# Te Kāuru Hou—a new leaf: Processing Harakeke (Phormium Tenax) for WholeGarment® Knitting Technology - Shima Seiki

**Kimberley Alexander-Maaka**
Ngāti Kahungunu / Ngāi Tahu / Ngāpuhi
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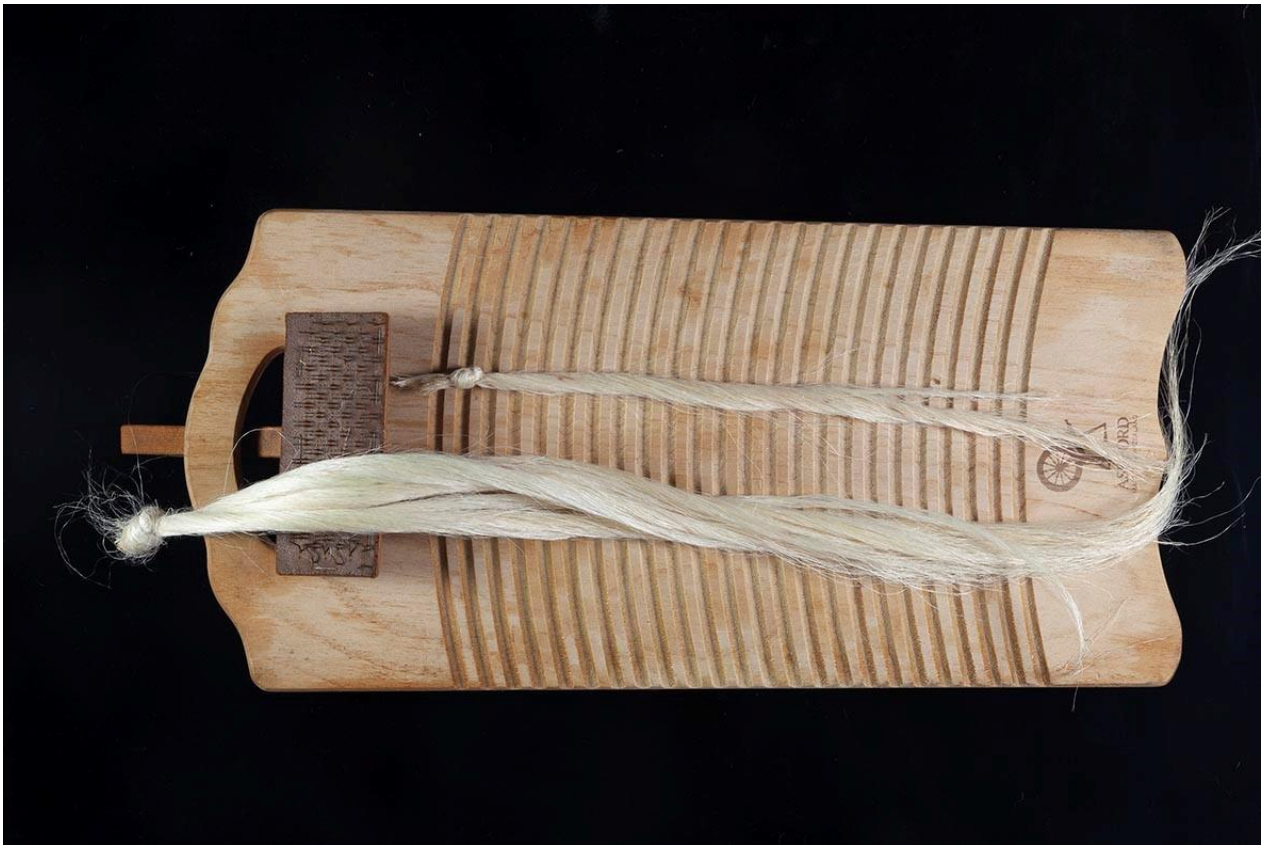

*Auckland University of Technology School of Art and Design*
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*Supervisors:*
*Andrew Withell*
*Natalie Robertson*

# ABSTRACT

*Keywords: Harakeke (NZ Flax), Phormium Tenax, Shima Seiki WholeGarment®, Innovative Technology, Plant Fibre, Te Ao Māori / European, Environment, Sustainable, Productivity, Textile / Fibre Technology, Identity.*

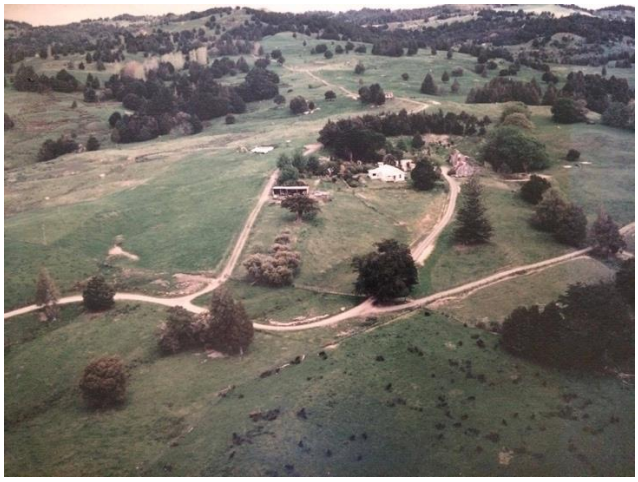
There is demand for high-quality natural fabrics, which are cultivated and transformed by processes that are environmentally and culturally sustainable. In response to this demand, and underpinned by Te Ao Māori worldviews and environmental values, this research meticulously questions how can harakeke advance technology while maintaining her integrity? The development of new techniques and innovations are explored to transcend harakeke (phormium tenax) from harvest to a digitally knitted structure - something that has not been achieved before.

The research specifically explores analogue (hand) and digital processes (WholeGarment® digital knitting technologies), the relationship of European sciences and Māori harakeke knowledges, and the interconnections between Raranga (weaving) and the textile design. The bridging of these areas give rise to opportunities for experimentation, creativity and innovation. This includes the development of new techniques for the successful processing and spinning of muka fibre using innovative binding solutions, combing and wave-set processes, and the knotting of fibre ends to create a fine yarn for further processing using digital knitting, as well as simple processes to soften the fibre after knitting.

The findings demonstrate how techniques from the past and present can be synthesized to create new and unconventional textiles. They also show how Te Ao Māori worldviews can augment and extend scientific knowledge, and when integrated with design, can transform natural plant resources into innovative, sustainable materials and products.

# PREFACE

I am of Māori and European heritage which requires navigating across and between two cultural worlds. Raised in Aotearoa between the Bay of Islands and East Coast communities, my cultural and industrious farm upbringing are integral parts of my identity and commitment to innovative growth. Such diversification of place allowed me to discover potential collaborative pathways within a digital practice using valued traditional knowledge and harakeke.



1. Kingsclere Farm, Okaihau, NZ. Photo credit: Whanau archives. 1980s.

As a young child, my maternal Ngāpuhi grandfather Graham Alexander took me with him to many marae hui as he took an active role in Māori land rights. On the marae, I would be left with the nannies and aunties to learn my way around. At other times, I would go to Nuhaka with my father's side of the whanau. There amongst my Rakaipaaka and Kahungunu whanaunga I absorbed knowledge about our cultural arts heritage from an early age. My great-grandmother Heni Te Kauru was our Kairaranga (master weaver), drawing on the rich environmental resource of fine harakeke that Nuhaka and its swampy surrounds provided.

