon apparent that the hydropulper would not fit through the standard sized door. Neither could it be lifted up 1.5 m through the windows after the security screens had been removed. Finally, after the removal of some pieces from the hydropulper, the heavy unit was able to fit sideways through the door. The other LHP was then lifted onto the truck to be taken to USP for retro fixing as another student project on TT.

The unit was tested under the 3kVA generator power, starting the next day (Tuesday), and it worked. It was tested under load using up to 3kg of soaked paper. It still worked and started under load. The author showed them how to test the pulp for a fine suspension of fibres (Figure 4.3.3.4**g) -** congratulations to all involved (Figure 4.3.3.4**h)**. Two loads / batches were trialled and the motor left on for an extended time to double check for over heating or problems.

Some paper was made by the village team and a photo of a lady (Mere) turning the machine on and the first sheets of paper to be made using the new machine (Naivakaucu 2007) (Figure 4.3.3.4**i**). They seemed impressed that it will make their task easier, safer and quicker (thus more economical) while producing better quality paper.

5.3.3.5. Turnkey: Results of Equipment Survey after One Year

After one year of trial operation the village hydropulper was not working. The motor base had slipped out of line with the pulley, creating an extra diagonal force to stop the free flow of the pulley mechanism. The author attempted to explain the mechanical situation to two village men on the day, but another person should have been authorised to service it and learn to service it better. Within half an hour the author had the hydropulper aligned and working smoothly again. The hydropulper was then allocated to the University for retro-fixing and servicing as part of an ongoing support helix. It was donated to the training group so they could develop a second set of equipment for professional training in other villages. It is part of a greater vision to have a full support service for the village with the help of local industry and a university intertwined-helix of support. Murdoch University and the inventor/author should be able to step away and empower the local helix for full support and complementary future research.

5.3.3.6. Turnkey: Summary

In summary, the modified appropriate 'sustainable turnkey approach' worked to introduce a new sophisticated piece of technology to the village.

The modified strategy was:

- to make it in Fiji,
- by locals,
- co-designed with the inventor /author,
- using locally available parts,
- with some input from the villagers to help ensure it could be fixed and serviced in the village or the nearest city (Suva).

The next level of help was from the University of the South Pacific and was important in that it introduced the engineering section to the project and made a better hydropulper. The next level for them would be to have control of the technology for the ongoing project in Fiji. The research students have already produced a University Engineering Masters document on making the hydropulper and the next year's students will have a working model, and access to the village, and the experience of the lecturer, and email support from Murdoch University.

The project has now empowered all levels of the helix with the best available technology, that the author, with 30 years of experience, and support to be leaders in the art and science of hand-made papermaking equipment.

5.3.4. Part D: 'Copy it Exactly' Improvements in Skills (Phases1-3)

5.3.4.1. Introduction

In discussion with some village delegates, it was decided to push on with the TT to start the next level of teaching and learning the new integrated paper making system. The 15th to 19th of January 2007 was allocated to this important phase. The project that week had a few hiccups before starting. A lot can also be learned from their priorities and it is well worth understanding these background issues. First the courier delays with staff on leave; a funeral; hungry abandoned children; diesel gone; and then the software skills were taught.

5.3.4.2. Other Priority-1-No Regular Courier

The courier was planned to leave Suva at 1pm. After much morning haste and last minute adjustments to make the new vat ready, and get to Suva City on time, arranging for a small courier truck ($20) to get all the bulky equipment to the meeting point at 12pm for the big courier to leave at 1pm, it was found that it had been and gone earlier that morning. There was a 'funeral' on and the courier left early to drop people off at the next village, and would be back later, maybe 4ish for the next trip. After waiting with all the gear and computer and things under the shop eaves for three long hours in the hottest afternoon sun, the courier truck miraculously came. The day was gone before it half started. People were happy to get on, and escape the heat, and four hours later we arrived in darkness, with my twelve bags and boxes placed/dumped beside the truck in the village, the precious new vat dumped on its side on the verge. An unceremonious end to what could have been a great presentation of the new vat. A smile and 'bula' revived the day as a few men were found to help lift the many bags to the bure (house).

5.3.4.3. Other Priority-2-Stop for Funeral

As it was still in the early New Year and many of the staff were still on leave, at funerals, preparing for the start of school, even helping to build the three new classrooms of the school, it was decided a key group would thus learn the new techniques then teach the others over the coming weeks. Tuesday was taken up with all the village women preparing for a funeral from the next village (the mother came from this village). The funeral was on Wednesday morning and the promise of papermaking in the afternoon soon dissolved into a long lunch, grog and socialising for the villagers.

5.3.4.4. Other Priority-3-No Diesel

Meanwhile the diesel for the paper making generator was given to someone else and we had to find another gallon. This took two days of convoluted negotiation to acquire $10 for 5 litres to help the papermaking workshop. The courier trucks were not even asked to buy a container that could have been delivered that afternoon in replacement. Perhaps because the phone to the village had not worked for a few months, and mobiles are out of range, and the courier drivers pass through at 3-5 in the morning. The author later found out that the driver of the courier truck (that also uses diesel) lives within walking distance of the village. The next time some spare diesel will be bought from Suva and the courier driver's details are duly noted to empower the workshops to continue if the community runs out of diesel. Adjoining villages are within 2 km but no diesel is available within 3 hours drive.

The lesson learned was that Fijians live for today, they do not store spare diesel, if they did, then someone will surely want it / borrow it and it's gone anyway, so bring your own petrol/diesel/fuel and know the local contacts/network.

5.3.4.5. Village Workshop

Meanwhile two more days went by before enough villagers came for the workshops. Thursday was a productive day as 100 new sheets of smooth technology paper were successfully made. Several pictures record the different stages of paper making and participants using the equipment (Figures 5.3.2.1e-n; 5.3.2.2a-g). The core group of 7 adults and several onlookers seemed to like the ease and flow of the new vat-couching/transfer curve stacking system, press and hanging out each to dry. As mistakes were made, they were duly highlighted and talked about in a positive constructive way. They were happy to learn by doing and making mistakes. Then they talked to each other in Fijian and taught and helped each other more. By explaining to one or two with English language and gestures, the understanding was soon passed on to others. A group photo captures the first sheet dried that afternoon (Figure 5.3.2.2a) and the first sheet with the new hydropulper in Jan 2009 (Figures 5.3.4.5ab).

The group could now start to appreciate the many new steps in making a higher quality paper. They could start to talk to each other about why the equipment was designed that way and the simplistic beauty of the new ways. The papermakers were excited about the feel and texture of the nearly '(super) smooth' paper. They were shown with that first piece how it still was not quite 'super smooth' and that the lint could be seen in the reflection of the afternoon sunlight against the paper.

5.3.4.6. Summary of the Copy it Exactly System.

The group seem to accept that they had made several important steps to making a quality writing paper. They had the potential to go on and make the better paper again in the future. The village people had other priorities that took precedence over learning a new technology. Some champions of the cause were found to keep the project alive. A more structured training course could be developed with guidelines to achieve certain skill levels and progress through making card paper to artistic paper to writing paper to more refined printer's paper to the hardest photocopier paper.

5.3.5. Summary of Introducing Higher Levels of Hardware and Software

New innovative technology could successfully be introduced and implemented into a remote Fijian papermaking village. Three methodologies were trialled as 'leapfrog' or 'turnkey' or 'copy it exactly' to demonstrate the many challenges involved at every level to ensure a successful project. The delegates of the Wainimakutu Village of papermakers were happy to learn the new tacit skills and learn the many steps and tricks to make a higher quality product. This is a time based learning skill that will improve over the months as they trial, use and reinvent better ways for them to do it and as they teach each other. There is room for error and variations to occur while still maintaining a quality product. They will need to further adapt the new ways to improve their standard way of making their normal flowery rough paper.

The foundation was now laid and an open supportive way of going forward was in place to keep on learning and creating a new superior quality of paper with the new skills and technologies. Now they were ready to explore the next 'vertical' methodology to help them use their new skills to make other paper products.

5.4. Part E: Vertical Technology Transfer: (Phase 4)

5.4.1. Introduction

This section is presented as an example of: ‘vertical TT’, to introduce new manufacturing skills to a UDC by value adding. This was achieved in three ways.

The first was to increase the existing paper size from A3 to A3plus. This effectively allowed 2 x A4 paper to be cut from the bigger A3 and doubled the output of A4 paper.

The second was to introduce the new smooth technology system which created a new marketing niche from rough art paper to smooth printers quality paper.

The third, to add value to the paper by making a higher grade of printing/copy paper for book making, publications, poems, and products for the church, the school or for sale. This was done using small, then bigger, then larger steps in TT. As there was no detailed initial plan to go by, the author created several initiatives to first understand and then develop a working plan or approach.

This evolved over a few years to be a successful strategy to introduce new ‘conversational English’ English-Fijian stories into the education system. This went beyond the initial scope of the thesis and reflected one more way of judging the success of the project.

5.4.2. Redesign the System for A4 Paper

The village papermaking system was designed for standard A3 sized art paper for use as wrapping paper by a cosmetic company. Their orders and system were totally designed for this company and with each coup, the orders stopped or decreased by 75% for a while, before recovering and stabilizing. Their village was thus too dependent on one outlet and one product line.

From the one A3 sheet they can get one clean cut A4 per sheet of rough paper. Research by the author has shown how the A3 plus system increases the frame size by 8 cm and thus allows for extra waste (4cm/side) to be cut from the A3 plus to cut 2x A4 sheets of standard paper. Output is thus doubled by using small changes in technology and systems. The same time is used and the same types of equipment and processes, but the increase in paper size can effectively double the output of the standard product for other product lines. The whole system is then upgraded to expand a little and streamlined to achieve a new production level. The wisdom of over two decades of research can easily be transferred to the village system.

In summary, this opens up new sources of product lines, from A3 plus paper and art, to A3 paper and art, to A4 standard industry printing paper. The whole production system can be streamlined to produce A3 plus paper more efficiently and profitably.

5.4.3. Smooth Technology

It has taken over two decades of part time research, by the author, to perfect the art and science of smooth hand made craft paper. This village has the wonderful opportunity to freely acquire the pioneering smooth technology, via the 'creative commons' licence, and leapfrog ahead of the world competition. From a remote Fijian highland village, they can lead the world in the implementation of the best available research and technology from Murdoch University and the author. The resultant smooth paper is suitable for high quality printing. Rather than just selling it to the printers it was felt best to trial it for publishing, providing another example of what can be done to empower a village.

Perfecting and refining the ultra high levels of the smoothing process will take years of science and tacit skills of papermaking research and first hand experience. This is now started in the village and needs more ongoing funding and training and time for everyone to master.

Perhaps it will be the next generation of young people, who are now at school, now reading books, who will push this technology to be adapted more in the village.

5.4.4. Publishing Skills

The paper was trialled for value adding into books, poems and stories. The process evolved over many years and in reflection is an interesting story of research.

The first period was a few years of networking with the Fijian Government Printers (GP) allowing the author to pre-test the concept of book publishing with the GP before approaching the village with a useless / impractical / irrelevant /western / idea. Blank and printed samples were given to GP for them to make a range of demonstration books from the smooth hand made paper (Figure 5.4.4a-f).

In the second period a few Fijian stories and poems were trialled over a few years and copies given to the local USP library for trial and comment. The head librarian, Ms Joan Yee (2002,5,6,7) liked the concept and encouraged it. They now have a few of these books in their library. Networking from Perth (W.A.) to Suva (Fiji) and Government Printers (Fiji) over a few years to form a base of good will and support proved challenging. The success of this was indicated by the fact that a new book can now be sent across from Perth to Fiji and more easily organised for binding and publication in this UDC.

For example, the author also shared a few stories over a bowl of kava with the local men after work or at functions. One edition was from an elderly Fijian villager, Mr Tiko Suliasi, who ‘spoke no English’ and at morning and afternoon ‘smoko’ the author encouraged him to share his rich and wonderful stories. After each sentence or paragraph the author asked the young Ratu to translate into English, and the author quickly made notes and encouraged him to continue. The author later converted the stories into poems while they were fresh in his memory. Back in Australia the author edited them and published a book for him. A year later a copy was ceremoniously presented to him in his village (Figure 5.4.4g) (Tiko's Poems and Stories of Pacific Isles), (Tikoiba 2002).

The third period was to show finished concepts to the village in Feb 2007 and Dec 2007. Discussions with the headmaster of Wainimakutu Primary School indicated that local education was becoming more important to them (Manumanununitoga 2007) (Figure 4.4.4hi). The local villages were always fundraising for the school and were currently doing a 'busy bee' to help make 4 new classrooms and teachers' accommodation. By securing the local primary school it meant the children could safely walk to school but they had to leave the village for high school. To then secure the high school was doubly important. Flow on benefits from local high schooling are more local teachers and rent for their housing, increased revenue for the school with boarding pupils coming from surrounding villages, and the fact that the local children do not have to leave the village.

The income of one local teacher, Vere (who married the chief's grandson and has three happy children in the village) has directly helped them pay for modern materials to make a concrete block house with a tin roof. The picture (Figure 5.4.4j), shows the house additions in progress. She is also translating one of the author's books into Fijian and thus completing the cycle of the paper being made in the village, translated and soon printed in the village (Figures 5.4.4kl). She was looking to buy her own computer, to use it for school and private use. The author went on a morning walk with her husband, Tako (Ratu Peceli), to see their sustainable vegetable garden/plantation on the distant hill and began to more appreciate their culture. Tako's concerns were in asking the author's advice on fertilising, soil, crop options, prices / different crops, transporting to the Suva market, and his frustrations that so much time was wasted in walking and carrying heavy dalo along rough bush tracks back to the village, then so much cost in transport to the Suva market, or to the international New Zealand market. They were the second last village along the inner mountainous road. His land went inland away from any road or infrastructure. It was necessary to wade back and forth across the river to just walk to his plantation which backs onto virgin forest. We were in heaven for a few hours in the last frontier of the Suva highlands. One was beginning to feel a part of their special community. Tako later studied an introduction to computers and printers and helped print the first book in the village (Figure 5.4.4l).

The fourth period involved rediscovering the many local indigenous stories that could be told and published in many books for the village. These could then be used for the school system to encourage more indigenous content in the curriculum (Manumanununitoga 2007),(Figure 5.4.4m). There was some initial interest shown in a meeting with elders and teachers in January 2007. The chief was also interested in a story of their village animal token. The small fish called 'beli' seemed to have special significance. A year later the author met with a local elder of the village, Mr Rev. Namani Manumaunitonga (grandfather to three generations of teachers) who was visiting the village. The project was discussed as were options to help. Mr Rev. Namani was very happy with the concept and asked his granddaughter to the meeting (Manumaunitonga 11Dec 2007). Ms Salote is also doing a teaching degree. A strategy was agreed upon to help them tell the story of their tribal village with help from the granddaughter to transcribe, edit and do a project as part of her studies. The end result would be an important local tribal story from the papermaking village as a holistic project. The paper would thus be made in the village, the editing done by the granddaughter, the transcript emailed to the author for help with editing, and the printing done in the village. The binding could be done either in the village or more professionally using the Suva Government Printers. The first follow up, in January 2008, to show him the examples of finished books and leave a picture of 'him and his granddaughter' printed on the smooth hand made paper, proved encouraging. Only time will tell now how the seed will grow to produce their first book of an original village story.

Another period, the fifth, involved a meeting, near Suva city, with Mrs Litia Tukana, who is being paid/sponsored to help write some books (Tukana 2004-8; Tukana 20005)(Figure 2.2.6ab). This education department project had been started but was waiting for funds to continue and finish the project. Meanwhile the author asked her to also start translating one of his books. She was a home-education teacher and now retired but she has the ability and skills of translating into both English and Fijian. The 'Bembe' book took a year to translate with three or more people helping and many revisions. One version was more 'word for word' and the next was more 'flowing-readable' to recreate the Fijian story. The last version had minor 'Bauan' words checked as the new official dictionary was since published in 2007. The result was then printed in the village in January 2008 as an example of the first book to be published in the village. This was presented to the translator, Mrs Vere. Her husband, Tako, had just finished an introduction to computer course for villages and was happy to help learn and print the first edition (Figure 5.4.4ikl). The headman Ratu and family were shown the books and were really impressed. This encouraged him to rejuvenate the project and network with the teachers and headmaster to help. They had their report released to say their school needed to improve its teaching and English levels. This could be developed into an integrated learning program with books made in the village by teachers to fit into the curriculum (Civinainima 2007) (Figure 5.4.4m).

A sixth period was to find out about a new group being formed to encourage Fijian stories and books for Fiji. They first met in Suva, Fiji, unfortunately after the author left in 2007 and could not be easily followed up. In time it would be good to network with them and help promote an holistic approach to printing and publishing their stories on the Wainimakutu paper.

A seventh period was networking with local men for men's stories (Figure 5.4.4g). On another occasion we had several Fijian labourers helping to landscape an eco-friendly pond feature in the garden by digging a 5 m trench and 2m diameter pond. This was cemented and large volcanic rocks were cemented in as features. Each 'smoko', the lads told the author several stories which feature in a group book on 'Stories of Fiji'. On another occasion on the death of a local chief, Ratu Peni, the author managed to translate a few nursery rhymes for the children as a legacy for him and the great work he did for his tribal village – matigali of Nausori. This evolved into 'Bembe, the Fijian Butterfly', where Bembe - who met up with some animals and plants that are considered 'totems' of villages - shared an adventure through the highlands of Fiji, Mt Victoria, Monasavu dam, Rewa River, to the ocean and had lunch under a coconut tree (Figure 4.4.4k). This introduced Fijian geography, science, numbers and places into a local story now rich with tradition. The book is: "Bembi: the Fijian Butterfly" (Westerlund,L.,Qiokata.V.,Vatucicila.L. and Tukana.L (2007),(Figure 5.4.4k).

For another period, the eighth, the author used the tribal untold story of grandmother's way of educating her children about sustainable harvesting of the fresh water prawns that provide important protein to the village diet. (see "Prawns, Eels and Coconuts" (Westerlund 2006) (Figure 5.4.4n helped by Dr.S.Kubuabola in left of Figure 2.2.6b). The village mother showed her five year old how to lift a rock in the tributary, check for larger prawns and then to replace it without disturbing their home. This five year old village girl went on to become the second Fijian woman doctor of Chemistry and Environmental Science. Only in reflection of her childhood did she realise the tremendous wisdom of her mother and Fijian culture in sustainable harvesting of prawns in the village. This story is also important to the Wainimakutu Namosi region as this is directly about their heritage, their fish, the eel, their coconuts, and their own childhood reality. In reading the books the author had already published they were impressed with the way their culture was duly reflected in the books. The 'eel' is another village totem-fish and their journeys from the highlands to the great Suva city of lights reflected this in many ways. They passed through villages with the other totems of coconuts, 'via' leaves and ceremonies. Using their 'eel' was initially considered 'tabu' (forbidden) by two of the Wainimakutu Village women, but on reading the story they were happy, smiling and honoured it was done so well and sensitively to their culture.

These periods all seemed to evolve and mature into the ninth period which was to work with the Fijian Education Department and try to encourage them to take on the project. Their outreach program heard of the author's project and they met on the village courier truck when returning from the village. Mrs Vatiseva Civinainima introduced herself as the 'Outreach Officer' for the Namosi region and was excited to learn first hand about the papermaking project and the author's views on how the schools were getting involved (Civinainima 2007). The following week we made appointments to meet at her office in Suva to expand on the project and meet the rest of the staff. Several book examples were collected and presented informally to the meeting in Suva in January 2008. Her immediate superior, Ms Milli, liked the concept and an initial meeting was held with their head of staff, Mr Namani Drova, He liked the concept and the author was invited to speak to the next regional staff meeting in February 2008 (Drova 2008) (Figure 5.4.4m). The group were already working on a concept of a 'conversational English' program to encourage Fijian students to learn more about their culture and use some conversational English in the village. The author's books were complementary to their program and they were happily amazed that the project was now making books for children with nursery rhymes and stories in both languages on the same page on the hand-made paper. They felt they could take this concept and trial it quickly in their program. They needed trials in 2009 ready for more serious trials in 2010.

Several books were then printed and presented to the Wainimakutu Primary School and it was hoped they could trial the books as a separate aspect of the project (Figure 5.4.4hikmno). A printer was donated to the primary school to empower them to use a quality printer suitable for the thicker hand-made paper (Figure 5.4.4p). This involved buying the ink-jet printer, extra ink and paper for the school (Figure 5.4.4q). The headmaster and staff also needed lessons on using the printer. It was planned to install it on a Sunday in February, after finishing the project and just before leaving Fiji.

As this was just after the cyclone 'Gene'(Feb 2008) the road to the school was flooded so it was necessary to walk a kilometre to the village school carrying the new printer. As the school generator only worked on school days they improvised with a portable petrol generator to run the computer and printer. The software was loaded and the new printer checked. The system was first checked with the author's portable laptop then installed on their school PCs (Figure 5.4.4pq). The PCs used an earlier version of 'Word 2003' and the settings were adjusted to work. The headmaster had minimal training in computers. He was appreciative of the help and support to install the printer and get it working. Two helpers were also shown how to add ink to the cartridges and insert them correctly.

We walked on to the last village to thank Tomasi for his help and stories and presented him with his book "No Fruit on the Coconut Tree" (Lasekula 2008) and a special book of "Duna the Electric Eel" (Nailauota and Westerlund (2008)) for him and his Village Chief, as that was the totem of their village (Figure 5.4.4rs). The cycle was complete, from waste paper and fibres, to recycling into paper, to printing books, to local Fijian stories, to using their totem as an important part of the story, to the chief's blessing, to helping the local primary school print and translate the stories into their dialect, to the education system trialling the books in the school. All were farewelled before leaving the village on the early morning courier truck.

5.4.5. Summary of Vertical Technology to Publishing Skills

It is very encouraging to see the vertical transfer of skills. The production system was changed to make a slightly bigger 'A3 plus' standard paper; smoothing technology was introduced to make a higher quality printer's paper was introduced; and the resulting paper was used to make books of poetry and stories for the children. This involved a few years of networking with the education department, general office paper suppliers; industry printers; and the Government printing office near Suva. This period of the project has explored several options for trialling the villagers and author's stories and allowed networks to develop in the hope that one or more may be successfully translated as a English-Fijian dialect traditional story. The production of several published books may lead by example to a major new craft industry for the village. This is now sustainable progress for one village but we also need to understand how to help the next village make similar paper and products for their use.

5.5. Part F: Horizontal Technology Transfer to Other Villages: (Phase 5)

5.5.1. Introduction

The ongoing helix of support and training of the papermaking project is also developed as an example of "horizontal" TT, to encourage the WHMP Village to own, modify and transfer the technology to another village. This could be considered the real long term sustainable outcome of any TT project.

5.5.2. Technology Transfer from Wainimakutu to Another Village

The longer term 'plan' (**P**IRI) of Phase 5 was to start to help them develop and modify the new technology for their empowerment and thus encourage them to teach, train and TT the principles to other local groups/villages. A substantial network of local and international organisations was needed for this phase to progress.

This was 'implemented (P**I**RI)'

1. by networking with a local business "Ecoconsult" to help develop a concept plan for future expansion (Liebregts 2007) (Figure 5.5.2a);
2. emails to the New Zealand University associate Ms Prue Townsend to introduce her to the new smooth technologies and how these blended with her rough-arty paper technologies (Townsend 2007) and her efforts to introduce new Hollander beating technologies;
3. networking with the Head of a regional training centre for women (the Secretariat of the Pacific Community - SPC) to train their women from the regional / international villages (Maka 2007) (Figure 5.5.2b);

4. networking with a delegate from the Pacific Islands Association NGO (Bolabola-Cema 2007);

5. networking with a technical skills organisation, the Centre for Appropriate Technology and Development (CATD), to help make the equipment with village young men from many regions (Bola 2007), (Figure 2.2.3pq);

6. networking with the University of the South Pacific Engineering section to help make the hydropulper, press and technical equipment (Kumar 2006,7; Omwubolu 2006,7; Koshy 2005,6,7; Wood 2006,7,8) (Figure 5.3.3.4h);

7. networking with the village lady delegates, Ratu Autiko and Mrs M Naivakaucu, to send over extra equipment and to provide coaching over the phone from Australia (Naivakaucu 2006-7-8) (Figure 5.1.3c,f-centre).

It was planned to start by teaching other village representatives the new skills in rough hand-made paper in August 2007 and see the new paper and range of pretty cards they made (Figure5.5.2d). Then experiment with the new Hollander beater (Figure 5.5.2e) and for the next years (2009+) to plan to sponsor the introduction of the author's technology to other villages.

5.5.3. Discussion

This process empowered the stakeholders to start networking with each other, and then to teach each other, knowing that they had the author only a phone call or email away. This process was only started for this thesis and would need further help and support to continue in the coming years.

The August 2007 workshop at SPC was successful in teaching several other villages the rough way of making the handmade paper. They consulted with the previous New

Zealand papermaker/artist from the University (Figure 5.5.2c). They invested in a new Hollander beater to grind the fibres and make arty paper (Figure 5.5.2d). The pictures from Ms Townsend were forwarded on to show the success and artistic effects they created. Ms Lia Maka secured over $20,000 in international funding to continue the programmed network with women from other regional and international villages.

The July 2008 workshop for one week was conducted by Mere Naivakaucu (2008) from Wainimakutu Village. She has learnt both techniques and the author strongly suggested that she be encouraged to help train the new group in the smooth techniques. This showed the success of the TT, that she was skilled enough to now co-lead the group. Mere was paid a training allowance and thus rewarded for her efforts. The training group made some smooth paper and appreciated the several books that were sent over as the author's examples. The group was empowered by their results and challenged to keep improving their skills in order to create books like that of the author. Networking with CATD resulted in designing and making the new equipment. They networked with the USP to encourage Dr D. Wood to help finish the press and hydropulper for their training centre (Figure 5.3.3.4h).

Support material was created to help them understand the new equipment and processes. A few critical books were published and sent to the USP Library and they sent a thank you letter of appreciation (Figure 5.5.3a). This was complemented with real pictures of the local people helping to make the equipment and demonstrate papermaking (Westerlund 2007abcde). A traditional thank you was offered in the form of a whale's tooth, hand woven mat, and sulu (Figure 5.5.4b).

5.5.4. Summary

The new innovative process of making paper and books in the remote village has started. It signifies the potential success of TT in this project. It has the potential to create a cooperative of villages making craft paper. They can then adopt the 'best available technology' to create a new range of papers made in a less developed country to first world standards. They will, in time, be pioneering the best available technology to the world and become world leaders themselves in horizontal TT from a UDC to another UDC or to DCs. They developed a local helix of support between the village, industry, university and NGOs, with international support from the author and Murdoch University.

Aid organisations can feel more confident that their investment money and time is being constructively used and magnified to help create a viable long term sustainable project based on recycling, saving energy, saving time, value adding, creating culture and craft books and a more holistic transfer of suitable appropriate technologies.

5.6. Summary for Fiji

From the literature review the author developed an integrated holistic model for this thesis starting with Fiji then BWLV. The selection process took a look at a range of Pacific countries before deciding on Fiji. A country search and networking helped to decide on the WHMP Village. The existing technology was assessed and plans developed to improve existing technology, thus to build onto it with new innovative technology explained in small steps, bigger steps, leapfrog steps, copy it exactly steps, and the modified turnkey approach to build and donate a new 200L hydropulper and 100 tonne paper press. This was implemented using the technical action research model and with Hall's holistic model. The project went further than its initial aims and initiated some vertical and horizontal models of TT.

The theory of small increments of improvements in TT (Harding 2002) proved successful for the project. The use of free white post-industry paper was innovative and appropriate. The sewing of sheets to make the special LTS was not up to the new smooth quality paper standard but adequate for their rougher hand-made paper system, as they had only simple treadle sewing machines. The making of simple equipment with them was a safe, solid, appropriate foundation.

The WHMP Village was ready for the next, bigger steps or jumps in TT (Harding 2002). This included making a vat for them, redesigning their vat, and making another vat more scientifically with them. It was then appropriate to introduce the papermakers to the crucial quality manufacturing improvements of aluminium –rust proof–warp proof 'moulds and deckles', The bigger hydraulic press with a 20-100 tonne capacity improved the production quality to new standards, and improved the OHS by using loft drying instead of smoky wood drying.

Some major changes in new innovative technologies were applied under the "leapfrog" approach (Dewar and Dutton 1986; Perkins 2003; Soete 1985). The couching transfer curve proved an instant success. A double couching transfer curve was made in the village using donated parts, the author's tools and equipment. The new smoothing process combined the new surface technology with chemical trade secrets to create a new high quality smooth paper for the printing industry. This was followed by an example of giving them new hydro-pulping equipment, 'turnkey' equipment and technology approaches (Efstathiades 2000) and just turning it on to work. This improved pulp quality which flowed on to developing their skills to the next level to help them master thinner, smoother, more consistent quality paper for a new market niche.

They were then ready for vertical TT approaches based on a new of line of business opportunities and licences to make books, poetry and school books (Gorg and Stobl 2002; Kugler 2006; Sjoholm 1999). The local primary school came on board, with the Headmaster taking an active interest (Manumanunitoga 2007,8). A picture at his school shows the books and teachers involved (Figure 5.4.4hi). Some books were then translated and trialled in the latter half of 2008 and 2009. This was monitored by the education department curriculum development unit in Fiji (Figure 5.4.4m). They can now introduce the books to different school levels and continue the foundations of the project. This is a longer term TT process and may need evaluating in a few years. This was extra to the project but may become a major holistic bonus for them as their precious ancestral history is now being recorded and published on paper made in the village, In future, books may be printed and bound in the village. If this is what one village at the end of the interior road can do, then there is hope for many other villages.

For the last phase of the Horizontal TT of the new papermaking system to the next village (Raunch 2003; Rajan *et al*. 1981) was important to empower them with skills, improvements and ownership to help them to train and make the technology. This was helped by other departments like USP Engineering which made the specialised hydropulping and pressing equipment and ran the training schemes to train new villages in smooth papermaking. Thanks to Ms Lia Maka and her team, they are now empowered to control making the equipment and teaching the new technology skills to their own people (Figures 5.5.2b-e).

This was done with a holistic view of many other models like the ‘Six Steps’ (Kearns *et al.* 2005; Hull *et al.* 2007; Prakhya and Hull 2006) and the ‘Systems Approaches’ by Fleissner (1983) and the holistic approach of the “Third Generation’ of TT (Halls 2007; Hay 2003; Hecht 1999). This was dominated by third generation perspectives.

It was trialled under the mandate of the ESCAP (2006) ‘program of action’ and an ‘action hands on pilot plant’ case study (ESCAP 2006-7; Findlay 1978; Rajan *et al*.1981; Spencer and Woroniak 1967) and ‘technical action research’ (Grundy 1982) of TT using papermaking as the means to test the model in a least developed country urban village versus an Australian urban village. More than that, it was a real village with an important agenda to help them improve their basic papermaking craft project into pioneering a super smooth quality paper production system that could soon lead the UDCs in technology.

The project was successful for TT but the ‘political coup’ has since crippled the country and hampered the good work of the project. For the year 2007, the production dropped by 75% (Naivakaucu 2007). The weak link seems to be that the remote village was totally dependent on one company (Pure Fiji) who buy their paper to the exclusion of others. Thus they feel they cannot sell the same paper to other companies. ‘Pure Fiji’ however uses many forms of packaging with the paper being but a small percentage of their business packaging. This will force the WHMP Village to re-strategize their marketing plan and make other paper products for other markets while keeping the 'Pure Fiji' company happy. This project offers them another way forward, to be independent of Pure Fiji ('one market') and limitations imposed by it. This offers them more products to sell, to Pure Fiji if they wish to be involved, and thus capitalise on the foundations they have made for the village. However it will be slowly implemented and more successful as the country returns to democracy. By such time there may be more training funds to rejuvenate the project and help them make paper, value add into books for schools, publishing poems, and stories to enrich their culture and education.

The pilot project began to test and shape a 5 Phase model of TT (Table 4.7). The model could then be further tested and refined with the Australian example.

Table 5.6: Summary of Phases and Lessons Learnt.

Phase		**Learning**	**Outcomes**
0	Foundation	Skills of villagers Facilities	Craft Papermaking for several years; Existing papermaking facility built; Support by some International help; Only one unique Village of skilled papermakers in Fiji.
1	Small Steps	Small changes in equipment and skills	Range of small changes in equipment and skills.
2	Bigger Steps	Bigger changes in equipment and skills	Range of bigger changes in equipment with industry help.
3	Leapfrog Steps	Leapfrog changes in equipment and skills	Some radical changes with industry and university help. Important hydropulping and pressing equipment co-designed and made in Fiji.
4	Vertical TT	Value adding and making new products	Small range of value adding skills into story books and paper products. Including local cultural stories.
5	Horizontal TT	Transferring to the next village.	Much interest: NGO and government organised training for women and many villages.

5.7. Bridgewater Lifestlye Village Case Study

5.7.1. Foundation

A parallel case study was conducted at the Bridgewater National Lifestyle Village (BWLV) in the coastal suburb of Erskine, 5km south of Mandurah, 100km south of Perth, Western Australia. A complete analysis is presented in a 206 page separate report (Westerlund 2012) and then critically compared to Fiji in Chapter 6 of this thesis.

After planning with the owners and managers over a few years, it was decided to build an arts centre to incorporate the paper making at the new venue. Within the range of National Lifestyle Village projects in WA, the new Erskine, Mandurah site, Bridgewater Lifestyle Village was chosen. The management, at that time, had a passion and a commitment to help create a positive, holistic, creative lifestyle for their villagers.

The author then went to the next level of visiting the village on five occasions during the first year and met some Bridgewater lifestylers and received a list of people interested in making paper. The author had a display, including background on the project and examples of paper, books, poems, and art (Figure 6.2.2a of Westerlund 2012) at the opening ceremony in September 2007. It was a good chance to meet more lifestylers and the interested lifestylers could see first hand the potential range of paper products and ideas in an informal environment. Some expressions of interest included wanting to make the equipment, make the paper, printing qualities and some stories to be published.

The technology was based on the existing LHMP process on display and undergoing research at Murdoch University Environmental Technology Centre and ongoing research from the Fiji experiences. This created an opportunity to establish and pioneer a range of new equipment for the new cottage industry group. A purpose built craft room was designed and built over a few years at Bridgewater. The papermaking room allocated was about 15sqm, with access through a large double sliding door to the outside, an internal normal door to the arts centre, standard 240V power, standard high pressure water (hot/cold), good lighting, a central ceiling fan for lifestylers and drying of paper, cupboards for storage and all within a craft designed building (Figures 6.2.2bcd in Westerlund 2012). The design was developed over two years with consultation from the author to encourage an open design with good access to water, power and drainage with some modifications for a larger sink and more taps. The building was supposed to be ready for October 2006 but was not finished until September 2007, just after the official opening of the whole complex in August 2007. There were further delays as the building needed Shire approval before the lifestylers could use it. This took another month or more. The first craft paper was made in October 2007 by the author while testing the equipment, then paper was made with the lifestylers in November 2007.

There were many layers to go through in dealing with the BWLV before a handmade sheet of paper was made. From meetings with the managers, to designing the arts centre, to building the arts centre, to networking with the lifestylers, to starting to make the equipment, to finally starting to make the paper and teaching the artisan skills of papermaking.

The legal side of sponsorship was sorted out over two years. This involved several visits to meet with the management team, putting forward some structured guidelines, discussing the design parameters of the arts centre to complement the papermaking needs, discussing funding requirements and limitations.

The next part was the building of the ‘arts centre’, which took another year. The building was co-designed with the help of the author to include craft papermaking features. The building was inspected a few times during construction and minor improvements made to optimise the papermaking functionality. This involved adding extra splash tiles around the border of the walls, adding extra taps above the sink to allow for special screw on fittings and easy to use big handles to control the water pressure, and changing the sink size to be bigger for the moulds and deckles to be cleaned.

The next part was making the equipment to new designs, concurrently over a year, and then working with the BWLV Lifestylers to make the paper, concurrently over the year 2008.

There were a few teething problems as the builder put in a flat floor instead of a sloping floor with a large 100mm central drain hole. The author met with the builder and on-site manager in August 2007, to correct the final phases and ensure the plumbing was improved , the extra taps installed, the power points lifted from splashing and tiles installed around the edges of the floor.

The author began meeting with the village men as they were settling into their new handyman shed in July−September 2007. This allowed a bit of time to get to know them and work out a strategy with which to proceed. The head of the team was duly appointed to help delegate interested persons with suitable skills to help with each facet of the equipment making. Several men assisted to make the equipment, providing some good fun bonding sessions (Figures 6.2.2fg in Westerlund 2012).

The author began informal workshops in October and November 2007 until it was decided the floor was still unsuitable for drainage and to let the BWLV team have a few months to fix the problem. In March of 2008 the workshops continued. The floor was left as it was and decisions were made to work around it, push the water into the drain and use more rubber floor mats. Some residents did not wish to use the opportunity to learn to make paper until the floor was safe. This created an impasse with management. The workshops went on informally as momentum was slowly created.

The Bridgewater site was chosen as the preferred first site of the BWLV. Once this was viable it was thought that other ‘lifestyle villages’ would follow with a semi-mobile papermaking facility. This meant that new designs would be needed to make the project mobile and usable by other NLV Lifestylers in the future. A space was allocated in the craft building and over 2 years it was duly built.

This meant the new hardware/equipment could be made from the start using the help of the lifestylers. The team leader pinpointed people in workshops to assist in making the equipment. Several women volunteered to help make the couching cottons so that they would be ready for the start of producing paper. The foundation plan was starting to come together ready for the papermaking part.

Papermaking is the base of many other craft activities. They could soon become expert enough to make a high quality craft paper for their own particular activity. The lifestlyers could share the hard work of learning everything about papermaking and make some paper using the collective skill of others to get them started. They could then use the paper to proceed with their own particular craft pleasure. Thus the Foundation phase extended over several years and, in the urban setting, was part of the planning and building of the lifestyle village itself.