1.1. Waihou Valley, Bay of Islands, Northland.

1.2. Kaihiki Bay, Bay of Islands.

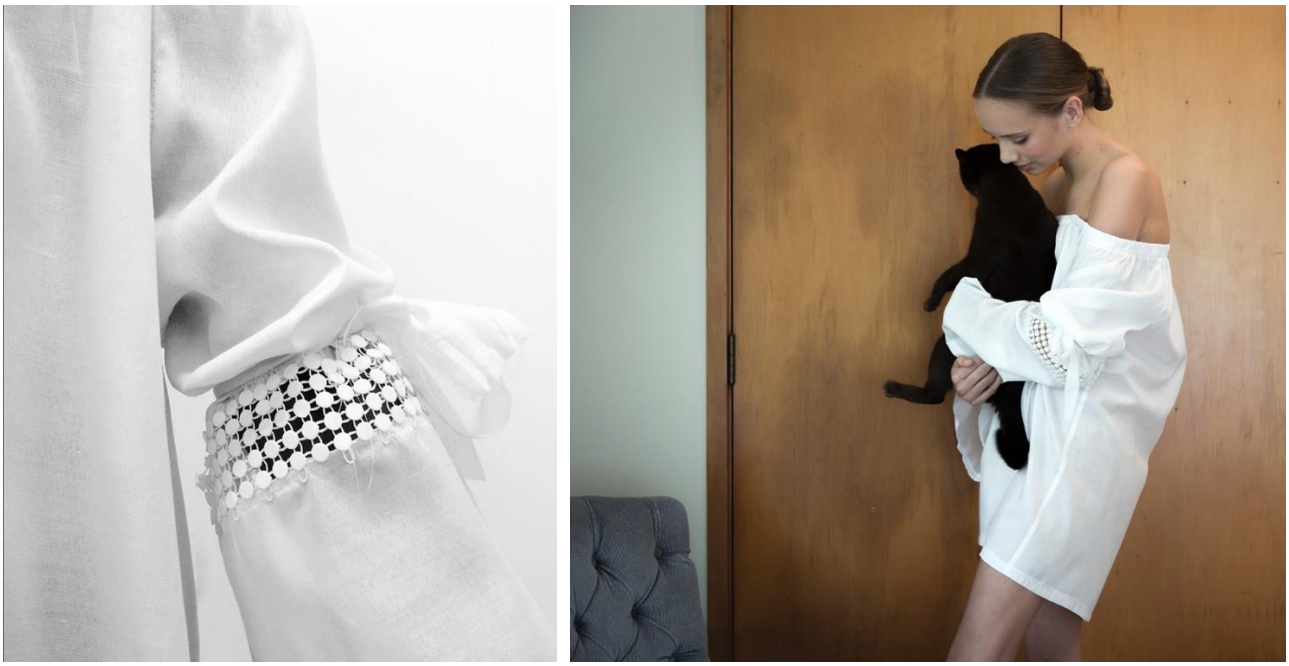
The lands of the North were also renowned for harakeke. Harakeke was on the farm I grew up on in the Waihou Valley, Okaihau, Bay of Islands. My mother lives there today, with our pā harakeke that has nurtured this research. This heritage has provided me with both tacit knowledge of the whenua and harakeke, and something else intangible—a passion for harakeke and its potential passed down through my whakapapa. It is this passion that has driven this project, a fascination for the properties of harakeke and its possibilities, and a vision that this fibre could be spun into a fine thread for use in the textile industry in new ways.

1.3. 2016 Design concept: Our spiritual connection with divine feminine (Papatūānuku). Photo credit: Oddsockgang. 2016.

As an indigenous designer, I aim to formulate conceptual and material design processes that are not detrimental to Papatūānuku *(Earth Mother).* This thesis considers the impact textile structures have on our environment, by using a sustainable approach to design. My tenure at AUT City Campus has allowed me to be able to work with some of the latest cutting-edge technologies such as 3D scanning, 3D printing, 3D knitting, laser processing and e-textile techniques that have enabled this practice. In these contexts, I believe harakeke has the potential to provide a biodegradable product that is supportive to a sustainable system long-term.

For me, in this research project, everything leads back to the land and the impact the textile industry has on the land. This project emerges from an early hunch that harakeke fibre could be adapted to the 3-D printing world and digital machine knitting technologies. I wanted to combine technology and craft and how bringing the two together could make better products. Our indigenous knowledge

can be harnessed to produce the present-day solutions we are searching for. This understanding aligns with Linda Tuhiwai Smith's statement 'binding ancient genealogies with contemporary realities'.[1] Te Ao Māori link Atua and humankind together with a common genealogy that spiritually binds us.



1.4. 2016 Digital Fabrication, integrating 3D printing technology into functional fashion design. Right: Photo credit Karen Reis. 2016.

For this project, I chose to continue from my fashion background as I had observed a huge disconnect between fashion studies and textiles, where peer fashion designers didn't understand the fibre properties of materials. I understood how clothing was made, so I wanted to understand how we could utilise harakeke muka as a resource, given our ancestors had. How could this help us today in the textile industry when self-profit comes before our environment and our communities? This research offers a new prospect for Māori entering the world of textiles and technology. This research is based on both the physical and genealogical kinship with Atua and finding a new pathway of learning. This research works not only on the physical plane but also on the spiritual level to express my conviction of a culture through technique.

Most significantly, the conveyance, preservation of these traditions, the organising and ordering of this research, was grounded upon methods of whakapapa. Whakapapa is central to Māori identity and the society we live in. It constantly worked to connect ideas, principles, beliefs and values with

[1] Linda Tuhiwai Smith, Te Kahautu Maxwell, Haupai Puke, and Pou Temara, "Indigenous Knowledge, Methodology and Mayhem What is the Role of Methodology in Producing Indigenous Insights? a Discussion from Mātauranga Māori." Knowledge Cultures 4, no. 3, (2016): 131-156.

practice and experience. Retracing my whakapapa deemed this research possible in locating truths collectively to understand the link between our past, our present and our future environmental problems. It symbolises the relationships and principles we keep with Atua and whenua to safeguard our future and foundations that this technique is informed and based on.

1.5. Pa Harakeke.

**Harakeke Terms**

This draws on the following terms named in Kahutoi Te Kanawa's thesis Toi Maramatanga. 2009.[2]

The leaf of the blade – rau

The opening of the blade - kauru

The withered dry blades, found at the base of the plant - pakawha

The roots/rhizomes – huahua paiaka or huahua pakiaka

The hard base of the blade – putake/take

The inner middle leaf – rito

The leaves either side of the inner leaf – awhi rito

The outer leaves of the awhi rito – matua or whaea (parent leaves)

The gel/resin from the lower blade - piaharakeke

The epidermis of the blade- para

The green waste known as – kukakuka

The fibre – muka/whitau

1.6. Pa Harakeke - Puketi Farm, Bay of Islands.

[2] Kahutoi TeKanawa, "Toi Maramatanga. A Visual Māori Art Expression of Meaning," (Master's Thesis, Auckland University of Technology, 2009).