5.7.2. Phase 1: Small Steps

The same method as Fiji, of simple small steps in TT was followed at BWLV's. Four systems were trialled.

(1) Using free post-industry waste cotton proved a fantastic opportunity to progressively push the percentage boundaries to create a more archival-cotton based art paper to 30% cotton, 65% waste paper and 5% flower and fibre features.

(2) The ladies helped teach the author to use the sewing machines and overlockers better and push the limits of making couching cloth to the next level. This was good to make a higher quality consistent couching cloth with less margins of error and much more professional when up-scaling the operation to 1000's of sheets per batch.

(3) The men helped with the cotton insert rods and likewise a new higher standard of consistent product was made using the more modern facilities at the men's shed.

(4) An improved stacking system was designed, made, and trialled to align each cotton couching sheet using the wooded rod inserts into a standard high production stacking and alignment system. In summary, several important small steps were made in improving the existing LHMP technology while encouraging and embracing the tacit skills, modern machinery and network system of the BWLV.

5.7.3. Phase 2: Bigger Steps

The same method as Fiji, of bigger steps in TT was followed at BWLV. Four improved pieces of equipment were redesigned, made and trialled, including: the vat, moulds and deckles, paper-press and drying.

(1) The vat 'looks the part', being professionally designed and made, and beautifully artistic for the BWLV lifestylers to use. The 'vat' is the heart of the birthplace of paper making and needs to look and feel critical to the process, the art and science of papermaking. The author's design process took the process to the next level of the 'copy it exactly' approach. It can now be taken to the next 'copy it exactly' level, like the hydropulper by being made in plastic at the company called 'Fusion Plastics'. Research time is expensive and this project has allowed ideas to be trialled and tested so that the next levels of paying for an industry partner to make a plastic prototype would be considerably less expensive. From a quote of $1500 for industry to design and make one from plastic, a wooden vat was made for under $200 in components. The design could now be reverse engineered to be made industrially. The ideal could then be adjusted to their standard plastic sheet size and the vat made from only one 8x4 foot sheet of 10mm plastic. The other advantage of plastic is that the offcuts are all standard widths that can be plastic welded into the shape and make a stronger, more water-proof vat. Smaller offcuts can be welded on as support strips and braces to help further reinforce the Vat. White HDPP is more expensive than black but white looks clean, is more appealing and easier to see where it is dirty for cleaning. The benefits of white outweigh the cheaper black finish. Several pictures help understand the achievements of the new vat (Figures 6.2.4.1a-p, Westerlund 2012).

(2) The craftsmen at the vat use the special moulds and deckles six times every minute to create a piece of paper which then rolls onto the new cotton couching cloth material.

The new design is critical to the new quality and high production parameters of craft papermaking while still being user friendly to the retirees. The same intense production system can make three hundred sheets of paper per hour per 5 craftpersons or a few special ones for the BWLV lifestylers. The frames need to be strong and rigid and flexible to withstand the intensity of use and abuse in craft papermaking (Figures 6.2.4.2a-g, Westerlund 2012). The new design exceeds the design guidelines and in an artisan's hands makes a supreme quality pulp layer ready for pressing and drying into paper. The BWLV lifestylers simply make the frames up and start using them, but it will take months for them to become artisans, appreciating the beauty and simplicity of the LAM design.

(3) A new press was designed and made with industry and BWLV help. In the papermaking process the pressure forces the water out of the pulp and through the cotton support sheet by a hydraulic pressure gradient. If the BWLV lifestylers press too quickly, it will destroy each sheet or up to one or two hundred in the pile and waste a day's work. The skill is in building up the pressure gradient slowly and gently letting the water escape and drip away. Many others have had a go at trying to press the paper (Figures 6.2.4.3i-j-k). One simple method is to only press as quickly as the paper is dripping water. If it starts running, the water is escaping too quickly. A lady is better at doing this process slowly and patiently because men tend to press too quickly and prove their strength without realising that it is a bad practice. Many BWLV lifestylers tried the new technology. It takes an hour to slowly build up the pressure and leave the paper to chemically set. As the water percentage lowers, the hydrogen bonding starts to increase and the chemicals start to react, and the fibrillated fibres interlock. With time, pressure, chemistry and heat the reaction creates a beautiful new smooth texture to the paper (Figures 6.2.4.3a-k, Westerlund 2012).

(4) Loft drying was developed and trialled in the studio. Drying is critical to complete the paper reactions to form high quality paper. If it dries too quickly the outside dries first and the inner is still wet and forces the paper to warp inward. If it dries too slowly it warps outwards. The new way of making paper with a smooth backing, to create the smooth side, forces more critical emphasis on controlling the drying.

5.7.4. Phase 3: Radical Steps

The same method of radical steps in TT was followed at BWLV. Three improved pieces of equipment were redesigned, made and trialled, including the transfer curve, the smoothing technology, and the turnkey approach.

(1) The new transfer curve was easy to make in Australia. The components were easy to buy at the hardware store, for wood and foam, and the cover came from a furniture making supplies shop. The design was from LHMP which has leapfrogged the normal flat couching system of traditional papermaking. The BWLV lifestylers can easily use the design and make a new couching system with it in the workshop (Figures 6.3.2.1ab, Westerlund 2012).

(2) Once again the use of the leapfrog technology of the smoothing system for the BWLV lifestylers was easy to initiate. The years of research were easy to adopt and use. This revolutionises traditional rough handmade paper into a smooth textured paper. This creates an opportunity for the BWLV lifestylers to then value add into printing, poems and publishing papers (Figure 6.3.2.2a, Westerlund 2012).

(3) The ‘Turnkey’ approach to making a hydropulper was a tremendous part of the project. The manager of leading Perth plastics engineering company, Fusion Plastics was approached to help design and make a new hydropulper using the design features of

the LHMP systems. Mr Chris Hind came to the ETC to see first hand the existing hydropulper design in a working environment. He initiated some designs and we had discussions over several months in 2006 to refine and improve the design using the latest best available plastic engineering technology in Australia. The design was costed and approved by Murdoch University Project supervisors, giving permission to start in early 2007. The hydropulping unit then took two months to make with numerous design challenges as we went along, incorporating the upgrades/ refinements. The unit was then trialled for a few months at ETC. The hydropuler design and use is a critical factor in the success of the project (Figures 6.3.3.3.a-m, Westerlund 2102).

5.7.5. Phase 4: Vertical Steps

The author trialled publishing of specialty hand made books over a decade and had to develop and learn how best to make quality paper for printers, trial several printers, use ISBN numbers and publishing skills to transfer these to the clients. This proved an enormous challenge and lots of memorable stories are explained in Chapter 6.4 of Westerlund 2012.

5.7.6. Phase 5: Horizontal Steps

The hardware and software skills of papermaking can be transferred in workshops over many months in an easy slow evolution of sharing the papermaking technology. Serious lifestylers would only need to spend a few weeks at Bridgewater (BWLV) papermaking studio to gain a lot of basic new technology and skills to start their own workshop. It takes months, years, decades to become a master papermaking artisan but the beauty and simplicity of this novel example of TT allows the BWLV lifestylers to quickly make a high quality paper and value add into their own needs of art paper, writing paper or quality photocopier paper for their books and poems. The groups can make parts of the technology hardware and some will master the software tacit skills of paper making and some will use the finished paper grades.

5.7.7. Summary

The BWLV lifestylers have learnt a new advanced papermaking craft technology use the 5 phase model of TT (ie. small steps; bigger steps; with jumps and leaps in technology, with advanced turnkey equipment and vertical skills of value adding for books and publications). In time, they will be empowered to own, adapt and transfer the range of technologies to others and other villages. The BWL Village is a strong collective of skilled individuals with time, money, and the opportunity in their retirement to learn a new advanced papermaking craft and value add into a range of paper, art, cards, invitations, certificates, poems, books and memoirs to enrich their lives.

CHAPTER 6: DISCUSSION

6.1. Comparing the 2 villages

6.1.1 Introduction

This Chapter compares and contrasts the two villages researched. The two villages are quite different, reflecting a wide range of facets of TT that can be explored and discussed. Some of the many aspects are craft, employment opportunities, empowering village women, making the equipment, adapting the most appropriate technologies, and creating a helix of support with industry, government, NGO's and university.

The thesis research explored many pathways to transfer environmentally friendly and sustainable holistic TT processes to less developed countries and to developed countries while using the best available appropriate technologies. The focus is on the cornerstones of economic viability, sustainability and suitability to cultural values. A structure was imposed on the TT to understand and assess each of the five phases in a more rational and logical process, allocating points and values to sub-parts of each phase on an equal basis.

This chapter will compare the TT generic model in the two case studies of each of the five phases as follows:

Phase 1: Small Steps;

Phase 2: Larger Steps Focusing On Hardware;

Phase 3: Process Software Skills Focussing On Software;

Phase 4: Vertical TT;

Phase 5: Horizontal TT; and further extrapolated for starting the research into

Future Phase 6: Marketing.

The survey, in Chapter 7, will be used to further compare the process for each of the Phases of TT.

6.1.2. Discussion of Phase 1: Small Steps in Technology Transfer

Both the developing country village, WPMV and Australian lifestyle village BWLV responded well to beginning with small steps in TT. A distinct difference between the two was the difficulty or ease of availability, the quality of tools, materials and equipment and the skill sets of the respective villagers.

In comparing the WPMV to the BWLV, the WPMV men and women who helped make the small steps in TT had restricted access to skills and tools of trade. The carpenter had no saw, the welder had no welder, although the electrician had some tools. The author had to augment the process by bringing in a range of woodwork and metalwork tools and a welder to ensure the project went ahead. Some tools were left in the village to help them fix and service the equipment. To put things into perspective, a carpenter in the WPMV deals with elementary wooden fabrication with only minimal skills and equipment like a saw, a hammer, and a chisel.

The BWLV men and women already had a range of skills with their own tools and equipment, plus the community group equipment. The men proudly brought out their latest tools and gadgets to create a high quality piece of crafted papermaking equipment. The collective group had a well decked out workshop to make almost any piece of low to medium level technology equipment.

The support hardware in the village was ‘non-existent’ – a one day return trip away, to Suva city and a range of small hardware stores, compared to BWLV, where it was just 5 minutes down the road to the first ‘Mitre 10’ hardware or 10 minutes to a range of ‘Bunnings’ warehouses and specialised hardware and tools stores in the city of Mandurah.

The WPMV had no regular day power, just a few (3) hours at night or a portable diesel generator during the day. The BWLV had full 24 hour use of power and many convenient power points in a professionally decked out workshop.

The BWLV women had a range of late model sewing machines and overlockers compared to one straight stitch and 2 treadle village machines, and even then the author had to buy some needles and cotton from Suva for the WPMV.

It was very difficult to make the simplest of equipment in the WPMV. The author had to bring all his own tools and bits and pieces to ensure success. The BWLV men had their extra own special tools that could also be used if needed in their own little sheds in the lifestyle village.

Given tools and 240V power, we managed to start making a range of equipment in the WPMV. By working with some champions and leaving them the extra tools to enable them to continue making and fixing the new equipment empowered them to continue the project.

For software skills, both groups appreciated small steps in learning new techniques until they were confident and happy in practicing the new skills. To begin by making and using a basic raw paper pulp, couching cottons, the wooden rods and the simple wooden framed stacking system guided them comfortably into making rough paper with this equipment. They were not afraid to embrace the new technologies. In summary, initial small steps in TT are very important for the group to more easily accept the technology and develop important new base skills before bigger steps are tried.

6.1.3. Discussion of Phase 2: Bigger Steps in Technology Transfer

As the WPMV and BWLV, moved onto the larger steps stage they experienced delays, but for quite different reasons, and the skills available to assist with equipment production in each village varied considerably. Health problems and the cultural aspect of the BWLV contrasted with skill shortages in the WPMV. The standard of equipment produced also varied considerably due to the cultural and economic circumstances of the respective villages.

The next phase, making larger steps in TT provided harder obstacles in WPMV versus BWLV. Cox *et al.* (2007) also experienced several training challenges and tried to use a training organisation. In order to avoid extended delays the Author had to make some parts of the equipment in his Suva home base where he had easy access to power and tools. With more time for the project more equipment could have been made in the village thus empowering them more but the author had to start cutting corners, get on and 'make it happen' to make the equipment and start transferring the more important skills of making paper.

Likewise in the BWLV project, the men's workshop was delayed in construction, then it was too close to Christmas and there were other excuses. The author had to complete some parts of the equipment himself at his Murdoch University equipment making laboratory, working with local industry for aluminium welding and fabrication, and at his home or after hours in the BWLV workshop, depending on help from whoever was around at the time. This caused more delays as the author tried to consult more and wait for the BWLV plumber and tradespeople to be available to help on specific parts of the equipment. Sometimes many pieces of equipment were being made at once in different stages waiting for the right help. At other times, helpers could do the easy parts while the author got the next hard part organised. The press needed a more specialised welder and his rig to more strongly reinforce the welds that had broken under trial. A local industry specialty aluminium welder was sought to help make a lighter press plate that the (older) lifestylers could lift more safely.

Sometimes the lifestylers had their own health problems of heart, diabetes, or operations on top of family commitments. As this was an over 45s lifestyle village the younger members were still working while the older members had more health issues. However, they still had the skills and we sat over many a cup of tea to discuss and improve the technology.

The vat was simplified for construction in Suva and BWLV using wood and components. The marine ply and pine were the same but the designs differed. The WPMV trialled a new innovative pull-toward-the-user system, while the BWLV trialled a new innovative side-to-side system that would be easier for semi-retirees to use. The Suva vat was further simplified and assembled by gluing and screwing. The BWLV vat was more elegant and sophisticated and constructed using tools in the modern workshop. An extra Vat base had adjustable legs and longer sides for easier use. The WPMV vat could be made more cheaply from one sheet of ply (versus 1.5 sheets) and sat on a free box to use. Ultimately the WPMV had an appropriate cheaper 'vat' to use in the village, suitable for purpose, while the BWLV had a fancy vat that served their more artistic style and allowed the author to pioneer some futuristic designs. These examples laid the foundations to progress to bigger steps in TT.

6.1.4. Discussion of Turnkey Approach in Phase 3: Leapfrog Steps in TT

Both village groups were limited in design skills, money, engineering skills, time and resources to make a very important machine like a hydropulper. The concept evolved to trial a modified turnkey example. Based on two decades of research, trial and error, the first LHP-I, succumbed to rust, motor burn outs, and faulty bearings. The second 1985 LHP(II) featured a 200 L recycled drum, a plastic recycled chemical liner, a side mounted single phase motor, a 20mm drive shaft, 2 standard bearings, a standard ‘A’pulley and a ‘cheap standard 8”saw blade. After years of use and trials, it was rebuilt to use for research at Murdoch University Environmental Technology Centre. When rebuilt in 1997, the rusted and heavily used inner parts show how important higher grade stainless steel and marine grade metals should be used. A lot of new engineering skills were developed over this time. The hydropulping machines were made by selecting small engineering companies near each of the international projects and were therefore comparable.

The WPMV first interim hydropulper (LHP-III) was successfully made near Suva city using local free and recycled parts with light industry help (see Figures 5.3.3.3abcdefgh). The WPMV next hydropulper (LHP-IV) was successfully made as a ‘turnkey’ example by students at the USP engineering department as a combined international university project (see Figures 5.3.3.4abcdefghi). The author re-designed and applied the technology, and used locally available parts of equipment and recycling principles to help make it in one week. A combined report on the process was published and presented at a conference (Westerlund L; Ho G; Anda M, Wood D and Koshy K: (2009)). The author then networked with the engineering section of the USP to help the University students make a hydropulper. A student book was published on their experiences of making a hydropulper as part of their Masters research (Dayal and Khan 2007). This proved successful over two years, but it was impractical to wait for two years, and this forced the Author to make one in a week. On the other hand, it is a long term project for the village and they now have the University involved in the longer term helix of support.

The BWLV hydropulper was made by industry partners, Fusion Plastics, in Bibra Lake, near Perth. This proved to be a very good sub-project where a higher technology machine was made to new standards of excellence using the latest available plastics engineering equipment and skilled operators. Their designer/manager Chris Hind helped discuss some important concepts (Figure 6.1.4ab). The use of the author's new and innovative designs and materials was also trialled for the LHP-V:

- The stylish white plastic was moulded by tradesmen to look clean and very professional for a craft project (Figure 6.1.4ab). They pushed the bending technology to the limit and made a 700mm diameter tube/drum. This encapsulated the inner drum and outer cover for the motor.
- The motor was cleverly hidden underneath and aligned with a special in-line 'love-joy' coupling system that ingeniously took out the vibration and transferred the electric power directly into the mixing bowl with only two standard bearings and a special water seal (Figure 6.1.4cd).
- The single phase electrical motor is ideally strong enough for direct drive, with mounting bolts onto 25mm plastic welded plates, at 20 degrees off centre (Figure 6.1.4e). It was cleverly welded with a FP127 model plastic welder (Figure 6.1.4f). It is protected under the 200L drum in a special extension of the drum. It can be fine tuned for alignment by the washers and bolts.
- The 'lovejoy coupling' also takes out any vibration and allows for quick, safe assembly and servicing (Figure 6.1.4g).

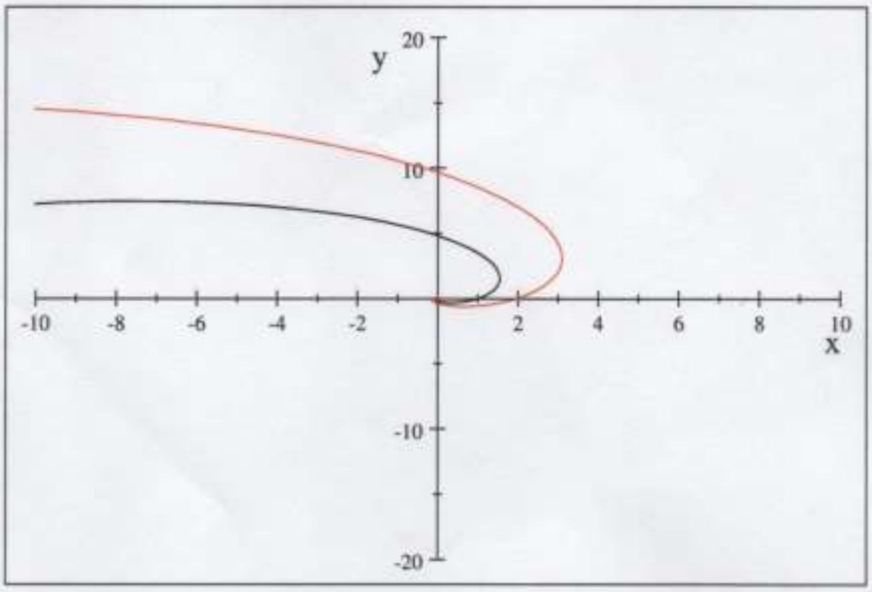
- A perspex inspection plate was cut into the side to aid visual inspection and to show off the motor and coupling to the BWLV lifestylers and staff, while also being a maintenance inspection hole (Figure 6.1.4g).

- The heavy duty 25mm base plate can just be seen, inside the drum, above this inspection plate, and it is at a special angle to allow optimal circulation of the pulp. It is designed to circulate and rise and fall back into the central chamber to achieve optimal cutting and dilution of fibres without blocking up with sticky pulp.

- The blade was a new reverse design made from highest grade stainless steel (marine grade 6), to prevent corrosion, and cut the waste paper and fibre into pulp more effectively (Figure 6.1.4h). The new novo design was based on analysis by a Mathematics Professor at Murdoch University.

Table 6.1.4: Blade Design transposed into a Mathematical formula (by Walter Bloom).

$(e^t \cos t, e^t \sin t)$, $(2e^t \cos t, 2e^t \sin t)$



The angle θ between the tangent and radius at any point on the spiral is constant (here, 45°). The a in $(ae^t \cos t, ae^t \sin t)$ is determined by the x−axis intercept. In general

$$(ae^{bt} \cos t, ae^{bt} \sin t)$$

gives the logarithmic spiral with

$$\tan\theta = \frac{1}{b}$$

and this determines the angle θ.

- At a practical level, the angle of the blade is always cutting and slicing at the cutting face at a critical angle (45^{o}) to optimise cutting. This also allows uncut cotton lint to keep being sliced along the blade and/or slide off. This stops the clogging of uncut fibres on the blade and saves hours of down time and contamination (Figure 6.1.4h).

- The electrical system had a triple safety feature to ensure it meets the highest safety standards (lower left in Figure 6.1.4a). The electrical box protects it from water splashes, the fuse protects it from power surges and the red knee cut off switch helps in emergencies. The top Perspex lid has its own cut off switch (top left in Figure 6.1.4a)..

There were many critical new research parameters explored in making the BWLV hydropulper. The finished hydropulper product could be useful for other product uses like pulping grapes or fruit for wines. New design and systems were developed that would make future hydropulpers even better, faster and cheaper.

The LHPs were delivered to each project respectively and ‘turned on’ to work. The WPMV LHP did not work at first due to the generator problem but it was soon ‘kick started’ to work. The BWLV LHP was fine tuned by the Author at ETC to work better, then transferred to the BWLV site at Mandurah. It worked perfectly there with no more need of changes. The WPMV LHP required a few changes and a rebuild with the help of the author and his tools, as well as a village electrician. On the positive side, this helped empower two local village electricians to fix and understand the technology while the author was in the village to directly help them. They only spoke Fijian and a few words of English but understood the electrical system (language). The BWLV life-stylers could just admire the good design and workmanship involved in their LHP. One life-styler was trained initially in servicing the LHP. It was also felt necessary to train a paid worker at BWLV. Each year it may necessary to visit to train someone to service it. Being close to Murdoch University allows the author to service it in the first year and the manufacturer could help service it in future years.

Both LHPs required post making adjustments by the author to improve the design to optimal working standards. These skills need to be documented and put into a training manual to ensure full transfer of technology skills (Supachayanont 2011). Perhaps this is a weakness of the process. The IP is still with the author and life-stylers will need to show a long term commitment to the understanding of the papermaking equipment and to the best ways to maintain peak operating performance. A year on, in November 2008, a new BWLV life-styler, showed interest in the hydropulper. He had worked in the Australian TAFE system and had made a range of equipment. It was good to discuss the important design features with someone who could appreciate designing and making equipment. This challenged the design principles further and subsequent improvements/ refinements were made. This also highlights the strength of the BWLV scenario as new retirees or life-stylers will continue to come into the village and rejuvenate the project.

The life-stylers want maintenance included as part of their lifestyle contract, as they have paid for the range of services and don't want the hassle of fixing the pool, the bowling green, the gardens, or the facilities. On that basis, it is better to also work with the staff who are paid to maintain the special lifestyle village. But the same problems occur with them, as they are paid to do a job, they do not have any first hand interest in papermaking. They might try to service the equipment each year or just leave it until it breaks down and then phone the author for help. It is hoped that some life-stylers and staff can work together and improve the equipment, and modify it to work better, and then make new equipment, and then empower the next BWLV to make their own range of better papermaking equipment.

6.1.5. Discussion of Smooth Paper in Phase 3: Leapfrog Steps in TT

In Comparing WPMV to BWLV, the WPMV loved the new smooth paper and the ease of making it. They seemed to treat it like new born babies and fuss over it during the making, pressing, drying and the delicate peeling of the paper. They were already paper artisans but the new smooth technology really inspired them to new horizons of paper making technology. The chief's grandson took an interest in printing the first book in the village that his wife (a primary school teacher) had helped translate. The children were fascinated to see the parents use the laptop computer and printer in the village to produce their first books. The value adding from rough to smooth opened up many new important opportunities for the village.

The BWLV life-stylers had a range of industry made smooth papers that could easily be bought at the local art shop or newsagent and were generally less impressed and less motivated. Some artisans were impressed and it encouraged them take on the new papermaking with the smooth technology. They were semi-retired and did not depend on papermaking for their livelihood or income, so it was a passing hobby for them. They liked the easy transfer curve and smooth technology and just accepted it. They were new to papermaking and new to the smooth handmade technology. They needed to be made aware of how problematic the rough, normal handmade paper is for printers and thus how superior the new technology was and that they were the first members of the general public to be offered this new craft technology.

Interestingly, this was revealed as late in the project as November 2009. A couple had returned from their Australian holiday and visited the Burnie paper mill in Tasmania where they had a tour and discovered how hard it was to upgrade the rougher, lower quality paper with limited end uses. This inspired her to appreciate and learn to make the new super-smooth paper and then lead the project for the village. This process of learning new equipment and processes of a craft activity takes time, and over the two years of setting it up, it was only in the last few months that they could start making paper for themselves and truly appreciate the better qualities of paper. Given time and networking with artists there is now a base with which to work.

One BWL lady with an outside art group, wants to make water colour paper with the BWLV group. This may involve inviting her group to visit BWLV and make paper with them. This can be seen as a good extension of the facility to the outside community to use and take advantage of. This will give it more community support and add honour and dignity to the making of a humble paper. Once some high profile artists get enthusiastic about the new paper's qualities, then the project will be seen as more successful. The BWLV already sponsor a major art exhibition each year and could sponsor prizes to use the new BWLV art paper. Then they could organise an inter-NLV art competition with the BWLV handmade paper. They could also organise some school art competitions using the special paper. They could have art and papermaking lessons for local schools at the paper studio. The base is now established for BWLV to take advantage of this opportunity and grow this project.

6.1.6. Discussion of Phases 1-2-3:'Copy it Exactly' Approach in TT

Comparison of WPMV and BWLV showed the ongoing need to keep improving the traditional skills with the 'copy it exactly' system, honouring those skills, building on them to improve skill levels and quality of output. Thus they move from 'rough card' to 'paper' to 'writing paper' to 'printing paper' to 'photocopy grade paper'. Obviously the WPMV were already papermakers, but they still needed specific tacit skills to use the new moulds and deckles, new vat, new transfer curve, new transfer couching cottons, new hydraulic press, new loft drying system and new dry press for smooth paper.

The BWLV life-stylers just learnt the new technique and accepted it as an easy system and then improved their techniques to make better and better paper. Some may be happy just making better paper more easily. It is that special wisdom of how to pulp the fibres, to add the chemicals, the temperature at which the chemicals react, the technique to scoop in and make a sheet, the new tacit technique to transfer the pulp onto the cotton couching surface.

This is followed by stacking and carefully pressing with 100 tonnes of pressure per square metre, then waiting for the smooth surface technology to work. When properly pressed, each damp and delicate sheet is carefully unpeeled then carefully hung out to dry. Each batch of 10-100-1000 sheets is then carefully tended to dry correctly, not too fast, not too slow, to 5-8% moisture content. This is sequentially followed by very carefully peeling each delicate sheet off the couching cloth, then dry stacking and pressing and if all is done perfectly they can end up with colour photocopy grade paper. The new super-smooth technology can then safely go through a modern printer.

Some life-stylers are already asking what about the inks? Are they safe or eco-friendly or recyclable? The ‘copy it exactly’ principle can be extended to continue the research and try alternative inks and chemicals to manufacture and maintain high quality paper and printing surface qualities. This is beyond the scope of this thesis but some artisans are already starting to pioneer this next frontier of papermaking.

Now the challenge for both is to keep developing their personal skills and techniques to make a better quality printer’s paper. This involves appropriate equipment, good paper fibres to recycle and an understanding of all levels of the manufacturing process.

The ‘copy it exactly’ approach has proved a good guide to document the inherent craft skills of the artisan so other not-so-skilled or motivated people can copy a working technique until they have the skills and years of training to become a master craftsmen themselves. The use of the new smooth paper for the printing industry will need to be followed up by some new handmade paper accreditation process.

6.1.7. Discussion of Phase 4: 'Vertical Technology Transfer'

The 'vertical models of TT' explored value adding the crude paper into standard A4 industry paper for printing and publishing in January 2007 and 2008. The initial aims of the project were exceeded as local traditional Fijian stories were translated by locals for the local primary school to help them acquire culturally sensitive and relevant books during 2007 and printed in January 2008.

This went further to network first with the headmaster and teachers of the local Wainimakutu School who wanted to independently trial the books in the school. Furthermore three books were then made and trialled with the help of one local teacher in the translation of one book, and three other teachers for another book. The project was also noticed by the education field support officer in January 2007 and then accepted by the curriculum development unit in Fiji, in February 2008, for them to trial it as a special project for 'conversational English' during the late term of 2008.

The BWLV group have no direct interest in making books for schools or culture. Their personal focus is on enjoying their retirement and lifestyle. Their books follow a similar vertical path of learning how to edit and write books of their memoirs or family stories or poems. With more free time and money they were able to make each book special for them and their family. They have more individual computer skills to do it themselves, with immediate family help, with the group help and support of BWLV writers' club, with the author's help or they can privately pay for IT help. The BWLV provide computers and online internet for the residents to use freely.

The contrast of WPMV with BWLV is highlighted in this Phase as they have different reasons for making paper, different skill levels, and different access to computers, printers and technology. The process would become very subjective and emotional as a remote village tries to struggle with creating basic employment in the village using a papermaking craft activity. The WPMV is a whole community and education is very important for their children. They will in time, appreciate the project more and extract more value from tribal stories written by local teachers and ranking local people that can be then translated into English, Bauan, and more importantly, their local dialects. The hope for BWLV is they will also generate new anthologies of their collective wisdom and pass them on to the next generations.

6.1.8. Discussion of Phase 5: 'Horizontal Technology Transfer'

The horizontal models of TT involved networking with an independent training provider to teach village women delegates from Fiji to come to the Suva city base to be taught first 'standard rough-surface papermaking' (August 2007) then the 'new smooth-surface technology papermaking' (August 2008). The first instructor was from the Wainimakutu Project and the second was trained in that village with both techniques and could then be the trainer in August 2008. This had the flow-on benefit of cost savings and saved using an expensive international consultant and the author. Combining the technologies proved more valuable and relevant to local needs to produce a quality photocopy grade paper with local fibre features and natural chemical sizing. This has done the author out of a job and empowered locals to use and teach the technology. They also researched new levels of eco-friendlier chemical research into sizing. A hybrid technology is now evolving using bits from both rough and smooth technologies with local fibre and chemicals from local plants. This could be considered the best objective assessment of the success of the project.

The BWLV life-stylers needed more time, a few years perhaps, to catch up to the existing Fijian craft enterprise. The BWLV have the capacity to quickly duplicate and transfer the technology and skills if there was a need in the communities for that craft activity. Unfortunately there appears to be too many more competing sport and other craft activities for the BWLVs.

From this case study, many other international groups also benefited from the ongoing research into the smooth papermaking process, technologies, hardware and software, as discussed next.

6.1.9. Discussion of Other Follow on Projects

Many other international groups also benefited from the ongoing research into the smooth papermaking process. The project was publicised on the www, with pictures of Fiji and BWLV and has overflowed with interest into other States of Australia, and countries of the world. This section will briefly highlight several areas of interest to reflect the range of flow-on ideas and activities.

The NLV group could also help by taking holidays in Fiji, spending a week in the village papermaking, or making or assembling new equipment.

NLV groups could adopt a new papermaking village and help make a range of equipment to start a new venture. One to three pallets of new equipment would need to be shipped to Fiji from Australia.

A full costing of a paper making pilot project has been done and is available.

Mr Norman Lassen (2008) emailed then phoned to discuss how to make a hydropulper for his TAFE classes. As fellow engineers we could discuss the finer points of the hydropulper design. He made one for his students to create pulp for artists to use in other media rather than for papermaking

Mr Ken Ibid (2008) emailed and phoned to discuss how to make a Hollander beater for his project. With help from some engineering friends and family he hoped to be able to make one for his project.

Ms Wong Yokemei (2008) emailed from the University of Malaya, Malaysia, to help the third year students design a hydropulper. They were looking at designing a hydropulper, headbox, conveyor system, heaters and systems to produce writing paper. The essence of the hydropulper and dilution ratios was discussed by email.

Mr Ronald Kyekanyi (2008) was concerned with the lack of papermaking technology available in Africa and was so impressed with the project's smooth paper he wanted to start a papermaking employment project for youth in Uganda. This would involve the local village and university in a major new project over a few years. His market research found that the local card for book covers was made from waste paper and was crudely made with an uneven texture. It sold for 0.20 (Euro) and was exported to surrounding developing countries. With free waste paper, and with labour at $2 per day ($Au), it would be a viable community power project. The town is twenty minutes from the city and within viable range. The base infrastructure to start the project is there with the village having good water and 240V power. This contact evolved to link in with the local university when delegates visited our IOBB conference in Fremantle in July 2008. They could see first hand the papermaking technology with a tour and demonstration at the ETC and thus start to appreciate more perspectives of the opportunity. Other research revealed another case study in the same village from a women's collective. The "Kigoowa Catholic Women's Development Association (KCWDA) has been empowered through group formation and aquaculture activities. This work also analyses the dynamic gender relations that exist in resource ownership, access and use in Uganda and the implications thereof for aquaculture growth and expansion. Included are the possible options for vulnerable people, especially women, to undertake to sustain their livelihoods and those of their families and the community as a whole" (Aganyira 2005). The fish project has been going for over fifty years and the community seem happy and positive to facilitate good sustainable TT aligned with the 'sustainable livelihoods framework'. Over the coming years, a papermaking craft employment/ training program could develop into a viable cottage craft enterprise.

A Western Australia group promoting international aid projects, met at an informal talk given on the 'holistic papermaking project' at the York Fayre in April 2008 and asked if a papermaking project could help create employment at the orphanage for girls she was supporting in South Africa. With sponsorship it could be developed into a viable cottage industry with flow-on training in papermaking, poems, stories and publications.

A Melbourne based Lions group expressed an interest in a papermaking project to help in redeveloping an East Timor community. They have the network and contacts to help make it happen and are waiting for the right and safe political climate.

A Melbourne University is already doing projects in New Guinea and are now considering to include a papermaking project as a viable community employment project. This would have the backing of the University and the several engineering students who already go to New Guinea each year to help.

A Peru contact wishes to set up a papermaking operation to help create craft employment in Peru. The low cost of labour and the desperate need for new employment creating initiatives could spur the project on. The government (which one??) is also launching a new initiative to work with English speaking developed countries to import appropriate technologies.

Thus several expressions of interest and support have evolved with the project. In time, with start up funding and community support, many countries of the world will have access to the new hardware and software technologies by the ‘creative commons’ approach of giving away the best available technology.

6.1.10. Summary

The following Table 6.10, compared the TT process in the two case studies and will highlight some key points:

Table 6.1.10: Summary of Parts of Phases for Fiji Vs Australian Village.

Phase	Example	Fiji	Australia
(0)	Foundation	Select Wainimakutu Village	Select Bridgewater Lifestyle Village
1	Small Steps	Very hard to make basic level technology equipment with limited tools in remote UDC village. Need new tools and basic workshop in village.	Very easy to make highest quality low technology equipment.
2-3	H/W	Impossible to make equipment with limited tools in remote UDC village. Need new tools, and advanced workshop in village.	Very easy to make highest quality medium technology equipment.
	Turnkey	**Industry** helped to make simplified, appropriate, fixable, BAT equipment for UDC. Need some special tools to service the machines in the village.	**Industry** helped to make highest BAT equipment for DC.
	Turnkey	**University** helped to make higher technology equipment. Now ongoing helix of support and new student projects to keep making new equipment with best available sustainable technology.	**University and Industry** helped to make highest technology equipment. Now ongoing Murdoch University and industry help needed to keep research going.
2-3	S/W	The **skills** of the village based craft persons were very good and very important to their employment. They need a certificate/diploma to now honour their craft skills.	Little interest was shown in learning the new **skills** to make high quality paper. Now ongoing TAFE support for art and papermaking **skills.**
4	Vertical (village)	**Limited skills in value adding** into books. Some teachers help translate. Desire to make many Fijian/English based school texts/books using local village stories/places/numbers/animals. Need the Curriculum development unit support from Suva to make a series of school books for each age range.	Some assorted interest in **value adding into art paper and craft**. Other groups like poets want to make special books from handmade paper. Now other ongoing interest to use the smooth paper for other artistic TAFE teaching, research and craft options.
	Vertical (Industry)	Important existing skills in value adding village paper into wrapping paper for an international cosmetic products; **New skills in quality smooth 150-200gsm paper for value adding** rough paper into smooth standard paper needs or books.	Printers are ready and able to make high quality range of paper, card, invitations, certificates, books and stationery.
5	Horizontal	Important local / regional **women's network to teach many villages**.	Very **good network to teach craft**: Limited interest to teach papermaking skills at NLVs.

The 5 Phases have become an important tool to understand and force some holistic sub-facets onto the transfer of technology. It is sometimes hard to differentiate the software and hardware components and to know when a small step becomes a bigger step or a leapfrog step, so there is some flexibility in the system to incorporate the concept of the process and allow each potential project to flex the boundaries and flow with the concept. The Five Phase model of TT is now tested in two regions and proved to be a valuable process to help in TT.

The Phases also proved to be a good structure to help evaluate the process. Building on this, the survey, will be used to further compare the process for each of those Phases of TT.

6.2. Analysis of the Technolgy Transfer Process

6.2.1. Introduction

This section describes the results of a survey that was undertaken in a separate project, at both the Fijian and Australian villages. It then goes on to look at the indicators of environmentally sustainable technologies using modified United Nations guidelines. A new model of TT is introduced in (6.2.5).

6.2.2. Wainimakutu Village Survey

6.2.2.1 Introduction

This section explains results for the Fijian village and references a separate report for more details. Westerlund,L.C. (2011) Report on a Technology Transfer Project to 'Wainimakutu Village, Fiji; Comparing with an Australian Lifestyle Village

The data concept is also presented in Appendix A. It is blurred to protect the names of villagers in the survey. The groupings of colours are blue for men and pink for ladies. Some groupings are Chiefly, administration, craftmen and women. The tallies are collated, sub totalled in yellow, and totalled for each Phase, for easy statistical analysis.

6.2.2.2 Results of the Wainimakutu Village Survey

The project pioneered an interesting use of the survey technique to try to quantify the TT process. Depending on which way the data is examined and what value is put on the process, the project could be judged to be successful or not. The critical parts of the process were empowering the village to make new equipment and use the new smoothing screening process. Where the transfer was not fully successful was in making the large steps in TT equipment. As this could not be achieved, the 'turnkey approach' was used to help make critical equipment in the nearest city to the village.