## Acknowledgements

*The research began as a 'rito', a new shoot nurtured by the matua rito and awhi rito, the leaves that protect the inner leaf—on one side, the world of my ancestors such as Heni Te Kauru, and on the other side, the world of the living, the future I want for my children.*

1.7. Heni Te Kauru with Kimberley as a baby. 1982.

*The awhi rito and matua rito leaves symbolise the nurturing I received from women who carried skills and knowledge. These include Ema Lyon who reconnected me to the processes and tikanga for harvesting harakeke. From her domestic pā harakeke, Ema showed me how to harvest the particular varieties of harakeke—kohunga and taeore—that were gifted to her from Diggeress Te Kanawa (Ngāti Maniapoto) from their whanau pā harakeke at Ōparure.*

*Master weaver and spinner Pat Old kindly welcomed me into her home and mesmerised me with her expertise and taonga (treasures). We shared a wonderful exchange in korero (conversation) of each other's design craft and how the two can come together.*

*For me, the cultural and creative research practices by Māori scholars that have enriched this growing field in recent years, including Kahutoi Te Kanawa, Rangi Te Kanawa, Rose Te Ratana, Gloria Taituha, Donna Campbell, John Turi-Tiakitai, amongst others, are becoming my academic pā harakeke. There is a whakapapa connection here to Dame Rangimarie Hetet and Diggeress Te Kanawa, who I wish to acknowledge as key to the revitalization of raranga.*

*This Master's thesis project would not have been possible without the contributions from so many acting as a constant source of inspiration in helping shape and reshape this valuable piece of work. Completing my Masters of Design at Auckland University of Technology, New Zealand has been a privilege and honour that I have had the utmost pleasure of journeying through, with so many.*

*Thank you to my diligent supervisory team Andrew Withell and Natalie Robertson. Thank you for the opportunity to explore this research with you both and for guiding me along the way. Your combine extensive mentorship was invaluable in its final completion. Thank you for believing in me, for keeping the faith and trusting in my processes.*

*My thanks to the AUT University TDL Manager Peter Heslop and Gordon Fraser for your technical expertise and space to experiment the processing of muka yarn.*

*A special mention to Joyce Ross, Pat Old, Elsa Lam and Ema Lyon who supported this work with their precious time and expertise in 'Harakeke, Spinning and Textiles'.*

*To my Heavenly Atua, my tīpuna, my loyal whānau and friends who inspired me throughout this endeavour. Thank you!*

*And finally, I would like to express my sincere gratitude and 'Great Love' for my 'Eternal Family' who I just adore navigating this life beyond. My ātaahua Māori Princesses, Keilani and Khora-Charley. And to my best friend, lover and protector, Terry Ruwhiu. I have never felt so blessed to have someone support me spiritually throughout my life and love me as you (all) do. I am truly blessed!*

*My Soul! My Heart! My Taonga!*

*I love you! …I love you more! …I love you infinity!*

*Always and Forever!!!*

*x Kimberley*


1.8. Shelley at The Polynesian Center, Hawai'i. Photo credit: John Wagner. 1979.

Pepeha

***-Ki te taha o toku papa***

*Ko Moumoukai toku Maunga*

*Ko Waikerepu toku Awa*

*Ko Manutai toku Whare Tipuna*

*Ko Hineahi toku Whare Kai*

*Ko Tahaenui toku Whenua*

*Ko Kaitamure te waahi tapu*

*Ko Ngati Rakaipaaka toku Hapu*

*Ko Ngati Kauaha toku whanau*

*Ko Ngati Kahungunu toku iwi*

***-Ki te taha o toku mama***

*Ko Whakataha toku Maunga*

*Ko Waitangi toku Awa*

*Ko Tauwhara toku Marae*

*Ko Rangiawhiowhio toku Whare-Tupuna*

*Ko Te Kai-U toku Whare Kai*

*Ko Ngai Tawake toku Hapu*

*Ko Ngapuhi toku iwi*

# Table of Contents

**List of Tables and Figures**

***Attestation of authorship***

*"I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the Acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning."*

*Kimberley Alexander-Maaka*

*September 2019*

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*September 2019*

# Introduction

## Concept and Development

*"Kua tupu te pā harakeke—the flax plantation is growing"*[3]

1.9. Establishing our new whanau Pa harakeke. 8+ mths growth from first transplant.

Underpinned by a Te Ao Māori worldview, this design thesis report demonstrates the development of a new technique that transforms harakeke (Phormium tenax) from harvest to a digitally knitted structure. Over the course of study, the research has formed into a 'kāuru hou'—a new leaf. The title of this thesis honours my great-grandmother Heni Te Kauru; the harakeke plant; and the ancestral wisdom that opened a new pathway for my research.[4]

[3] The whakatauaki here is a Māori proverbial saying that refers to a family raised well.

[4] Te Kāuru is a Ngāti Kahungunu ancestral name passed down from Te Kāuru-o-te-rangi who fell at the battle of Te Pakake in 1824. Te Kāuri is memorialized in a poutokomanawa that travelled to the United States as part of Te Māori in 1984, now on loan to the Hawkes Bay Museum and Art Gallery. David J. Butts. Nga Tukemata: Nga Taonga o Ngati Kahungunu, (The awakening: The treasures of Kahunungu. In *The Politics of the Past*. Edited by P. Gathercole, D. Lowenthal. New York and London: Routledge. 1994.

Distinguished ethnographer Te Rangihīroa (Sir Peter Buck) wrote extensively about weaving and consequently the plants associated. At the forefront is harakeke which he describes in detail:

> *The Māori recognize several varieties with different quality of leaf and different strength of fibre. The famous katiraukawa, whose fibre was so sought after for weaving, is too thick and strong in the leaf for baskets and mats. Whilst it can be so used, other varieties with less fibre and a softer blade are preferred.*[5]

This description shows that Māori cultivated harakeke according to the purposes it was to be used for. Te Rangihīroa gave a close reading here of the leaf form and the names that Māori gave to different parts. In summary, he wrote:

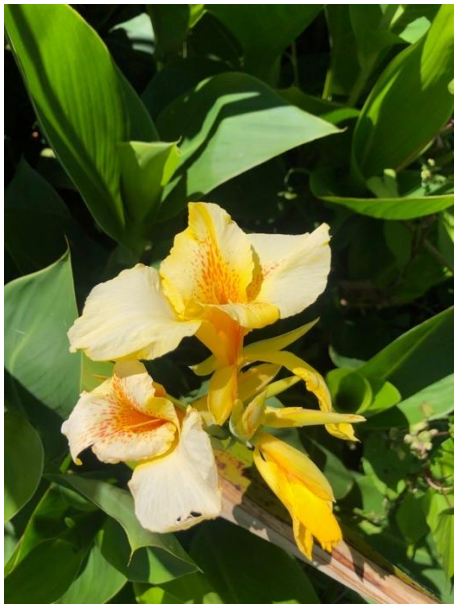
> *The Māoris (sic) called the part above the diagonal line of coalescence the kauru, or leaf, and the part below they called the putake, or butt.*[6]

2. Tending to our Kingsclere Farmstead Pa Harakeke.

This description of the kauru is given another interpretation by renowned weaver and scholar Kahutoi Te Kanawa as 'the opening of the blade'.[7] The depth of Māori knowledge of harakeke expressed through naming the structure of the plant has ramifications for this research. As I

[5] Te Rangi Hiroa (P. H. Buck), "Māori Plaited Basketry and Plaitwork: I, Mats, Baskets, and Burden-Carriers" (1921): 707. [Read before the Auckland Institute, 19th December, 1921; received by Editor, 21st December, 1921; issued separately, 18th June, 1923.]. http://rsnz.natlib.govt.nz/volume/rsnz_54/rsnz_54_00_007750.html
[6] Ibid., 707.
[7] Te Kanawa is the granddaughter of Dame Rangimarie Hetet and daughter of Diggeress Te Kanawa, both acknowledged as being at the forefront of the revival of raranga in Aotearoa.

delved into botanical and natural biological analysis of harakeke, I had an epiphany, that despite everything I had learned to date about harakeke as flax, was fundamentally flawed. Harakeke is not flax. Harakeke is a monocotyledon species, while flax is a dicotyledon species.[8] I discovered in my research that using a plant from the same lily plant family (aloe vera) led to a significant breakthrough in my muka processing. I discuss the implications for this research in-depth later.



2.1. Phormium tenax - Lily plant family.  Our whanau farm.

This research develops methods through experimentation explored within the space of textile and digital design.  A synthesis of unique processing solutions is employed to fabricate a high-quality source of continuous muka—a prepared flax-like fibre yarn extracted from harakeke—through to product. Indigenous knowledge systems are implemented throughout and are significant to this research in improving different aspects of sustainable production within complex infrastructures.

The Textile design sector needs more quality eco-friendly materials cultivating better sustainable processes which are essential to our environment and physical well-being. Internationally, awareness of the need for sustainability has driven new textile research. Here in Aotearoa, some textile producers are exploring hemp (Hemp NZ & NZ Yarns)[9] as a sustainable fibre. This research commences with an understanding that in the textile industry, harakeke has been misunderstood as flax.

[8] B. Lowe, D. Carr, R. E. Mccallum, T. Myers, B. Niven1, R. Cameron, A. Gorham, C. Holtham, And K. Te Kanawa. “Identifying Harakeke (Phormium Tenax) Cultivars Using Whītau and Fibre Aggregate Properties”. Natural Fibres in Australasia: Proceedings of the Combined (NZ and AUS) Conference of The Textile Institute, Dunedin 15-17 (2009). ISBN: 978-0-9598019-3-4.

[9] Hemp New Zealand and NZ Yarns have become partners in developing new yarn blends.
Comparison of harakeke with hemp fibre as a potential reinforcement in composites. Efendy Aruan & K Pickering 2014.
Commercial hemp farmers include Oil Seed Extractors (Canterbury), The Hemp Farm (Waikato) and Hemp Technologies NZ (Taranaki). Other NZ hemp businesses include Hemptech and The Hempstore, both in Auckland. Retrieved from: https://norml.org.nz/about/hemp/how-to-apply-for-a-hemp-permit/

During the late 1800s-1900s, harakeke was the heart of the commercial flax-fibre industry and 'for a time the fibre was New Zealand's most important export commodity.'[10] Sisal replaced harakeke in rope and sacking production leading to the collapse of the industry here.[11] As I will discuss later, my work examines this vacuum left in the commercial textiles sector. As Harris and Woodcock-Sharp note:

> *'From an early stage the commercial phormium fibre industry was interested in the plants selected by Māori as a means to improve the quantity and quality of fibre produced, and Māori varieties were the parents of commercial varieties selected (Scheele & Walls 1994).'*[12]

Internationally, there is revived interest in harakeke's distinct qualities across current scientific research for plant fibre and seed oil,[13]. Locally, research has been undertaken to explore harakeke's valuable anti-fungal properties[14] (Rangi Te Kanawa with Dr Gerald Smith) for conservation of kakahu—garments.

In summary, my research aims to bridge:

- Analogue (hand) to digital processes through knit structure technologies
- European sciences and Māori harakeke phormium fibre knowledges
- Raranga (weaving) and fashion textiles sectors

Bridging these perspectives gives rise to the opportunity for experimentation, creativity and innovation. These are guided by Māori environmental values and Mātauranga Māori.

> *Papatuanuku is a living organism with her own biological systems and functions. She provides a network of support systems for all her children who live and function in a symbiotic relationship. The different species and genera contribute to the welfare of other species and also help to sustain the biological functions of Mother Earth both in their life and death. Māori Marsden. 1992 Kaitiakitanga.*

To realign with our environment and return to Papatūānuku (Earth Mother) natural plant resources, this thesis rests on the philosophical foundations behind traditional Māori creative art expression (toi raranga) and sustainability (kaitiakitanga) within textile conceptions. It aims to formulate a critical inquiry of harakeke within Māori textiles and technology, illuminating its sacred value and potential in the sector.

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[10] Warwick Harris and Mairehau Te Ua Ani Woodcock-Sharp. "Extraction, Content, Strength, and Extension of Phormium Variety Fibres Prepared for Traditional Maori weaving." New Zealand Journal of Botany, 38.3 (2000): 469487.

[11] Although it is not the subject of this report, it is acknowledged that the flax industry had detrimental impacts on health of Māori people who left their hilltop pā to work in swamps. Kaihu the district north ripiro west coast south hokianga: The Flax Industry, 1780-1900. R. Mold, & E.Maude.

[12] Ibid., P470.

[13] Tan Minh Le and Kim Pickering, "Harakeke (Phormium tenax) Seed Oil" 2(015).

[14] Accessed September 2019 from: https://www.sciencelearn.org.nz/resources/1271-preserving-harakeke-taonga

> *'By acknowledging the past and laying down the foundations for the future; past, present and future are brought together in one space'*[15]

**Harakeke – Past**

> *The Māori world view acknowledges a natural order to the universe, a balance or equilibrium, and that when part of this system shifts, the entire system is put out of balance. The diversity of life is embellished in this world view through the interrelationship of all living things as dependent on each other, and Māori seek to understand the total system and not just parts of it.*[16]

Māori have an intricate, holistic and interconnected relationship with the natural world and its resources with a rich knowledge base developed over thousands of years[17]. Many Māori view themselves as one with the whenua (land) and often can link their whakapapa (genealogy) directly through their ancestors to the spirit realms. Everything is connected by wairua[18]. Accordingly, these are animated by the 'hau ora', the energy that drives the cosmos. The whitau fibre extracted from harakeke is mentioned early on in cosmogonies, such as in this example from an oriori (chant) from Te Whanau-a-Kai, one of the eastern seaboard people of the Horouta waka.

| | |
|---|---|
| *Nā Tu-i-te-repo, nā Tu-i-te-wao,*<br>*Nā Tu-te-hemo-rere, nana Rangi-tahuri;*<br>*Nāna te whitau, ka roia hei kaka, Ka mahana i ahau.* | The Oozy-swamp, the Oozy-forest-swamp;<br>Tu-te-hemo-rere begat Rangi-tahuri;<br>She grew the flax from which the cloaks were woven<br>That now keep me warm. |

Phormium tenax is the New Zealand flax plant (Harakeke) used for Māori traditional weaving (toi raranga). The place of harakeke in Māori legend is of great significance, coming under the guardianship of Hineteiwaiwa. Tane the God of the forest married several wives to produce different families of children. From one wife was born the healing trees, from another the building trees.

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[15] Marsden, M. *Beyond Science*. Unpublished paper 1990. Auckland.

[16] Garth Harmsworth & Shaun Awatere, *Indigenous Māori Knowledge and Perspectives Of Ecosystems. Ecosystem services in New Zealand – Conditions and Trends, (Lincoln, New Zealand,* Manaaki Whenua Press, 2013), 274-286.

[17] Mason Durie, *Whaiora: Maori Health Development,* (Auckland: Oxford University Press, 1994).

[18] Tānia Ka'ai and Rawinia Higgins*, "*Te ao Māori–Māori world-view." Ki te whaiao: *An introduction to Māori Culture and Society,* (2004): 13-25.