6.2.2.3. Summary for Wainimakutu Village

The project is comprised of several important Phases of TT. All are important for different reasons. The women would have to design, make and sew the cottons for couching, while mainly men with technical skills would be needed to make the wood and metal equipment, in order to get the low technology equipment ready for the papermaking. The higher technology equipment needs to be learnt, redesigned and made according to local conditions. This is beyond the scope of the village so local industry needs to help, as well as the local university. In time the governments would see the value in the project and could support it by doing collective workshops and facilitating training programs using the new technology.

The survey looked at it more objectively and put a value on each personal contribution. A village lady can sew some cotton couching sheets and learn the dextrous-tacit skills of papermaking to create a high quality new product. The industry can go on making other technologies and support R&D into the small scale papermaking equipment to be made locally. The university can take on designing and making the new hydropulper and press and develop ongoing student projects over many years to support the pioneering new craft industry.

The survey suggests a minimum of five people who know about each part of making or using the new technology: this equates to a 5:1 ratio is needed for low technology skills to be transferred and a minimum of 10:1 for higher technology skills. If ten persons can half learn the various skills, then collectively they have 5 people equivalent who know all the technology. Their individual skills may be in sewing, woodwork, metalwork, design, welding, electrical, machining and engineering to help make the many types of equipment but many women need good tacit skills to use the equipment to make a higher quality paper range of products. In this village, thirty women are now good at making the new paper and in time these skills will be transferred to the others in the village environment. If the survey was repeated in a year, then from 30 to up to eighty women may get top rankings for making quality paper. The real transfer of technology has occurred in the village and the support will then be seen in industry and university. It could be argued that industry and university research is needed more at the start of the project. Once established, the village is empowered to use the technology while industry help with maintenance and repair and the university continues to help design newer and better machines.

6.2.3. Environmental Indicators of Environmentally Sustainable Technologies

The results of the survey are tabulated in Table 6.2.3. It is based on a modified version of the template reference in IETC (2003). The left column is added and gives a ‘minimum’ or ‘maximum’ value on the ‘indicator’ to help align all the indicators to be valued to best benefit the holistic environment.

Thus minimum/maximum and five star rating were modified by the author to objectively quantify and indicate the best achievable outcome (Karakosta et al 2010). A minimum of pollution and a maximum of village employment is one example of each. Any quantities or comments can be included under Quantity (Qty). Some comments are simplified to be: not good ‘ng’; ‘g’=good; ‘vg’ = very good for sustainable transfer of technologies. Some percentages are included to help define quantifiable limits up to the ideal of 100%. The water potential could be 100% from the village rain water; or 100% recycled paper as the raw material. Some comments are included in (brackets). Some expanded indicators are repeated and each point allowed its own line for this case study. The special equipment has many recycled components and features, but only one for each will be featured as an example.

Table 6.2.3. Evaluating the transfer of recycled papermaking technology to a UDC using the modified 'five star environmental indicators of environmentally sustainable technologies' from IETC (2003). The star rating is based on how much the author analysed it benefits the best environmentally friendly and sustainable parameters.

	Environmental Indicators for ESTs.		
Min/max	**Criteria** /Indicators	**Comments**	**Rating**
	Technical Suitability		
max	address fundamental scientific and engineering principles	vg	*****
max	production or process yield	vg	*****
max	contaminant removal rates or treatment efficiency	small	*****
min	potential for generation of secondary pollutants or by products	small	*****
min	Noise (hydropulper noise for 15min/batch of 4kg)	some	*****
min	thermal lose or radiation emissions	none	*****
max	performance at different settings or locations	vg	*****
min	sensitivity to specific operating conditions (prefer dry weather)	g	****
max	reliability (for a remote village)	vg	*****
max	Replicability	vg	*****
min	potential for system failure	low	*****
min	profiling of risks and uncertainties	low	****
	Average rating		*****
Criteria	**Compliance with Regulations and STDs**		
max	Quality of waste generated: water: air: solids;	low	*****
max	quality of waste controlled by environmental permits	none	*****
max	compliance with local and regional standards	yes	*****
max	Compliance with MEAs (POPs; Biosafety; ISO) International STDs.	yes	*****
max	Availability of reliable data	yes	*****
max	Part of a third party assessment program (eco-labelling. ETV)	can be	*****
	Average rating		*****
Criteria	**Eco-Efficiency and Conservation Of Biodiversity**		
max	Useful life (in accordance with optimal performance specifications)	years	*****
max	Efficiency of energy, water and materials used	vg	*****
max	Lifestyle performance (GHD emissions throughout lifecycle)	vg	*****
max	Use of renewable resources	vg	*****
max	Incorporation of closed loop processes	vg	*****
max	Design for the environment	vg	*****
min	Cumulative air, water and waste emissions	low	*****

min	Impact on ecosystem health and integrity (biodiversity & ecological footprint)	vg	*****
	Average rating		*****
Criteria	**Protection of Water Resources**		
min	Water use	vg	*****
max	Conservation of water	vg	*****
	…can use and reuse tap water if needed	vg	*****
max	% of recycled water	vg	*****
	…village rain water	100%	*****
	…Murdoch university treated bore water	100%	*****
	…hydropulping water (can use bore water/rain water)	100%	*****
	…vat water from screening can be reused for pulping	90%	*****
	…transferring water can be collected and reused	50%	****
	…pressing water can be collected and reused if needed	70%	****
	…evaporation from drying	10%	***
min	Level of treatment (primary; secondary; tertiary)	Prim	*****
	…Murdoch University uses reverse osmosis experiment	100%	*****
	…village has fresh clean drinking quality rain water	100%	*****
max	Overall water efficiency	vg	*****
	Average rating		*****
Criteria	**Optimisation of Materials and Energy use**		
min	Use of fuels and energy resources (**equipment)**	min	*****
	…Hydropulper made from recycled 200 l drum	vg	*****
	…Hydropulper 240V s/ph motor reused from broken equip.	vg	*****
	…Vat made from recycled bath tub; or 1 sheet ply	vg	*****
	…Screens made from recycled aluminium moulding	vg	*****
	…Transfer curve made with reused trampoline mat	vg	*****
	…Stacking racks made from recycle wood	vg	*****
	…Drying racks made from recycled wood	vg	*****
	…Press made from recycled metal	vg	*****
	…Press boards cut from recycled plastic/acrylic	vg	*****
	…Couching clothes re-sewn from old cotton bed sheets	vg	*****
	…All equipment can be made/serviced in local workshop	vg	*****
min	Use of fuels and energy resources **(process)**	vg	*****
max	…use of solar energy to heat water for soaking paper	solar	*****
max	…use of solar heating of water for pulping	solar	*****
max	…use of air (loft) for drying paper/ fans/ time/ tin roof	radiant	*****
min	…use of 4HP diesel motor generator as required in village (15 minutes / 4 kg dry paper batch/ 200 litres pulp)	diesel	***

max	Quantity of renewable resources	99%	*****
min	Quantity of non-renewable resources	1%	****
max	% recycled and reused materials in the production process	99	*****
max	…waste paper post industry/ office/ home	100%	*****
max	…clay and particulates recycled from waste	100%	*****
max	…waste cotton linters	100%	*****
max	Use of environmentally friendly resources	100%	*****
max	…local made papermaking studio using village labour	100%	*****
max	… studio electrical wiring using village electrician	100%	*****
max	…local village grown fibres for raw material (5% of product)	100%	*****
max	…local village grown flowers (5% of product)	100%	*****
max	Use of locally sustainable resources		*****
max	…local river sand for cement work for building	30%	*****
max	…local village grown fibres for raw material	30%	*****
max	…local water supply	100%	*****
max	…local village grown flowers for features in paper	100%	*****
max	…local village grown flowers/crops for chemicals	95%	****
max	Duration of product life cycle	years	*****
max	…art paper (from cotton lint = archival)	years	*****
max	…books (from paper = acid buffered)	years	*****
max	Energy efficiency and savings	vg	*****
max	Overall efficiency of resources use	vg	*****
	Average rating		*****
Criteria	**Minimisation of Toxic Materials and Waste**		*****
min	Quantity of waste generated:	v.low	*****
min	…water: (200l/4kg dry paper; recycled or to garden)	garden	*****
min	...air; (none)	n/a	*****
min	…solids (to the garden or worm food)	5%	*****
min	Quantity of toxic and hazardous waste used /generated	none	*****
max	% of waste material used as raw materials for other industries (based on industrial ecology and CASE principles)	worms	*****
max	Quantity of by-product recovered	garden	*****
	…waste paper during manufacture is repulped	99%	*****
	…waste offcuts after manufacture are recyclable	99%	*****
	… waste flowered papers are recycled as flowery paper	99%	*****
	… ink colours are sorted and recycled as coloured paper	99%	*****
min	Cost of pollution control abatement technology	none	*****
min	Need for waste treatment and disposal	worms	*****
min	Ultimate disposal costs of unmarketable by-product and waste	nil	*****
min	Overall operations and maintenance costs (labour intensive)		****

	Average rating		*****
Criteria	**Protection of Terrestrial Resources** /Indicators		
min	Space required for construction (20-100 sq metres)	small	*****
min	Compatibility with intermediate or adjoining facilities or systems	vg	*****
min	Transportation and materials flow requirements (collect waste paper from Suva and local courier service is good)	vg	*****
min	Potential for soil contamination	n/a	*****
min	Potential for geomorphology, landscape and eco-hydrological impacts	n/a	*****
	Average rating		*****
Criteria	**Protection of the Atmosphere** /Indicators		
min	Air emissions (village use minimal local sustainable firewood to dry paper)	ok	**
min	Potential for long range transport of atmospheric air pollutants	small	*****
min	Potential for climate change impacts	helps	*****
	Average rating		****
	Selected Socio-Economic Indicators for ESTs.		
Criteria	**Financial Viability** /Indicators		
min	Capital investment (…designed to be high/low tech for village)	low	*****
max	…Capital investment…craft building built by villagers	vg	*****
max	…Capital investment…equipment built by villagers	vg	*****
max	…Capital investment…equipment built in local city	vg	*****
max	…Capital investment…equipment built in local university	research	*****
max	Return on investment…financial	low	*
max	Return on investment…social	high	*****
max	…Return on investment…AID Project	high	*****
min	Payback period…financial	1-5 yrs	*
max	Payback period…social	0-100 yrs	*****
max	…Payback period …AID Project (then help the next village)	vg	*****
	(depending if you want financial or social investment) Average rating		* or *****
	Operations and Maintenance Viability/Indicators		
min	Management and labour costs (employ women in village UDC)	$3/hr	*****
min	Expertise and skills requirement for operation (low for village)	vg	*****
min	Expertise and skills requirement for maintenance (need help)	Vill/city	*****
min	Utility costs (water)	free	*****
min	Utility costs (energy/electricity): (part of village scheme) … (portable generator is used as needed to run hydropulper)	low	****
min	Costs of other consumables (smoothing film)	low	****

min	Costs of pollution prevention and control	nil	*****
min	Costs of residuals management	nil	*****
min	Costs of solid waste disposal	nil	*****
min	Cost of environmental remediation and restoration	nil	*****
min	Cost of natural capital (free sustainable forest for village clan)	free	*****
min	Cost of environmental health and safety liability	free	*****
min	Frequency of maintenance (designed for low maintenance)	low	*****
min	Parts and service costs (designed using local parts and service)	low	****
max	Overall cost effectiveness (…labour intensive + some machines)	high	***
	Average rating		****
	Responsiveness to Local Need and Benefits		
max	Public acceptance (new papermaking Vs mat making/craft)	vg	****
max	…Public acceptance…in Wainimakutu Village	vg	*****
max	…Public acceptance…in Wainimakutu Village Primary School	vg	*****
max	…Public acceptance… in Wainimakutu Village High School	vg	****
max	…Public acceptance…town	g	***
max	…Public acceptance…city- Suva	g	***
max	…Public acceptance…Fiji (another craft activity)	g	***
max	…Public acceptance…village in the Pacific	g	***
max	…Public acceptance…village in a UDC with lower labour costs	vg	*****
min	Public health and safety risk	vg	*****
max	Social benefits	vg	*****
max	Cultural value	vg	*****
max	…Cultural value…locals stories printed on books (invaluable)	vvg	*****
max	…Cultural value…support a remote subsistence rural village	vg	*****
max	Employment (appropriate village employment)	vg	*****
max	…Employment (women in village)	vvg	*****
	…Employment (youth in village)	vvg	*****
	…Employment (men in village)	limited	**
max	Use of local resources	vg	*****
max	Capacity building requirement	vg	*****
max	…Capacity building…village	vg	****
max	…Capacity building…nearest city=Suva/industry/university	vg	****
	Average rating		****
	Perceived Scientific Quality of information supplied		
max	Reliability of data		****
max	…Reliability of data…Village		****
max	…Reliability of data…Village P School		****
max	…Reliability of data…Suva School Curriculum		****

max	…Reliability of data…Suva business		****
max	…Reliability of data…Suva / University		*****
max	…Reliability of data…Suva Printing Industry		*****
max	Reliability of data…Murdoch Uni Support (remote/ ph/ email/ time/ mail/ send parts/network/www)		*****
max	Existence of QA/QC program …(to be established)		****
	Available comparisons to existing systems…(first remote pilot plant based on established Australian craft project)		****
max	Transparency of data collecting and reporting (evolving)		***
max	Third party substantiation (evolving, with university support)		****
	(a few more years are needed to develop this) Average rating		****
Criteria	**Others Not Mentioned in ESDs: /**Indicators		
max	Eco-tourism (can now promote the village for Fiji tourism)	vg	*****
max	Transferable to the next village	vg	*****
max	Example of village craft project	vg	*****
max	Example of best available international craft technology	vg	*****
max	Example of micro finance project	vg	*****
max	Example of university/international AID project	vg	*****
max	Scientific support by www / emails/ ph/ publications	vg	*****
max	Scientific support and future research opportunities	vg	*****
max	Scientific support to pioneer 'best available technology'	vg	*****
	(added by Author for discussion) Average rating		*****

The modified United Nations list is now more comprehensive for several phases. By including the first column, it forces a positive evaluation of each criterion to gauge the maximum environmental holistic benefit. It could be streamlined to focus on 10, 20, or 50 key factors and multiplied by 10, or 5, or 2 respectively to get a standard percentage rating.

Under the use of fuels and energy resources, several extra criteria were added that were relevant to the project. This helps to explain how each piece of equipment can be deliberately redesigned to be made from locally available, recycled, free or standard components. Each piece of equipment could have included several points on recycling, appropriate design or features, but the point was made by one example of each piece of equipment. This could be expanded depending on the focus of the research.

For the use of energy, a deliberate decision was made to use solar hot water. For heating, the use of solar/ radiant heat off the tin roof to help the paper drying, could be made. The only questionable energy use was in using a portable generator for hydropulping. The new hydropulper was made to make the process several times more efficient. The village has since connected the studio to the village power grid that can then run for a few hours each night. By changing their work routine they could use the hydropulper at night and have the pulp ready for the next day and save using the portable generator. The village is also looking at a hydro-power scheme from the fresh abundant river water. This would create an eco-friendly source of power for the village.

The major low score is for 'return on investment'. If the project is evaluated for maximum return for investors to make a profit then it would fail. If the project is seen as a 'green project' or 'social project' or a 'women's employment project' then it would succeed. There are not many opportunities for women to work in their own village while also being available to cook, clean, garden, baby sit and perform their domestic duties.

The public perception is lower as papermaking is a new craft. It is similar to their traditional mat and tapa making and can be accepted as a complementary craft (Spicer and Me 2004). They are becoming more interested in education, reading and books so this complements their need to appreciate their beautiful culture and start recording it on paper/books. Three books were made by the author and translated into Fijian by locals as an important ongoing project. The books are now on trial in the schools and will be further translated by teachers for each student level.

The quality of information is still evolving. It takes years for a project to get started and slowly evolve to maturity. Meanwhile a few books have been written by the author on how to make the equipment and learn the processes. These text books are now in the USP library and in use by the training agencies. As they learn to make better paper, then the printing industry will improve the rating and use for printing. From writing paper, to offset machines, to multi-press machines, to photocopiers, to colour copiers. Art paper using cotton lint could also be made to archival standard. With the ongoing help of ETC at Murdoch University and USP, then more standards could be met in time.

Some other indicators were included to help discussion. Since 1982, eco-tourism has become an important new industry. The www and homepages can promote eco-friendly initiatives and generate income and business leads across the world. A homepage was included to promote the Wainimakutu Village in 2008. This has already led to some marketing leads to help sell paper from the village. The village can now help in pioneering the latest and best available technology research. This will empower them to be world leaders in new papermaking technology that is functional in a UDC environment.

The table of environmental indicators was useful and the Plans A, B, C, D can also be evaluated.

Plan A was to make equipment in the village. The low technology equipment could be made in the village by bringing in all the components and tools to make it. The village men were interested to help make the transfer curve, assemble the moulds and deckles, and make a wooden stake rack.

Plan B: was to network with business engineers that can redesign and build equipment for papermaking near the city of Suva, Fiji in January 2007. The use of locally available components was encouraged. The use of local engineering skills was acknowledged and worked with (Sharma 2006). The designs would be modified as the components became available and evolved with the project. The technology hardware was then delivered and trialled in the village with some further software training. A papermaking press was made with donated industry off-cuts of metal, a volunteer from the village to weld, and the principal author's help in Suva (Westerlund 2007b).

Plan C: was to network with the engineering section of the University of the South Pacific. The hydropulper was made as a 'sustainable turnkey approach' with the help of local industry and the University (Westerlund 2007a) and resulted in a paper being published (Westerlund *et al*. 2009). The students also submitted/published a Masters project on building the hydropulper (Dayal and Khan 2007).

Plan D: was to network with the national training providers to continue the project. This involved networking with a regional consultant, Mr Wilco Liebregts, who was familiar with the project in the village (Liebregts 1998); networking with the Director of PACE-SD, Professor Kanayathu Koshy; networking with the Head of Community Education Training Centre Human Development Programme, Ms Lia Maka, to start training other villages (Maka 2007-8); networking with Mr. Joe Bola, Director of the Centre for Appropriate Technology and Development (CATD) to start training his students in making the whole range of new papermaking technologies to continue the project (Bola 2006). In time it can be a very successful project to empower a UDC with the best and latest available craft technologies.

6.2.4. Summary of the Surveys

The survey showed the strength of the Wainimakutu Village to learn to make the new smooth papermaking technology while the supporting strength of the city to help by making specialised equipment, printing technology, university research and engineering support and finally marketing from successful industry partners.

The project was symbolically successful in both villages to pioneer the introduction of new levels of best available technology in Phases 1-5, while honouring tacit skills of craftsmanship and being sensitive of traditional culture. The project satisfied the three criteria: to be a sustainable, eco-friendly and economically viable handmade craft enterprise, by valuing the culture and traditional stories now printed on unique smooth handmade paper. These criteria were considered to be more important than the normal business ideals of profitability or 'return on investment'

The survey suggested that the contribution of industry and university is most significant in the first year of the transfer of technology. Subsequently the numbers of villagers using the technology increased along with their respective skills, while only a few industry people were needed to keep the equipment going and to continue the research.