Tane then found Hinerauamoa, the smallest and most fragile star in the heavens, who became the female element Tane had been searching for to create humankind[19]. From their union came Hineteiwaiwa, the guardian of raranga and whatu, childbirth and also the cycles of the moon[20]. Forster cites the power of Hineteiwaiwa which 'is evoked in relation to womanhood, childbirth, parenting, the performing arts and weaving.' (see for example Yates-Smith 1998; Simmonds 2011; Murphy 2014.'[21] While Hinerauamoa is acknowledged as the initiator in the art of weaving, well known Māori Atua (deities) associated with raranga are Rukutia and Huna. Rukutia translates to mean 'bound together' and is believed to be the founder of weaving and plaiting.

Kairaranga (master weavers), were traditionally initiated into Te Whare Pora (The Ancient House of the Art of Weaving). Kairaranga are known to possess intricate knowledge of harakeke and their natural environment. The customary title today is not exclusive but can be applied to all contemporary weavers of the plant. A weaver intrinsically aligns themselves with the atua (God) of weaving; they connect the teachings to their everyday life and to them, pa harakeke (plantation) is a living, breathing person[22]. Master weaver Donna Campbell states that 'Te Whare Pora then is a conceptual as well as physical space of creativity and connection interweaving mātauranga Māori and art praxis'.[23] Although my own research operates in the space between textiles and raranga, my sense is that it is guided by the tenets of the Whare Pora in harvesting and care of harakeke.

For Māori, the importance of this plant provided essential parts of life. Numerous fundamental items were made from harakeke in Māori society prior to European colonisation, including many different kinds of basket (kete), clothing (kākahu), floor mat (whāriki), and fishing net (kupenga). Buck[24] notes that "with the exception of kiekie and toi used in some rain capes, the fibre used in Māori garments was obtained from the leaf of the Phormium tenax." The 'muka' fibre is a native and natural resource that provided Māori communities with many uses. Weavers favoured using harakeke for its durability, strength, fibre content and availability. These qualities have been significant in my exploration, which I will unpack later.

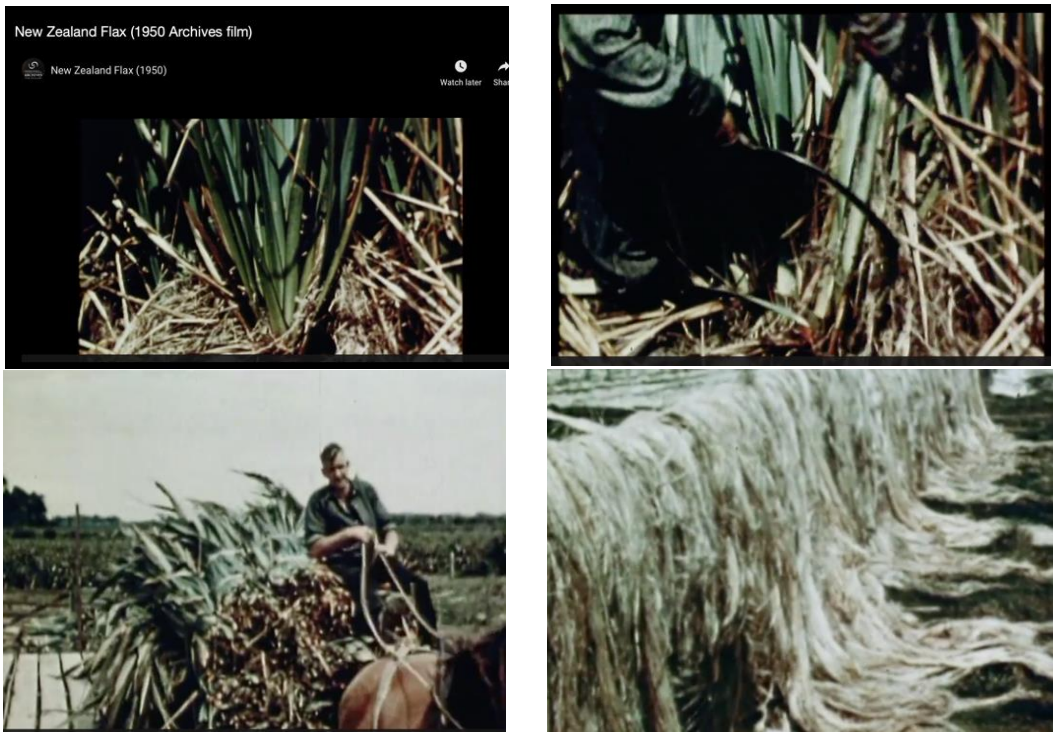
Before 'sisal' fibre became the preferred choice of the time, hand-dressed muka fibre was exported overseas in a lucrative European trade[25] to produce industrial items shipping ropes, fishing lines and net making[26]. Europeans recognised the value of harakeke and its potential by observing

[19] Elsdon Best. "Omens and Superstitious Beliefs of the Maori. Part I." The Journal of the Polynesian Society 7/3 (27 (1898): 119-136.
[20] Best, 1898.
[21] Margaret Forster. Restoring the Feminine of Indigenous Environmental Thought. *Genealogy 3*/1, (2019). 11; https://doi.org/10.3390/genealogy3010011. https://www.mdpi.com/2313-5778/3/1/11/htm
[22] Best, 1898; Te Kanawa, 1992.
[23] Donna Campbell, "Ngā Kura a Hineteiwaiwa: The Embodiment of Mana Wahine in Māori Fibre Arts"(Doctor of Philosophy, University of Waikato, 2019).
[24] Hiroa Te Rangi, and Peter Buck. "The Evolution of Maori Clothing." *The Journal of the Polynesian Society,* 33/1 (1924): 25-47.
[25] Flax and Fibre, 2008.
[26] Durie, 1994.

Māori. The traditionally extracted muka fibre by Māori people was exported to Sydney and England as harakeke became a marketable commodity. Māori 'haro' method of extraction was preferred by traders for its superior quality fibre and tensile strength. However, the exploitation towards Māori, the laborious process of prepping harakeke and muka combined with a history of colonial factors, abruptly ended bartering, over time during 'the Māori Land Wars'.

This caused early European settlers to adopt innovative new technology to continue and sustain export of muka. As Landcare researcher Sue Scheele has pointed out, flax mills were established in places where harakeke was naturally located. In the first decades of the twentieth century, the fibre from harakeke was somewhat surprisingly New Zealand's biggest export. Scheele notes that development of machinery could harvest large quantities of fibre however the method of extraction produced an inferior quality in fibre to that extracted traditionally by hand.[27]

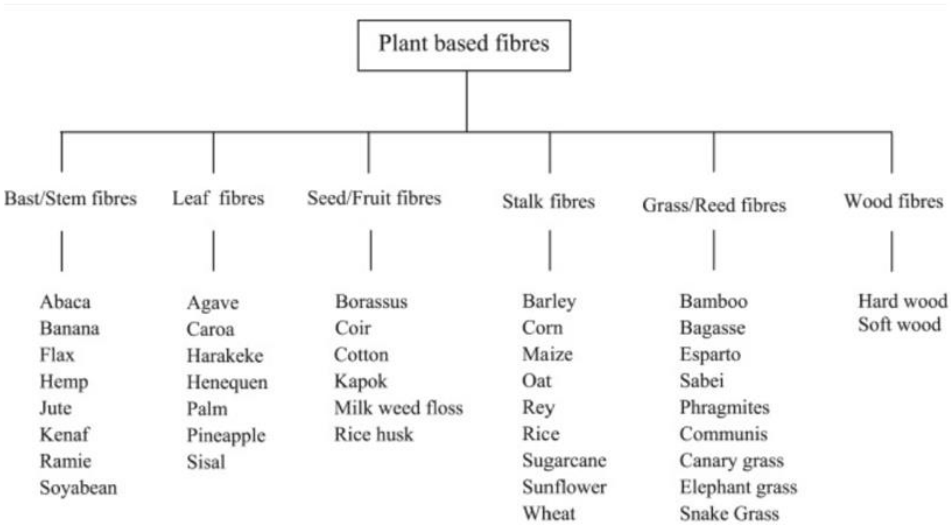
During this period Māori traditional methods of sustainability and the importance of kaitiakitanga were overlooked by European and a large number of Māori were forced to move and work in unhealthy flax swamps to gather harakeke for trading. Māori custom, partaking of the outer leaves only to sustain the life of the plant were restructured into new practices of harvesting Pa Harakeke completely after five years. Despite overwhelming evidence to the contrary of these new practices with social structures, ideologies clashed and 'an epidemic of the disease 'yellow-leaf' in the important Manawatu production area caused a decline in production'.[28] Eventually in time the industry was unable to sustain itself and dissipated with a change to cheaper synthetic fibres.