After one year, since introducing the new smooth papermaking technology, the project was evaluated by the author and supervisors using the modified 'five star indicators of environmentally sustainable technologies' from IETC (2003) (refer to Table 6.2.3 and Summary Table 6.2.4).

Table 6.2.4. Summary of EST Survey from Table 6.2.3

Summary: Environmental Indicators for ESTs.	
Criteria /Indicators	Rating
Technical Suitability	
Compliance with Regulations and STDs	*****
Protection of Water Resources	*****
Optimisation of Materials and Energy use	*****
Minimisation of Toxic Materials and Waste	*****
Protection of Terrestrial Resources /Indicators	*****
Protection of the Atmosphere /Indicators	****
Selected Socio-Economic Indicators for ESTs.	
Financial Viability /Indicators	****
Others Not Mentioned in ESDs: /Indicators	*****

The international guidelines were adapted and improved to derive more meaningful data. The technique reinforced the results, with a 4 to 5 star rating - out of five - for the project. Therefore the TT process was evaluated and objectively judged to be successful for a UDC. In time the project should get a full 5 star rating and be a shining example of an eco-friendly recycling project for a UDC. The Achilles' heel of the project is helping the village to market and sell a value-added range of products on the international market. This is beyond the scope of this project and the political coup in 2006 severely crippled new industries in Fiji. Developing countries must have a stable economic and political base to help the transfer of long term TT projects. The support of international aid projects and church groups is also important in the long term success of transferring technologies to stable remote village communities.

At a practical level the project was successful for developing and trialling a new TT model using the 5 Phases and that can now be evaluated along United Nations guidelines. This template could be used for many other TT projects. The template could be refined to focus on 10 main topics and 2 subtopics. This could create a 20x5 point rating system to get 100 points or a percentage equivalent for easier international comparisons of success.

6.2.5. New Model of the Flow Chart

The flow charts 3.3a and 3.3b are justified in this project. They could do with a division line for hardware and software. This final generic model could be further presented as:

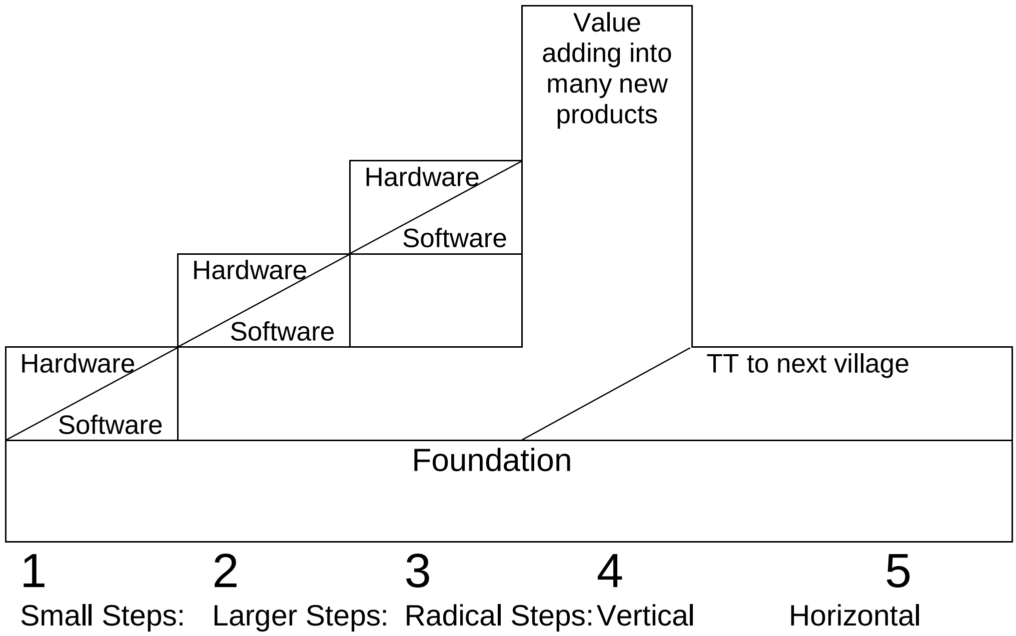


Figure 6.2.5: Flow chart of the 5 Phases of Technology Transfer:

The Figure 6.2.5 shows the progression from small steps-1 to bigger steps-2 to radical steps-3 to vertical-4 and then horizontal-5 technology transfer. It also acknowledges the hardware and software parts and the process of building on 1-2-3 before you can go up in 4 and across in 5. This is an evolving cyclic process of improvements. It is applicable to a single pilot project and there should be a cyclic loop of ongoing advances in technology transfer to help UDCs. For Fiji, there is a village (matagali) approach that may need to be developed to understand the importance of each village-matagali and a cluster of projects to flow on and help each village and region.

6.3. Results of Engineering Improvements to Hardware

6.3.1. Introduction

The design and engineering of all craft papermaking equipment was re-evaluated to produce the best available technology subject to being able to make or assemble it in the village with local industry and local university engineering help.

6.3.2. Engineering Improvements to each piece of Equipment

A summary of the engineering improvements made during the project is presented in Table 6.3.2 and explained below.

Table 6.3.2: Hardware Made in Each Phase to Achieve the Highest Quality Craft Handmade Smooth Paper for Photocopiers and Printers (From Table 4.1c).

Phase	Equipment/ Process	Code (Ref)	Village	HW/ SW	Industry University
1	Couching Cottons	LCC	$make	HW-SW	
	Stacking	LSR	$make	HW-SW	
	Bench		$make	HW	
2	Vat	Vat	$make	HW-SW	
	Alum Mould /D	LAM	$make/T	HW-SW	Industry
	Press	LPP	$make	HW-SW	Industry University
	Drying		change	SW	
3	Transfer Curve	LTC	$make	HW-SW	
	Smoothing	LSS	Free$ +Lic	SW	
	Hydropulper	LHP	Donated University	HW-SW	Industry University

The new smooth papermaking process is a combination of another decade of PhD research to perfect the science and art of a new high level hand made recycled A3plus paper that can be cut into 2 x A4 standard sheets, now being trialled for higher grade printer paper and photocopier paper.

Mould and Deckle (LAM)

The new mould and deckle, LAM, is made from standard Australian and now New Zealand moulded aluminium (so it does not warp or rust or mould) and inserted with a higher strength mesh to make a more level layer of fine 2-3mm pulp. This helps create consistent 150-200 gsm paper for the photocopier. This minimises blockages and downtime in printing runs and build up the confidence of printers to use the paper. The village can access free / donated offcuts of mouldings and maybe make one for $50. An Australian glass window framer can make luxury modules for $500.

Vat (L'Vat)

The new L-Vat is specially made from one sheet of marine quality board with special angles of entry to ensure a novice can make a perfect sheet of pulpy-paper the first time. It also helps control the pulp volume and concentration to maintain a critical range for printers paper from 150-200gsm. The concentration can be controlled, for example, a refill of 2000ml will make a 200gsm paper. This allows a novice to simply add a 2 litre scoop of pre-made pulp each time to ensure 200 gsm paper. A village can afford 1 sheet of 8x4 foot standard marine ply (less that $100) 8mm thick to make one vat in the village using basic carpentering skills. An expensive white HDPE 12 mm thick plastic L'Vat can also be made for $1500.

Hydropulper (LHP)

The new L'Hydro-Pulper (LHP) is a 200 litre (recycled plastic) drum with a special L'Pulping Blade (LPB) and water seal and standard bearings, on a 20mm stainless steel special threaded shaft, with safety electrical switches designed to chop paper into 1-2mm pulp.

The Fiji University Engineering Dept has now the design and engineering skills to help make a BAT L'Vat. The cost factor came down to many donations and some bought parts. The time factor took a year to make it as a student project.

The local Fiji industry partners can also make a suitable BAT LHP. A hydropulper was constructed in one week and was working in the village the next week.

In Australia, the design and manufacture of the highest quality, best available technology LHP, cost $10,000. This hydropulper features 8 to 20 mm white HDPE plastic, wrapped around a 700 mm radius drum, with internal single phase motor, love-joy direct drive coupling, standard bearings, special water seal bearings, special drive shaft and special blades. The new L'Pulping Blade (LPB) is a marine grade 6, stainless steel blade with a reverse designed and special cut angle to slice through the toughest pulp. The special angle was derived from a mathematical analysis.

Cotton Couching Sheets (LCC)

The new L'Couching Clothes (LCC) are made from cotton with a special insert of 10mm dowel, and sewn to a special size (650x450mm) for the stacking system +- 5mm. Different textures can be used to create special effects on the surface of the paper, A table cloth will emboss the flowers of the design under 100 tonnes of pressure. Cloth can be recycled from hotel industry linen waste. New cloth can be less than $1 per sq metre on special roll off-cuts. The new streamlined size and rod make it quicker and easier to use in maintaining higher quality consistent paper.

Stacking Rack System (LSR)

The new L'Stacking Rack system (LSR) is a guided stack rack, for 5 LCSs; with 600x400mm boards for easy removal and entry into the press. In the village it can be made by a local carpenter from a few lengths of 2x1 inch dressed pine ($10 of wood). In Australia, modules could be made and ready for assembly in a remote village ($300 per module).

Paper Press (LPP)

The new L'Paper Press (LPP) is a modified bench press with a 600x400mm thick base plate for transferring 100 tonnes per square metre of critically even pressure over the newly forming pulp into paper. It is stacked with layers of the board and 5 LCCs and 5 LSS and up to 20 sets =100 sheets of A3 paper. A cheaper UDC village press was made from metal off-cuts, welded together, and a 20 tonne press fitted. The total cost was less than $100. A similar bench press can be bought as a standard press in a Suva hardware store for $2000, and modified to suit. An Australian higher technology press could be made for $5000.

Smoothing Technology: (LSS)

The L' Super Smoothee (LSS) technology is a specially coated film that is inserted into the pressing process to create a unique smooth side to one side of the paper under controlled temperature, pressure and drying time conditions. This is one critical component for making the best, most consistent printers paper. This can now also be used for colour photocopier paper. Each unit cost about $1 AU, plus a special coating process that is done only by the author. This IP needs to be protected and shared to UDCs under license of the creative commons.

Software and Science Skills

The software skills are the tradespeople's skills in making the equipment; the artisans' skills in papermaking; the scientific skills to improve the process; the design engineering skills to improve the equipment; the chemistry skills of controlling the papermaking; the physics skills of pressing the paper; and the evolving cyclic process of refining technology to keep testing and improving each aspect over time and decades.

6.3.3. Conclusion

This project has allowed the author to continue testing and pioneering the best available technology to make a superior quality craft paper for artisans. The hardware can at one extreme be simply made or assembled at the remote UDC village, and made with local industry or university engineering department help. More expensive modules can also be made in Australia and shipped to anywhere in the world. The equipment ideally needs to be designed using local parts and service technicians of that country. This is part of the holistic transfer of BET to help a remote village in a UDC.

CHAPTER 7: CONCLUSIONS

7.1. Introduction

Technology transfer is a process for developed countries to work with less developed countries to move forward holistically to improve the quality of life of all citizens by adding technology to local village craft to attain higher quality, higher volume production and/or lower unit costs. The many models of TT have been reviewed and a new model, whereby innovative, appropriate, sustainable technology can be used to help less developed countries is explored and developed in this thesis.

A 'technical action research' methodology was applied to transfer the best available free technology via a 'Five Phase Model'. This generic new TT model was tested with a controlled pilot plant in a remote island village with the high quality craft technology of papermaking, and value adding into traditional story and hand-made and printed books. The process was then applied in the different cultural setting of an Australian Lifestyle village.

The first village was in the highlands above Suva in Viti Levu, Fiji as the developing country setting, while the Western Australian National Lifestyle village offered developed country conditions. Industry, university, government and non-government partners are principal actors in introducing innovative new technology forming a 'helix of support'. The Fiji industry partners, necessary to manufacture the technology and progress to papermaking were the Wainimakutu Village (craft papermaking), Pure Fiji (Marketing), On Time Engineering (making the hydropulper), and the Engineering Department of the University of the South Pacific (networking and making the hydropulper and press). The Australian Industry partners in the helix of support were the National Lifestyle Villages (sponsors and craft papermaking), Hercon Industries (chemicals) and Fusion Engineering (co-design and make the hydropulper) and Murdoch University Environmental Technology Centre (networking and trials).

Less developed countries sometimes seek help to select and implement new technology, equipment and skills to progress their country, community, business and craft enterprises in an economically viable, sustainable and culturally sensitive way. The mainstream research is focused on profit and control of intellectual property by the developed countries and multi-national corporations. There was little research and few strategies on how to empower less developed countries, their regional universities and small engineering businesses and how these can then focus on the village craft enterprise with best available technology and free IP to help sustainable, community employment projects.

The newly developed 5 Phases of sustainable TT model applies where technology is being freely given without the complications of IP transfer and management structures. It transfers knowledge via making the specially designed and modified equipment locally, with industry and university partners, and via informal workshops in craft papermaking with the direct involvement of the author sharing in the village situation as opposed to supplying all outsourced pre-made equipment, written procedures or formal training methods.

7.2. Technology Transfer Model

The technical action research method showed that technology is transferred at low to medium to higher levels of equipment use and better production methods by the 5 steps of the Phased approach. The Five Phase Model developed in this thesis begins on a 'Foundation' of understanding the village's present situation then improving 'hardware and software' by distinct stages that build on completion and acceptance in each previous stage.

The technology is defined as 'hardware', the equipment, and 'software' , the artisan's skills, know how, production and management procedures. The TT encompasses making the production equipment using locally available materials and labour, so expertise of making the equipment is transferred along with the artisan skills of making the product, in this instance high quality craft paper. The making of equipment, artisan's skills, and new production procedures can be taught and assessed in workshops in the village and then in the nearest city for the industry and university partners.

The Foundation (0) and five main Phases of the model are now defined as:

Foundation (0): getting to know the existing village, their culture, level of technology, management and craft skills, seeking the blessing of the chiefly families, and finding potential key champions of success. The TT process covers transfer of both hardware and software for truly sustainable industry in the site.

In ‘Small Steps’ Phase 1 of the TT begins with small steps introducing small changes to equipment made and then used to produce the standard base product. The 4 sub changes introduced in this part of the project are:

1. Improving raw paper fibre sources;
2. Making the transfer couching-cotton sheets and making the rods that go in them;
3. Making a work bench to hang the special couching cottons;
4. Making a wooden stacking-guiding system.

In this phase, existing village wooden moulds and deckles were used. The new source of free post industry waste paper could substitute for their bought fibre. The paper could easily be reprocessed using the new hydropulper (Phase 3) and 2kg of fibre would make 100 litres of pulp in 15 minutes; saving time, energy and resources. The new cotton and rod couching designed could be made and sewn in the village, but newer sewing machines (overlockers) are needed to get to the next professional level of manufacture.

The TT workshops can start trialling simpler ‘small steps’ - changes in technology in the safety of the village. This equipment was assembled in the villages, transferring the basic skills of making the lowest technology equipment, and using it to make a rough grade of paper. These simpler technologies and steps were easy for them to understand.

For software skills, both groups appreciated small steps in learning new techniques until they were confident and happy in practicing the new skills. To begin by making and using a basic raw paper pulp, couching cottons, the wooden rods and the simple wooden framed stacking system guided them comfortably into making rough paper with this equipment. They were not afraid to embrace the new technologies.

In summary, initial small steps in TT are very important for the groups to more easily accept the technology and develop important new base skills before bigger steps are tried.

When all stakeholders are happy, Phase 2 is introduced with 'Bigger Steps' in hardware and software technology. This involves making some more specialised equipment with local industry and university help while trying to source standard components locally. The villagers and local industry partners helped to redesign and build some modified equipment for better papermaking. The 4 examples of equipment in this Phase included:

1: Making better 'moulds and deckles';
2: Making a new papermaking 'press' with local industry help;
3: Improving the drying process:
4: Making a better Vat.

Some new software skills were transferred in using the new equipment to make a better quality paper faster and more skilfully, building on the skills learned in Phase 1. Local industry starts to be brought in to make more sophisticated pieces of equipment initiating the partnership with the industry, university and government helix of support network to prepare for later phases of horizontal transfer of technology via local resources to other local sites without intense intervention of the transfer agent. This acknowledges the progressive layers of skills to make progressive leaps in quality and quantity of production using the example of craft paper.

In Phase 1 the new moulds and deckles were assembled in the village from new standard aluminium off-cuts from the security windows industry in Suva. They are also a more advanced aspect of Phase 2 and 3 of engineering technology. The aluminium does not rust, warp or get mould like wooden frames. The new screens inserts are stronger and flatter and create a superior transfer of even pulp fibre distribution over the whole surface. This enables new standard gsm range of papers to be made for the printing industry. From thick 300gsm, to 250gsm, to 200gsm, and now down to 150gsm. This is still thicker than 80gsm industry paper but now suitable for photographic paper and cards. Handmade paper can now reach a new standard of competing against manufactured paper in niche markets, but more radical changes are still needed.

In Phase 3 the foundations of Phases 1-2 enable more radical 'Leapfrog Steps' in advanced technology to firstly reach the level of the other craft made paper (the opposition) and then to 'leap frog' past them and gain a competitive edge with the new smooth paper technology. This creates a niche opportunity to make a range of better products, better service, and/or cheaper products. In this case study, a new technique of making rough paper into smooth and super smooth hand-made paper was transferred from the inventor (author) to the villages. To make the smooth paper, this Phase introduced:

1. Making and using the 'transfer curve';
2. The new 'smoothing technology';
3. The 'turnkey approach' of making and using a new Hydropulper.

All new hardware and software was more easily accepted by building on Phase 1 and Phase 2's previously new equipment and techniques. The new transfer curve professionally transferred the pulp to the couching cloth in one continuous motion within only 5-10 second cycles. The new smoothing technology could be accurately placed on the couching cloth and set in place in the new stacking system then pressed with 100 tonnes per square metres to impart a high quality sheen to the paper. The combination of chemicals, temperature and drying regimes resulted in a new superior smoothness technology.

Within Phase 3; a new, 'sustainable turnkey approach' was developed and evaluated to transfer the higher technology side of making equipment in the nearest city, with a small engineering business and engineering department of a university local to the village. This empowered a remote craft village with the flowing interconnections, a helix of university and business support from the local regional city with the wisdom of 'best available technology', to become world leaders using the newest hydropulper and technologies in their craft.

Similarly, in the Australian lifestyle village, industry and university partners were engaged to co-design and build higher level technology, in this case, a hydropulper using the 'sustainable turnkey approach' where outside expertise forms a helix of support that enables ongoing technology development and maintenance after the research project is completed.

In Phase 3 'Leapfrog Steps' and the 'copy it exactly' approach proved to be a valuable guide to teaching progressively better skills and technology. It essentially refers to mirroring of standard techniques to develop new standard operating procedures to result in consistent and high quality standards of production from rough arty paper, to card paper, to writing paper, to photocopy grade paper and then to colour photocopy grade paper with the 'copy it exactly' approach. When the new hardware and software technologies have been transferred directly by the inventor/transferrer/author, many new skills have been developed by the villagers and the helix of support is established, and then they can move to Phase 4.

Phase 4 involves the 'vertical TT'. Value adding turned raw standard production into a higher quality product and a wider range of products can be made in the village. This created a new opportunity to make other products like writing quality paper and books. Some books were made in the village by the author bringing a laptop computer and printer to the village and actually printing a few editions in the village with the help of the Chief's son, and extended family with local teachers to help translate it into their dialect. This was subsequently trialled in the local schools and by the curriculum development unit of the education department in Fiji.

Once the village artisans of women (90%) and men (10%) have mastered the art and science of the craft they can progress to Phase 5, the 'horizontal TT'. This can be symbolically 'carried' out to the next village using their new skills in papermaking and with the ownership of the new improved IP. This was implemented with the help of a women's training provider who networked with many villages and NGOs. This provided more potential opportunities for important jobs for women in the village and brings cash flow to support the villager's cultural way of life. This complemented their local skills and needs. More village based employment projects can now get funding to continue this research into viable and sustainable projects.

This project provides a solid basis for further research into a future Phase 6 concerned with marketing eco-friendly and sustainable projects in a new world paradigm.

Meanwhile, the National Lifestyle Village, in an Australian setting, was also involved in a parallel project. The life-stylers were more concerned with using the new innovative technologies and tacit skills in developing a specialised art and craft activity to complement their lifestyle. The author could work with skilled retired tradespersons and help pioneer new small and large and radical changes in technology. The author's findings from trial and error over 3 decades could be redesigned to the next levels of practical use and application. Significant results were achieved with all levels of the equipment to collectively help refine and develop a higher quality of papermaking technology.

7.3. Comparison and Evaluation

At an engineering level, significant new advances in equipment hardware and software were re-designed, tested and trialled in a working cottage industry environment.

The parallel projects were evaluated from three main perspectives:

1. The implementation of the 'technical action research' was measured by the quality of the new craft paper produced for the printing industry. Several types of quality books were printed, bound and published as real examples. This involved successfully extending the project guidelines and networking with the Fiji government printers, local teachers, education department and translators.
2. The second, a modified point system survey was developed to complement the five Phases by rating the making of the equipment and transfer of craft (papermaking) skills, then vertical and horizontal transfers. This could now be used as a template for other craft and TT based activities.
3. In the third, United Nations guidelines were also used to trial the evaluation with a maximum coefficient and rating system to generate optimum values of eco-friendly sustainable transfer of appropriate technologies. This could now be used as a template for other TT projects.

In summary, the project involved trials of a new generic TT model with two pilot plants to transfer appropriate and sustainable craft technology for two culturally different settings. These were objectively evaluated, by the author, to be 90-95% successful, using the new 'Westerlund's Five Phases of Appropriate and Sustainable Technology' approach.

An innovative 'sustainable turnkey approach' was successfully developed and trialled and empowered the regional industry –university –village –inventor helix of holistic support with the 'best available technologies'. A 'Copy It Exactly" approach was also trialled to recognise their level of skills with making progressively higher levels of paper quality.

At a holistic level, a United Nations modified evaluation system quantitatively confirmed the positive qualitative outcome. These improved approaches can now all be used as a template to help improve the transfer and evaluation of craft technologies to other developing countries.

7.4. Conclusion

The thesis successfully explored the barriers and benefits in developing and transferring new cottage industry papermaking technology using Westerlund's Five Phases of Appropriate Technology Transfer Model. New innovative handmade papermaking craft equipment was redesigned, re-engineered, and made with three levels of help: village/industry/university engineering; and tested in a real field trial in a developing country. The "technical action research" method of setting up the two sites with the same papermaking technology proved that both a underdeveloped country and a developed country are able to use the same technology to achieve their respective desired outcomes.

For the Fijian village those outcomes were employment and income for the village producing paper at a higher quality and volume than prior to the introduction of the TT. This established a base for the value-added activity of making the paper into books for artistic and educational use. For the Australian village, the outcome was an enjoyable craft activity they could use as an outlet for artistic expression.

The TT was achieved by applying a newly developed 'Five Phase Model' of TT that progressed through stages of first 'small steps', 'bigger steps' and 'leapfrog steps' to higher quality and volume of production; then 'vertically' value adding to the base product and 'horizontally' transferring the entire technology to other villages. Progress through these Phases and sub-phases as a method of TT empowered villagers to learn, adapt and work with the technology in comfortable stages appropriate to their culture, so they accepted higher and higher technology and skill development (hardware and software) with accompanying higher quality and volume of paper produced.

Part of Phase 3 was to develop a sustainable turnkey approach. This involved changing the priority of the traditional turnkey approach to empowering the local village, then industry and university partners with the 'best available technology'. That 'best available technology' was redesigned with local input, using locally available technology and parts. This stage applied the 'triple helix model' of innovation in which universities, industry, government and non-government organizations feature as principal actors in the national innovation system.

A scientific survey developed specifically to measure progress through the 'Five Phase Model' is included and quantifies the success of the results of hardware and software transfer. A modified United Nations 'five star indicators of environmentally sustainable technologies', from the "Seven C's Model" of successful transfer and uptake of environmentally sound technologies, measures the eco-friendly benefits of this particular paper making technology.

The research shows the TT satisfies the three major cornerstones of being socially acceptable, economically viable and able to sustainably; and many other new cornerstones; by using the best available technology in varying cultural settings when implemented via the Five Phase Model of Technology Transfer.

The two sites enabled successful trials of a new generic TT model with two pilot plants to transfer appropriate and sustainable craft technology for two culturally different settings. This was objectively evaluated to be 90-95% successful using the new 'Five Phase Model of Appropriate and Sustainable TT'.

7.5. Ideas for Further Research

There are several areas of ongoing and future research.

Chapter 6 introduced the new area of alternative inks and chemicals to make hand made papers and industry made papers.

Chapter 6 also introduced the handmade paper 'Accreditation Process'. This could involve a TAFE certified course in Australia to recognise the new levels of scientific achievement in developing a world first in smooth hand-made paper technologies. International conferences could invite delegates from around the world to learn and share the pioneering research and hands on techniques of the new papermaking processes.

This 'sustainable turnkey approach' was successfully presented at the IOBB conference in 2009 and became part of a chapter of a book. Two Masters students also presented an Engineering project on making a hydropulper at the University of the South Pacific. More flow on projects, over the years, will now keep the equipment maintained and new technologies developed for the paper making village in a sustainable and empowering process. We can link in with ongoing research at Murdoch University and keep the international network going.

This could further be focussed on empowering UDC village women with craft technologies for employment and education improvements. Another complementary impact of the research is how technology can be improved using clean development mechanisms with more sustainable lifecycle analysis and creating more employment for women in the village. The women need craft employment options in the village and they need to be there for the children, school, garden, food, and church activities. Thus they have a precious few hours each day to do craft activities at their home or village.

The Phases could be extended to 6 and 7 and more. Phase 6 could involve marketing the UDC or WPMV papers and production technology. Phase 7 could improve the management systems, and so on. It is part of a greater vision to have a full support service for the village with the help of local industry and a university helix of support. Murdoch University and the inventor should be able to step away and empower the local helix to provide full support and complementary future research.

In conclusion, the Horizontal TT Phase could help more village based employment projects get approved funding based on this new standard 'Westerlund's Five Phases of Appropriate and Sustainable Technology'. This research base can be also used in many other craft and small business technologies and help generate more viable and sustainable projects.

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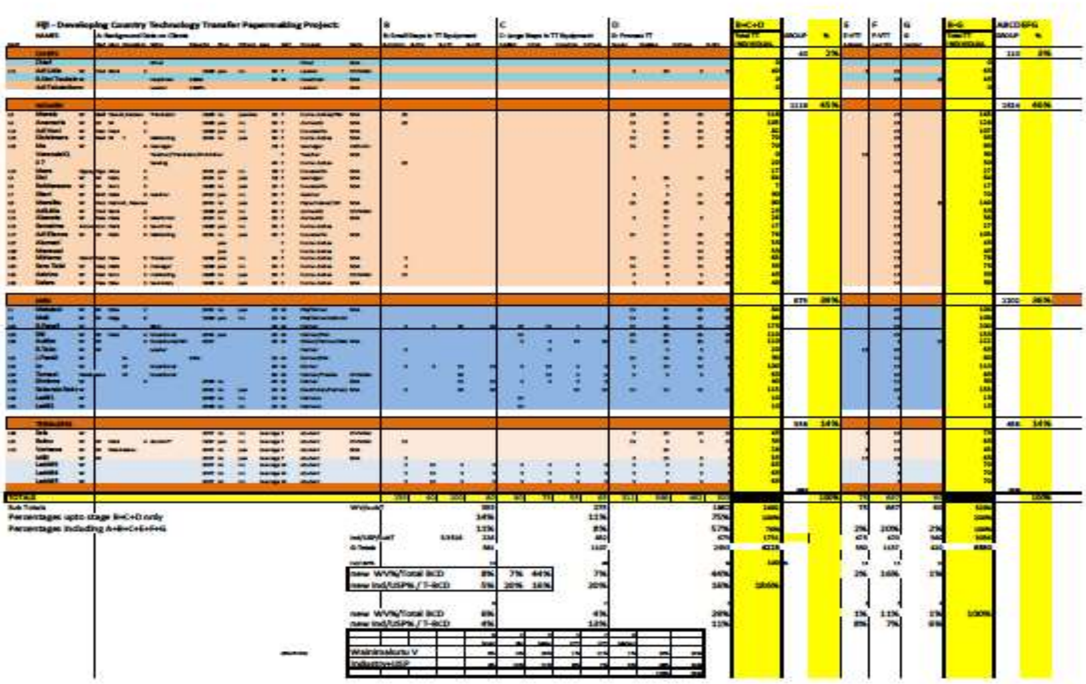
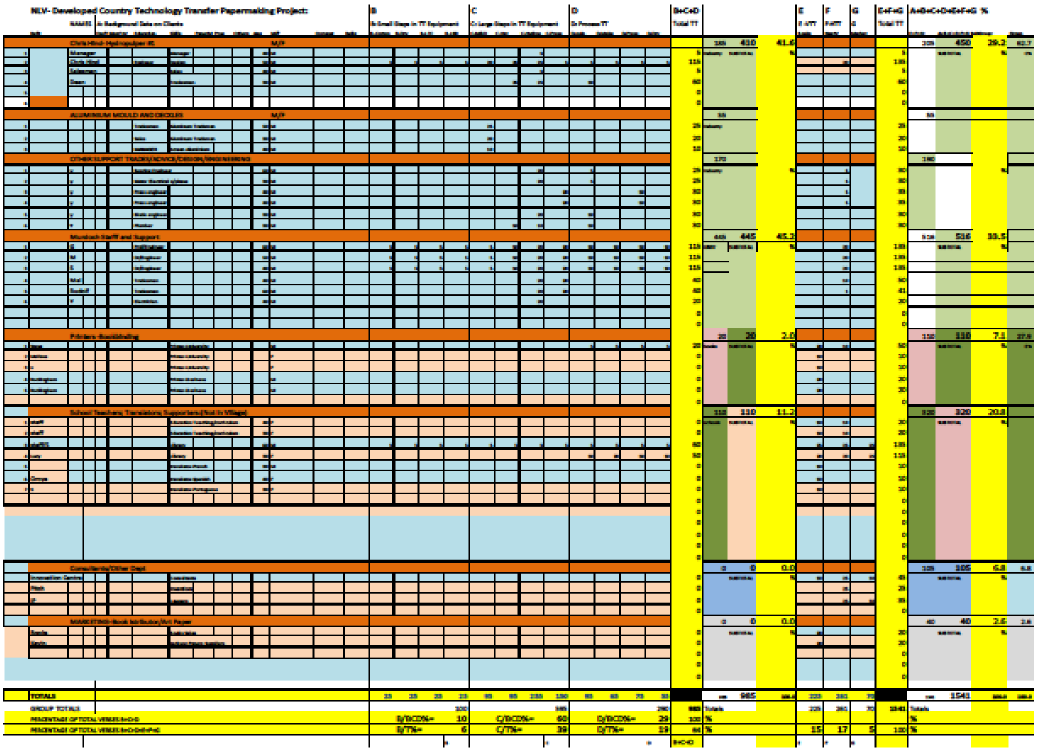
Appendix: A: Results of Wainimakutu Village (Westerlund 2011)

It is blurred to protect the names of villagers in the survey. The groupings of colours are blue for men and pink for ladies. Some groupings are Chiefly, administration, craftsmen and women. The tallies are collated, sub totalled in yellow, and totalled for each phase for easy statistical analysis.



Appendix B: Results for Bridgewater Lifestyle Village. (Westerlund 2011)

It is blurred to protect the names of the lifestylers in the survey. The groupings of colours are blue for men and pink for ladies. Some groupings are administration, scientists, tradespeople, craftsmen and women. The tallies are collated, sub totalled in yellow, and totalled for each phase for easy statistical analysis.



Appendix C: Pictures of the Science of Technology Transfer.

Figure 2.2.2a. The chief's grand-daughter; in front of the village hall, telecom satellite and solar panels. Three SAT phones now service villagers.

Figure 2.2.2b. Sustainable wind energy: Several windmills above the rugged Sigatoka valley, 100km northwest of Suva.

Figure 2.2.2c. The Monasavu Dam, in the highlands supplies sustainable water and hydro-electricity to Suva.

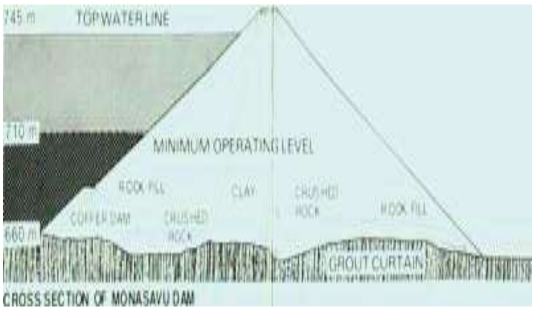


Figure 2.2.2d.Monasavu Dam, low levels in Dec 2008 threatened hydro-power supplies to Suva.

Figure 2.2.2e.Then next month, overflowing with heavy double cyclonic rains in Jan 2009. The cyclones also flooded Nadi tourist town and the Sigatoka valley where much of the food is grown.

2.2.3. Smokeless Stove.

Figure 2.2.3a. The original entrance to Ballantine Memorial School where the smokeless stove research was pioneered.

Figure 2.2.3b. The Author with Mrs Powell who used the original smokeless stove pioneering technology still at the school.

Figure 2.2.3c. The original technology grid Mrs Powell cooked on (lower-right), the big pots (centre) and handling sticks (stick through the handles to help safely pour off the hot water), the smokeless stove (left), the outdoor cooking area, cement floor and tin roof.

Figure 2.2.3d. A close up of metal hot plates in the Fijian design of the appropriate technology smokeless stove.

Figure 2.2.3e. The then, newer international technology gas stove that replaced the smokeless stove.

Figure 2.2.3f. The current appropriate technology at Wainimakutu Village using a modern oven for bread-baking. Made in the village using a 200 litre drum, special cement kiln bricks and local sand.

Figure 2.2.3g. The Author had a village tour to view traditional sustainable housing.

Figure 2.2.3h. View thatch walls using local bamboo fibre, harvested and woven.

Figure 2.2.i.The Author had a village tour to see floors made of ‘first cut’ local timber for floor and supports.

Figure 2.2.3j. The Author (L) and Eroni (R) helped extend the tin/wood house with a kitchen and best local technology tall chimney in remote Saqani village.

Figure 2.2.3k. The kitchen extension and tall chimney (right) designed, made and tested to best available village skilled artisans and technology for Eroni and Susannah .

Figure 2.2.3l. Author helped train 2 village men with modern electric tools.

Figure 2.2.3m. We were treated to the first nice buns made by Susannah in her new kitchen.

Figure 2.2.3n. The buns were cooked in a 30cm round pot.

Figure 2.2.3o. We added a 500l rainwater water tank; diverted from roof gutters; on local rock foundation; and made a rock frog pond with the overflow system.

Figure 2.2.3pq. Discussions with Mr Bola, the Director of Centre of Appropriate Technology and Development concerning the stoves, and range of appropriate technologies that they teach the student delegates from many villages to make.

Figure 2.2.3r. Some of the CATD students ready to take their skills back to their villages and empower them with best appropriate make-able technology.

2.2.4. Coconut:

Figure 2.2.4a. The coconut tree is called the tree of life in Fiji. It has many uses from food, drink, cosmetic oils, timber, fire wood to rope.

Figure 2.2.4b. Coconut oil industry is very important to Fiji. They are trying to build better presses to help the villages extract more precious oil from the white flesh.

Figure 2.2.4c. Roko just climbed the tall coconut tree with feet and hands to present guests with a refreshing drink.

Figure 2.2.6ab. In her retirement, Litia, a school teacher had her Fijian stories published.

Meeting with Litia Tukana (right) and her sister, Serean, who helped translate in the village, on how she helped as the Author to publish her Fijian book.

Figure 2.2.7. Pure Fiji Water now bottles a great range of internationally accepted drinking water from the artesian waters near Nadi, Fiji.

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Pictures 2.2.8a. The Author meeting Tako. (Ratu Peceli). He could now afford a chainsaw, cut their own free timber from tribal land and buy modern bricks and cement with help from his wife's –teaching income. This village house was a modern example of best available local and bought supplies for a remote village.

Figure 2.2.8bc. Meeting Meriadani, the local regional nurse (with her first child) at her new station between the remotest villages near Wainimakutu Village. She was the first to greet me and speak some English on my original village trip helping to make me welcome and to understand village protocol.


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The/her nursing station was built as a government funded community project. Built by locals using affordable modern supplies trucked in from Suva city.

Pictures 2.2.8d. The villagers going to market start leaving the villages by 3am in the morning, crowded into the back of a truck with everyone's produce they pick up from villages along the way. They travel the dangerous mountain gravel roads, and arrive in Suva by 8-9am to sort out their produce ready for sale.

Figures 2.2.8e. The villagers travel in cramped conditions in the truck where the middle is full of cassava bags, dalo bundles, yaqona bundles, pineapples, bananas and sometimes livestock like pigs, goats and chickens.

Figures 2.2.8.fgh. The many creeks flood and damage the bridges and gravel roads. Temporary repairs may take a week; then months to years for bridge repairs. Landslides in the monsoonal season claim lives each year.

Figure 2.2.8ijk. The pandanas leaves are collected and dried on the village grass. The women sit in social groups and weave mats for cultural gifts or sale at the Suva.

Figure 2.2.8l. The traditional catching of fish has now changed in the village by using a 1metre wide and 10 metres long net. The fish are shared amongst the chief, church minister and villagers. The fish must be cooked within a few hours or the catch will be ruined in the tropical heat.

Figure 2.2.8m There is opportunity to develop the sale of tropical fish.

Figure 2.2.8o. We inspected a sea-side tourist backpackers resort that uses lily ponds to treat the grey water wastes in an eco-friendly way.

Figure 2.2.8p. The school wanted to trial the old technology and make a modern library building, thanks Bill. They also showed me how they smoke the roof fibres to stop the insects eating it.