2.2. New Zealand Flax Industry (1990) film

[27] Sue Scheele, "Harakeke: The Rene Orchiston Collection" © Landcare Research New Zealand Ltd. Manaaki Whenua Press, (2005): 6.
[28] Ibid, 6.

Harakeke (Phormium tenax) and other species whaririki (Phormium cookianum), are often referred simply as ‘New Zealand flax’ and mistaken for ‘common flax’ species (Linium usitatissum). Scientists David and Pailthorpe categorise Harakeke—a perennial plant of the genus ‘Phormium tenax’—as a “leaf fibre” as New Zealand hemp.[29] From the Linaceae plant family, Linen textile is made of flax, genus ‘Linum usitatissimum’, a bast fibre obtained from the stalk of *dicotyledonous* plants.[30] Its growth form is soft, not woody. Both plants; flax and New Zealand flax; scientifically identified as Phormium tenax, have no relationship to each other. Harakeke originates from the lily plant family, distinguishing the native plant to other popular fibres widely used in textiles such as cotton, flax, sisal, hemp and bamboo. This is where I learnt the importance of identity. Harakeke wasn’t flax but why is referred as New Zealand flax? While there is a significant amount of research referring to the incorrect terminology, I could not find one paper relating to how important this is for New Zealand textiles. Harakeke has similar characteristics to flax which ‘linen' is made from and is a competitive fibre on the global textile market. The discovery Harakeke is from a completely different plant family has significant impact on this research.




2.3. Plant-based fibres table. Source, Figure 4. ’The Potential of Harakeke’. Le & Pickering, 2014.

[29] David, Shantha and Michael Pailthorpe, “Classification of Textile Fibres: Production, Structure, and Properties”, Chapter in James Robertson, Michael Grieve (Eds.), *Forensic Examination of Fibres* (International Science and Investigation. Second Edition, (London & Philadelphia: Taylor and Francis, 1999).
[30] Ibid, 11.

A number of recent scientific publications have elucidated aspects of harakeke growth and have provided information about some of the approximately sixty varieties known to Māori.[31] Different varieties of Phormium tenax produce more fibre than others, with a number known for their superior grade and quality of muka. These varieties are; Arawa, Makaweroa, Ngaro, Opiki, Parekoritawa, Ruapani, Ruawai, Tapamangu, Taumataua, Takirikau, Tapoto and Whareongaonga. Three cultivars; Arawa, Tapamangu, and Makaweroa are commonly revered to be of highest quality for its 'silk-like' fibre content that is found amongst them all. However, the varieties nurtured by Diggeress Te Kanawa and her whanau include Kōhunga and Taeore.

> *'Black-edged varieties are regarded by some weavers as having the best muka. The wellknown varieties 'Kōhunga', 'Taeore' and 'Tapamangu' fall into this category. However, having a black edge and/or keel is not necessarily indicative of good fibre. There are excellent varieties with orange keels and margins, such as 'Arawa' and 'Makaweroa'.'*

I used a range of varieties for testing including Kōhunga and Taeore, from Oparure. I also used Arawa and sometimes just what was available or gifted to me.

2.4. Transplanting Harakeke.

[31] See, for example, Harris, Scheele, Brown & Sedcole, 2005; Harris & Woodcock-Sharp, 2000; McBreen, Lockhart, McLenachan, Scheele & Robertson, 2003; Scheele & Walls, 1994.

Harakeke is respected through tikanga (customary practices) and conserved through the practice of Kaitiakitanga (guardianship). Kaitiakitanga means 'guardianship' and defines the act of conserving customs and traditions, including its purpose and means.[32] The condition of harakeke and quality of muka fibre obtained can be a good indication of the state of the overall ecosystem and care of the plant or soil quality. General lack of care and non-maintenance towards a Pā Harakeke result in poor soil health inviting disease and low quality of fibre for textile use. In my own experimentation, I noted a relationship between the quality of the fibre and the conditions of the pā harakeke and soil health, particularly dry conditions.

The Textile Industry is one of the most polluting industries globally, with serious environmental impacts. Given this, designers such as myself are beginning to question their own practices. Within a society driven by market considerations, conservation and sustainable management policies must eventually fail.[33] In a market-driven economy, values that revolve around economics rank uppermost. This value overrides spiritual and human considerations and the profit motive becomes the prime value.[34]

With an increasing global awareness around the environment and our green processes, research is re-visiting natural plant fibres for their efficacy into future products. This has also seen a revival of interest in New Zealand's very own native plant Harakeke (NZ Flax) for its traditional benefits. Some of these range from pharmaceuticals for the plant's medicinal properties, cosmetics for its skincare benefits, agriculture in farming, its ecological purposes and its abundant uses in apparel.

> *'Rather than just designing products (whether visual or tangible), designers will also have the opportunity to design systems that can address and facilitate a number of concerns, ranging from procurement and transport of raw materials, to production, distribution, marketing, and sales, as well as any associated environmental and social issues.' (Crouch and Pearce, 2012: 27-9)*[35]

As spiritual beings our earth is our garden and it is important to honour and keep care of its sustenance that is necessary in life.[36] Maintaining an equilibrium towards the overall care of harakeke sustains the plant; the efficiency of a sustainable structure; and the quality of the fibres for design purposes.

[32] Marsden, 1992
[33] Marsden, 1992
[34] Marsden, 1992.
[35] Christopher Crouch and Jane Pearce, Doing Research in Design: (London, Bloomsbury Publishing, 2012
[36] Marsden, 1992.

**New Technology – Future**

> "Illumination is from above, a revelation gift from God. When it occurs, it acts as a catalyst integrating knowledge to produce Wisdom" *-Marsden, 1992*[37]

As future technological advancements appear with a drive towards more ecological and biofriendly interventions, digital technologies provide openings of new opportunities in harakeke production and manufacturing. I originally ventured down investigating how I could fabricate a 'muka' PLA blend continuous filament for 3D modelling. The transition towards Whole-garment knitting to produce a 'muka' yarn for knitting technology was natural.


2.5. WholeGarment® Shima Seiki.

*AUT electronic knitting machines offering; cut and sew, fully fashioned and WholeGarment® (seamless) knitwear, knitted products.*

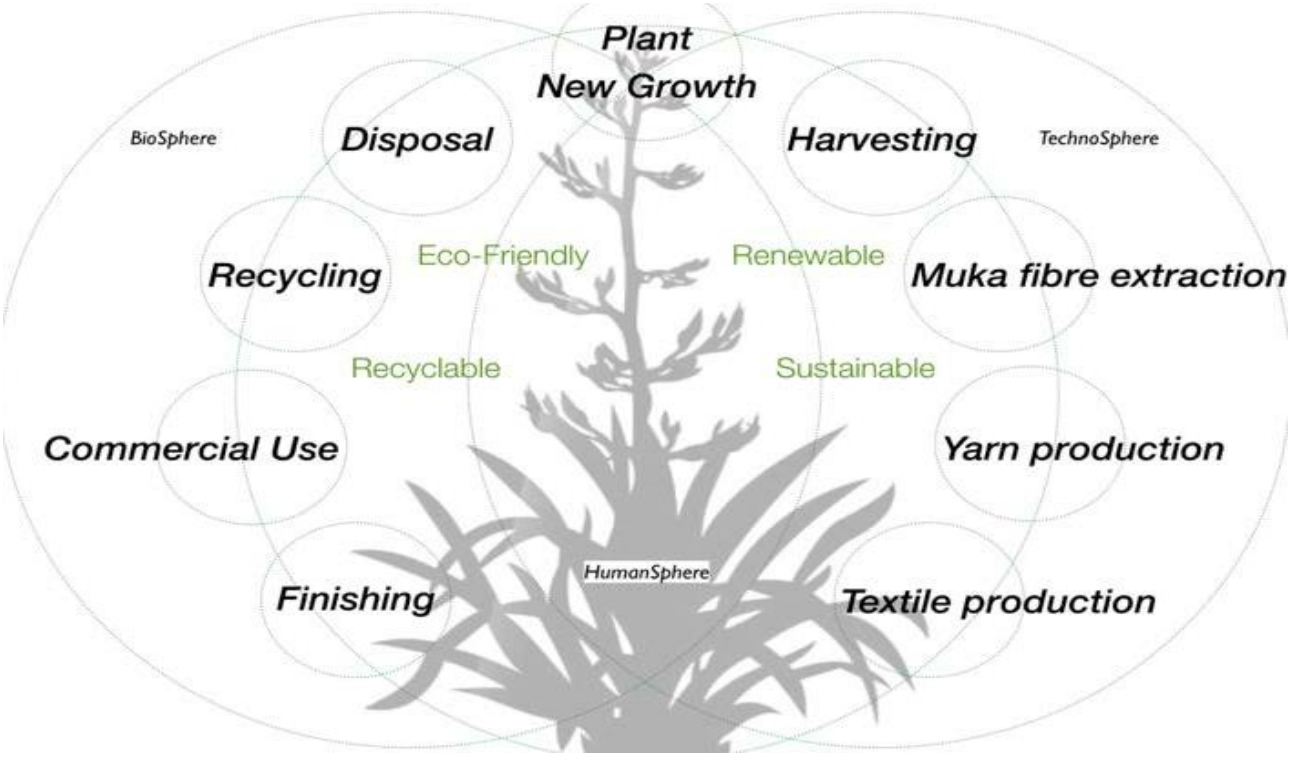
WholeGarment® (registered trademark of Shima Seiki),[38] is a computerised knitting machine that creates seamless, three-dimensional, knitted to form, textile structures directly from the machine. Seamless technology is versatile in nature with infinite opportunities in the small and large-scale markets, both locally and internationally. The flexibility WholeGarment® seamless knitting provides in the foundation of geometric structures allows for the creative investigation into specialised semi-industrial knit yarns that incorporate special features such as moisture management properties. The digital world of textile fabrication reaches across many disciplines and contexts other than apparel. Contemporary designers now consider how skills and talent can be applied through the transition of knowledge into the real world around us.

[37] Marsden, 1992.
[38] Whole garment knitting minimises time and cost associated with sewing providing a quick response to production scalability, consistent quality and material savings. Production in consumer markets are personalised to fit an array of consumer silhouettes to provide fit and comfort.

To date, no method of Harakeke cultivation has been discovered that maximises both quality and yield of muka fibres for knitting yarns. Rangi Te Kanawa, is a NZ textiles conservator at Te Papa Tongariro in Wellington, who works with scientists to protect culturally woven Indigenous Māori pieces. While manufacturing is only one part of the supply chain, Te Kanawa encourages a harakeke industry that would be self-sustaining and have quadruple sustainability that is of benefit to NZ culturally, socially, environmentally and economically.[39] By learning from the past, Harakeke could provide a plethora of opportunities in competing on a global market once again.

When understanding whakapapa systems in each specialised singular domain, we are better equipped to shift from product to people/customer and construct conceptual technological vehicles that allows the purposeful solutions and opportunities relevant in helping us maintain our environments.

[39] Michelle Riley, "Harakeke: New Zealand Flax: An Historical Perspective and Overview of Current Research into Future Use," (2004).




2.6. My kaupapa Maori muka textile production model.

To explore Harakeke muka fibres from harvest to digitally knitted structures without compromising cultural values, this Masters research project uses a Kaupapa Māori methodology. Like many researchers before, I have found Linda Tuhiwai Smith's seminal book Decolonizing Methodologies to be pivotal and liberating.[40] Along with the work of other indigenous writers, Smith emphasizes the importance of writing about indigenous spiritual beliefs and world views, as a part of research. Chapter 8 'The Twenty-five Indigenous Projects' provided core tenets— connecting, envisioning, creating, and discovering are particularly relevant to this project.

> *'Connecting is related to issues of identity, place, spiritual relationships and community well-being; envisioning—'dream a new dream and set a new vision'; creating—'creating is about transcending the basic survival mode through using a resource or capability which every indigenous community has retained throughout colonization the ability to create and be creative' and 'it fosters inventions and discoveries'; discovering—'navigating new science and technologies and incorporating them into indigenous development'.*[41]

[40] Linda Tuhiwai Smith, *Decolonizing Methodologies—Research and Indigenous Peoples*, (London and New York, Zed Books, 2013).
[41] Ibid, 2012. 149-159.

Each of Smith's statements above confirm for me that dreaming, inventing, discovering, and using a resource in a creative way are relevant to design research. The textile-based model is a system of processes techniques and protocols represented within an indigenous scope which is affordable and preserves the structural integrity of Papatūānuku. It provides the framework within which this thesis technique is derived from. This aligns with Sarah Jane Tiakiwai's notion of weaving as a metaphor for drawing together the methodological and theoretical frameworks.[42]

The concept is located in Māori cosmology and embodies a wider spectrum of Māori spiritual traits and tikanga (customary practices) associated with toi raranga through practice. Cultural knowledge is applied to science research which intertwine and fuse the secular and sacred together. The methods in creating this unique technique are encased in Māori rituals, science and sustainable practices applied in a variety of ways. These allow a descriptive mode of transportation to be able to *'*create something new through that process of sharing is to recreate the old, to reconnect relationships and to recreate our humanness.'[43]

Here, I turned to Matiu Ratima's challenge that 'Māori spirituality must remain central to the investigation, and so must the challenge for academics to continue to 'make space' for Kaupapa Māori within the Academy.[44] I took up this challenge acknowledging the spiritual dimensions of this research.

Communication with the natural world and ancestors, as well as knowing that comes through dreams, visions and intuitions, forms an integral part of Indigenous Knowledge Research.[45] It ensures certain tikanga are in place, are tacit, time-honoured, and experiential. Mead explains "although this might be carried in the minds, tikanga Māori puts that knowledge into practice and adds the aspects of correctness and ritual support".[46] Observing tikanga is part of the ethic and exercise of kaitiakitanga (sustainability) throughout this methodology.