3.2.3 Facets of Models.

Figure 3.2.3a. Fiji has viable reserves of copper above Suva in the highlands but the environment is too sensitive to currently mine.

Figure 3.2.3b. Many villages, like Wainimakutu, Namosi, are located on the river edges, below steep hills, and subject to landslides and flooding. ‘Waini’ is local for two rivers meeting. In flood, these two rivers flood into some of the village and isolate the village for weeks.

Figure 3.2.3c. The Namosi region is too steep and dangerous to mine. It is the headwaters to the proposed Ramsar wetlands west of Suva.

Figures 5.2.1.3a. In the truck to the village, the Author thus informally met some village men. Timothy was uncle to the nurse and help later translate a book; helped later to make equipment and discuss environmental programs.

Figure 5.2.1.3b In a truck trip, the Author thus informally met a school teacher who helped discuss the educational system. The driver, (Siti) proved another champion as he helped pick up equipment from Suva and networking.

Figure 5.2.1.3c Welcomed for breakfast by Mere and Autiko, in the Wainimakutu Village. She was involved in the papermaking workshops and could speak very good English to help become a champion of this project. Autiko helped weld and drive the truck/bus to town.

Figure 5.2.1.4a. It was very important to get the Headman's blessing, Ratu Kinivilliame Taukeinikoro (2007). He initiated and supported the original papermaking project over several years. I was initiated with white face powder, Sulu and welcomed into the village.

Figure 5.2.1.4bc. It was very important to get the blessing from the Chief's family and share a bowl of traditional grog.

Figure 5.2.1.3d. It was very important to get the chief's wife – Lidia involved in demonstrating the new paper technology.

Figure 5.2.1.5a. It was very important to get the headman (left) , his wife (holding paper: now deceased); Author (green shirt); village papermaking delegates ladies - Mere and Miri; and key stakeholders to meet with Prof Koshy (right) at the regional university USP.

Figure 5.2.1.5bc. It was very important to informally network with the past, present and interim leaders of governments.

Figures 5.2.1.7abcd. Local drala plants and local flowers are grown and collected for processing for sustainable papermaking.

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5.2.2. Fijian Papermaking Technology.

Figure 5.2.2ab. The cevuqa (wild ginger) plant fibre is beaten by mallet or stick or rock on the river stones to break down a 2-3cm stem into a fibre source then boiled.

Figure 5.2.2cde. A Hollander beater is used to help grind the long thick bark fibre into shorter finer fibre (15-30min/10l).

Figure 5.2.2f. A wooden A3 mould and deckle with ordinary wire is used in a wooden vat.

Figure 5.2.2g. They transferred from the mould to the flat couching surface by pushing and rocking the frame until the layer of pulp is transferred.

Figure 5.2.2h. Then pressed in a simple screw press. This presses some water out and help make the pulp flattened. Tiko also helped to weld things and advice..

Figure 5.2.2i. Ladies then peeled off each sheet pasted onto a tin drying operation.

Figure 5.2.2jkl. They then peeled off each sheet pasted onto a hot tin. Each sheet is tended to till it is dry. Fire is used as the sustainable heat source from local (free) timber left over from the fibre / bark.

Figure 5.2.2mn. Then dry peeled and quality control.

Figure 5.2.2op. Pure Fiji used the beautiful A3 paper for packaging cosmetics, and the opposition copied it.

5.2.3. Small Steps.

Figure 5.2.3.2a . We rolled the cotton onto the village hall for cutting and making the couching cottons.

Figure 5.2.3.2b. Two treadle sewing machines are appropriate for helping to sew the sheets into the couching sheets.

Figures 5.2.3.2c. The afternoon progressed better with 150 cottons being sewn for the day. An overlocker is needed to make another x,000 sheets to commercialise the process.

Figure 5.2.3.3ab. The varnishing was done with laying them out in rows, varnishing and rolling along a bundle of 20 dowels. The children loved to look on and have fun on their holidays. A workshop is needed for the men to create a dedicated area for them to make equipment for the project and their family needs.

5.2.3.4: Small Steps: Stacking System:

Figure 5.2.3.4a. A simple wooden trolley was made, with 400mm internal gap, in which to neatly stack the new couching sheets in.

Figure 5.2.3.4bc. Tools and components, like drills, varnish and dressed timber was bought in to make a better couching trolley included in the LSR design.

Figure 5.2.3.5ab. They soon learnt to use the new stacking system to carefully align each set of 5 sheets on the board.

Figure 5.2.3.5c. The screw press was used to trial both pressings and empower them to see the differences.

Figure 5.2.3.5d. The new press empowered the ladies to use the new yellow 20 tonne press.

Figure 5.2.3.5e. The press boards, sandpaper and varnish were supplied by the Author to help make more boards in the village.

Figure 5.2.2f. Grandad sandpapers and varnish more press boards in the village.

5.2.4.1. Bigger Steps: Vat

Figure 5.2.4.1a. The big old wooden vat was rotting and needed replacement.

Figure 5.2.4.1b. Making a vat. The new vat was a new radical design using side to side motion and drainage section.

Figure 5.2.4.1cde. The ladies like to use the new technology vat and felt empowered that they could do it.

Figure 5.2.4.1f. They then wanted the Author’s help to make one from their design. This was amazingly done in one day with three helpers, with the Author’s tools & design features to improve their standard design.

5.2.4.2: Bigger Steps: LAM

Figure 5.2.4.2a. The oversized A3+ size is designed to make one guillotined cut A3, then 2 standard A4 papers.

Figure 5.2.4.2b. The A3+ size is designed to be used flat side up and the deckle on top to create a natural deckle edge.

Figure 5.2.4.2c. The ladies can achieve highest quality transfer of even pulp formation using the new technology moulds and deckles on the transfer curve.

Figure 5.2.4.2de. The Author improvised and brought the LAM components to the village for assembling to empower the men to help make the equipment and fix it in the village.

5.2.4.3: Bigger steps: Press

Figure 5.2.4.3a. The WHMP press was made in Suva as a simple mechanical screw type press to be used in the village.

Figure 5.2.4.3b. The LHMP standard 20 tonne press over the A3+ surface area was based on modifying a standard bench press.

Figure 5.2.4.3cd. Local Suva businesses gave some offcuts of metal for the press.

Figure 5.2.4.3ef. Author and Ratu Autiko helped with his good welding skills.

Figure 5.2.4.4a. The delicate damp paper is painted out to the edges to allow even spreading, then tended to, until dry.

Figure 5.2.4.4b. The fires are carefully controlled to just give a consistent heat on the tin. A lot of smoke and soot is bad for the OHS issues.

Figure 5.2.4.4c. Parents and family help make the new drying lines.

Figure 5.2.4.4d. It was quick and easy to hang the couching clothes for drying the paper, using 2 special parallel grip pegs.

Figure 5.2.4.4ef. Mere and friends tended to the new super smooth paper sheets like new born babies. It is a critical part of the process to get to about 7-10% moisture content before peeling.

5.3. Radical hardware+software:

Figure 5.3.2.1.a.The A3+ size is designed to work best over a special L'Transfer Curve (LTC) that was made in the village.

Figure 5.3.2.1b. We re-designed a double unit for the village to suit the size of the studio and medium capacity of production with teaching 3 men . The 2 inch foam is inserted inside to absorb the water.

Figure 5.3.2.1c . Two men helped. It is important to train all levels of men for wisdom , empowerment and support.

Figure 5.3.2.1d 'learning by doing' .

First align the mould to the cotton rod.

Figure 5.3.2.1e. The young man who already is doing this in their system already has a good strong technique to produce consistently good paper.

Figure 5.3.2.1f. Second: start to roll.The young ladies have the strength in their arms to easily do the new technique.

Figure 5.3.2.1g. Second start to roll. The elders were taking an interest in the new technology transfer.

Figure 5.3.2.1hijkl.Continue to roll with strong wrist + arm action.

Figure 5.3.2.1mn.Then exit without drips on the delicate paper that would destroy a now valuable sheet of damp paper.

5.3.2.2: Leapfrog Technology Transfer

Figure 5.3.2.2a. Shared the passion of the first sheet made in the village.

Figure 5.3.2.2b. The 5 couching sheets are aligned over the guides, stretched square, and layered flat on a board to form a 'sandwichee'

Figure 5.3.2.2c. The sandwichees are put in layers in the press. The old and new ideas are first trialled with the old screw press.

Figure 5.3.2.2d. The sandwichees are put in layers in the new press. The ladies had a go using the first new press in 2008.

Figure 5.3.2.2e. The ladies had a go using the second new USP press in 2009.

The top bar is already bending and needs to be re-designed and reinforced.

Figure 5.3.2.2f. The wet- paper is hanging to air dry for 1-2 days in dry weather.

Figure 5.3.2.2g. Mere is demonstrating how the dry paper is delicately pulled along the diagonal across the paper to expose the creation of the super smooth surface technology.

Figure 5.3.2.2.hi. “Sayawa”, the marketing phase the Murdoch University students used for their marketing report on options to sell the village papers. The four students help learn to make the paper at ETC Murdoch.

Figure 5.3.2.2j. Sharing the magic of the first sheet of smooth hand made paper from the second new technology hydropulper in Jan 2009.

Section 5.3.3. Turnkey.

Figure 5.3.3.3ab. Making a hydropulper with industry help.

Figure 5.3.3.3cd. Two other delegates (champions) from the village (Ratu Peceli and Maria) came to the workshop a few hours each day and to see how much work was done in making the industry- made hydropulper in the closest city, Suva.

Figure 5.3.3.3ef. A photo of the group working on the hydropulper in the engineering business. Special thanks to the manager for being a champion of the project.

Figure 5.3.3.3g. A wood/ply cover was cut and made to shape in the Village. This helped empower them to be a small part of the bigger technology transfer project.

Figure 5.3.3.3h. The hydropulper motor was stripped down and realigned to work better. There were two electricians in the village who were able to help.

5.3.3.4. Turnkey: USP

Figure 5.3.3.4a. USP Student hydropulper ready for appraisal. They submitted the project as part of their Masters.

Figure 5.3.3.4b. USP Student hydropulper helped by support staff to make specialised bearings, pulleys and drive shafts.

Figure 5.3.3.4**cd**. A few design features were discussed and improved with staff of USP Engineering workshop.

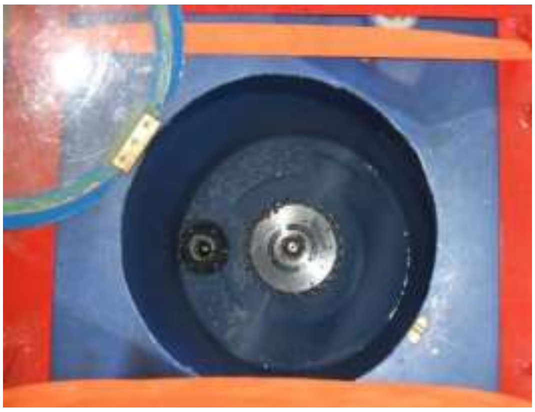


Figure 5.3.3.4**e.** The machinist did a good job of machining a 20mm bore hole and cutting a pin slot using a file. The pulley was increased from 2-3 inch to get 750rpm blade spin speed.

Figure 5.3.3.4**f.** The student engineering department generator was used to test the unit. It was modified with many electronic controls to test remote power starting conditions.

Figure 5.3.3.4**g.** The pulp was tested in a bowl of excess water to gauge the fineness of fibre suspension (1-5mm).

Figure 5.3.3.4**h.** Many thanks to Dr Wood for being a champion of the university project.

Figure 5.3.3.4**i.** Mere Naivakaucu turning the USP hydropulper machine on for the first time in the village.

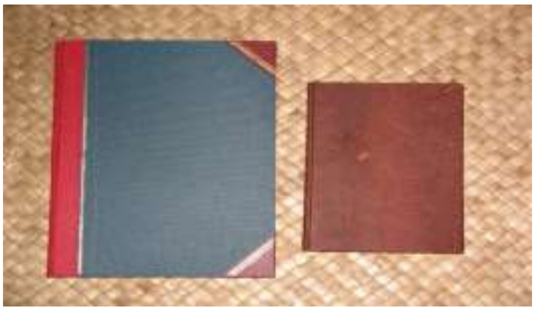
5.3.4. The 'Copy it Exactly'

Figure 5.3.4.5a. The different 3 stages of paper making and participants using the equipment.

Figure 5.3.4.5b.A group photo captures the first sheet that dried that afternoon.

5.4. Vertical Technology Transfer

Figure 5.4.4abcdef. Reams of A3plus paper being guillotined; and printed samples of poetry were given to Government Printers Suva, for them to make a range of demonstration books that could be made using the new smooth technology hand made paper.



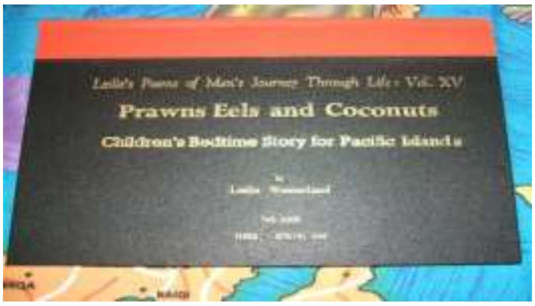


Figure 5.4.4g. Tiko's Stories. A year later a copy was ceremoniously presented to him in his village. Tiko, who speaks little English, with his English-Fijian
book.

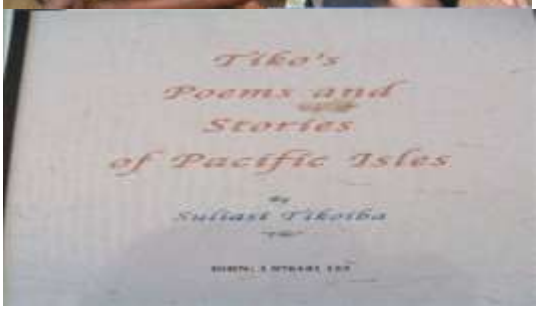


Figure 5.4.4hi. Show the Headmaster Mr Paula Manumanununitoga , the books; and teachers involved.

Figure 5.4.4j. Vere’s (above right) income has directly helped them pay for modern materials to make a concrete block house and tin roof house (below=Author’s husband, Tako (Ratu Peceli).

Figure 5.4.4kl.Tako, had just finished an introduction to computer course for villages and was happy to help learn and print the first editions of his wife’s book.

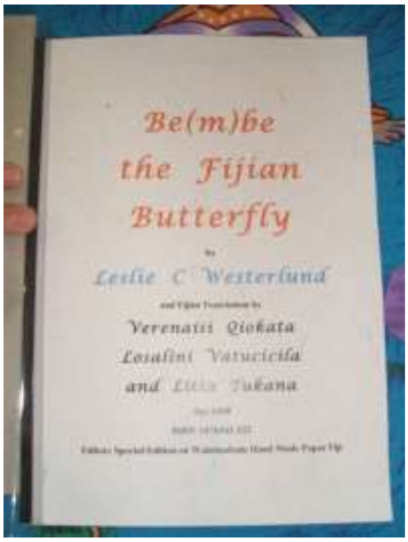


Figure 5.4.4m. Meeting with the curriculum development unit in Suva to promote the new book concept in schools (Milli; Drova; Author).

Figure 5.4.4no. Books based on sustainable village life.

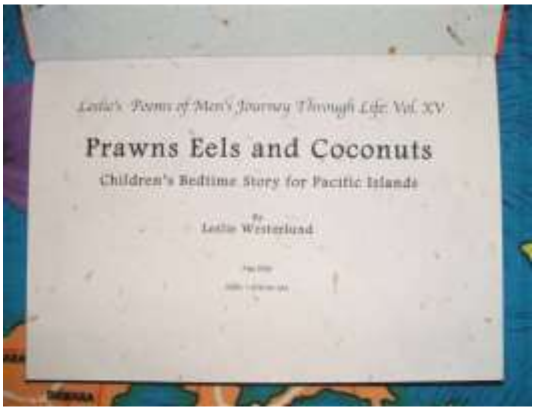


Figure 5.4.4pq . The printer was first checked with the Author's portable laptop then installed on their school PCs. The headmaster showed two staff to learn how to add ink and insert the cartridges.

Figure 5.4.4r. Presenting Tomasi with his first book, using a local story of the coconut tree and re-translated by his niece back into Fijian local dialect.

Figure 5.4.4s. meeting the chief from the next village, the last inland village before thousands of hectares of rugged mountains. He wants a special story of the local fish species that is a totem for his village printed on the paper.

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5.5 Horizontal transfer.

Figure 5.5.2a. Networking with a consultant, Mr Liebregts in Suva. He helped set up the original project over several years and secure funding and national support.

Figure 5.5.2b. Networking with Lia Maka, from the women's regional training centre near Suva.

Figure 5.5.2c. Networking with Prue Townsend (centre) giving more workshops on papermaking with Lia's network in Fiji.

Figure 5.5.2d . Some of the new paper cards the group were able to make using new improved hand made technologies.

Figure 5.5.2e. Experimenting with the newly imported Mark Lander Hollander beater from New Zealand. It grinds the tough fibres better into raw pulp.

Figure 5.5.2f. Networking with the USP and Dr Koshy and his newsletter after presenting a seminar to their group.

Oceanic START Waves

Figure 5.4.3a. Thank you letter form USP Library for networking and donating some Fijian books on handmade paper.

The University of the South Pacific Library

Figure 5.5.4b. Receiving a traditional whales tooth for helping in a village, while dressed in traditional sulu, while seated on a traditional hand made pandanas woven mat.

Figures 6.1.4ab. The stylish white plastic was moulded by tradesmen to look clean and very professional for a cottage industry craft project. Leslie, centre with Chris Hind from Fusion Plastics right and Stuart Dallas from ETC, left.

Figures 6.1.4cd. The in line water seal was improved using two water seals that were inserted back to back to ensure extra long life and resistance to leakage under extreme conditions.

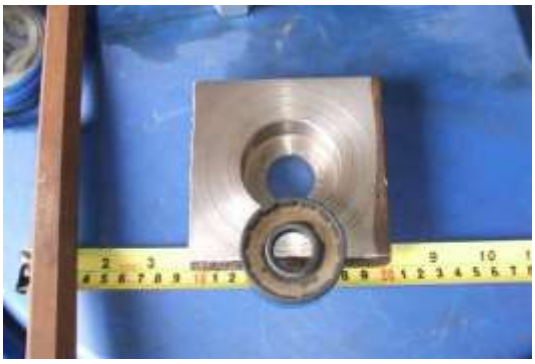

Figure 6.1.4e The single phase electrical motor is ideally strong enough for direct drive, with mounting bolts onto 25mm plastic welded plates, at 20 degrees off centre .

Figure 6.1.4f. The plastic welding was done with a FP127model.

Figure 6.1.4g. perspex inspection plate was cut into the side to aid visual inspection and to show off the motor and coupling to the BWLV lifestylers and staff, while also being a maintenance inspection hole

Figure 6.1.4h. The blade was a new reverse design made from highest grade stainless steel (marine grade 6), to prevent corrosion, and cut the waste paper and fibre into pulp more effectively.