Here, Ella Henry and Hone Pene provide a succinct explanation that has further affirmed my understanding and application of Kaupapa Māori methodologies:

> *Kaupapa Māori is both a set of philosophical beliefs and a set of social practices (tikanga). These are founded on the collective (whanaungatanga) interdependence between and*

[42] Leonie Pihama, Sarah-Jane Tiakiwai, and Kim Southey."Kaupapa rangahau: A reader. A collection of readings from the Kaupapa Rangahau workshops series, Te Kotahi Research Institute, (2015).
[43] Smith, 2012.
[44] Matiu Ratima,"Making space for Kaupapa Māori Within the Academy." MAI Review LW 1.1 (2008): 3.
[45] Polly Walker, "Journeys around the Medicine Wheel: A story of Indigenous research in a Western University," *The Australian Journal of Indigenous Education*, 29, no. 2 (2001): 18-21.
[46] Mead (2003) p.7

*among humankind (kotahitanga), a sacred relationship to the 'gods' and the cosmos (wairuatanga), and acknowledgement that humans are guardians of the environment (kaitiakitanga), combining in the interconnection between mind, body and spirit. Taken together, these ethics inform traditional Māori ontology and assumptions about human nature; that is, 'what is real' for Māori.*[47]

Kaitiakitanga is practised through tikanga and maintained through tapu/noa (equilibrium) that focus on conserving and protecting the value of the plant harakeke and support community development.[48]

[47] Ella Henry and Pene Hone, "Kaupapa Maori: Locating Indigenous Ontology, Epistemology and Methodology in the Academy." Organization, 8.2 (2001): 234-242.
[48] The environmental benefits reduce greenhouse gasses while conserving resources for a high-performance apparel.

# Design Practice - Fibre to Product

Fibre to Yarn to Textile Interfaces


2.7. Creative Mind-mapping design process.

## *A guide to muka yarn fabrication (Tahi-Waru)*

### Characteristics of spun yarns/mechanical process

The process of textile spinning entails twisting strands of fibres together. Although this simple principle of twisting together strands has been mechanised and industrialised, traditional handspinning fibres with the aid of a spinning wheel is still widely practiced. The fibre is rhythmically drawn out, twisted together, then spooled onto a bobbin. The grouping of fibre filaments, with the addition of a twist, creates yarns that change depending on what raw material is

utilised. Factors that impact the end product of yarn include the length of fibres and their quantity, along with the degree of twist.

A thicker yarn may be created if desired by spinning multiple fibres or yarn together which is a process called plying. The quality of the muka knit structure is greatly dependent upon the process before it meets digital technology. Yarn must be twisted strong enough to glide and handle any resistance caused throughout the mechanical digital stage. A breakage in yarn during knitting (particularly a hole or a barré) can damage the entire garment.

I found that to make a textile fabric, a continuous yarn, three key skill sets are required, with mastery of weaving, a spinning and digital. One is not greater than the other. They are all equally important and hold value in the overall cloth. Pat Old, a master weaver and spinner from Tauranga, was the only person I could find that had successfully spun muka for hand applications. She was the keystone in catapulting my research forward.

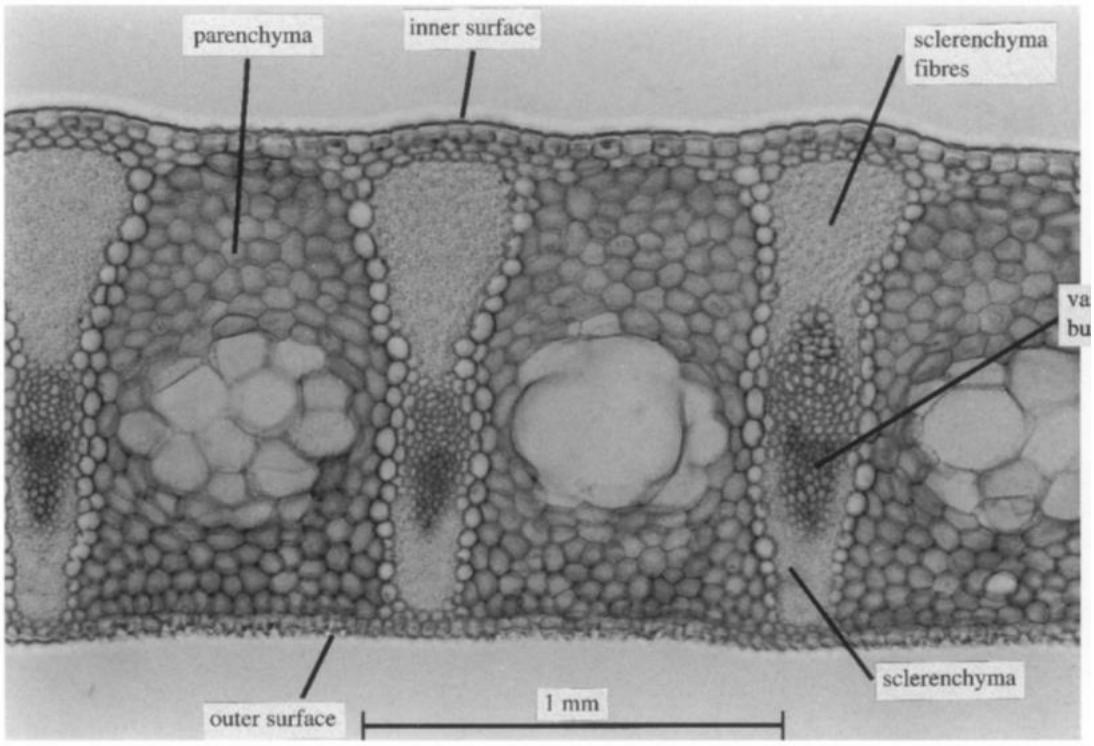
Pat graciously shared her technique which follows a similar process to European flax and kindly donated samples of her muka thread with a small bundle of prepped fibre to get me on my way. The fibre was harvested from her own Pā Harakeke outside her home. To receive such a gift is special to traditional weavers as there is a mutual understanding and appreciation of the laborious process and time required to produce such items.

From here, Elsa Lam (Master Spinner) from Auckland was wonderful in supporting me through the beginning stages of spinning and together spun about 5m of thread using Pats technique to test through the knitting machine. Unfortunately, the yarn kept snapping through the machine tensions and the test failed. This is when I had an epiphany and realised my end design application has a different purpose and would require something new. I needed a continuous yarn that was strong enough to withhold the mechanics of technology and smooth and fine enough to glide through the needle heads without snapping them. The challenge with plant fibres is the inconsistency in achieving a fine thread without the fibres sticking out and catching. The fibre has variations throughout and can be brittle.

This is when I decided to apply my cultural knowledge with science to discover solutions in understanding developing muka in a new way in cohesion with the digital world around us.

> *Additional analysis of microscopic images of the tissues permit to study the correlation between this elastic and ultrasonic tissues properties and main microscopic features*

*like cell size and cell wall thickness, which are determined by the different function of these tissues.*[49]




2.8**.** Light micrograph of a section through part of a leaf of Phormium tenax. *Source, Biological Sciences, Figure 1. King & Vincent, 1996.*

This made me think of the different functions needed to process a yarn through the knitting machine. Understanding the basic technicalities of knitting code and mechanics of the technology was important to finding what the thread needed to glide through successfully.

Commercial knitting technology requires, 1. the thread needs to be thin enough to go through the multipile needle heads and 2. strong enough to with-hold the tensions at rapid speed.

The elastic modulus[50] tested in this paper was important in understanding the plant on a micro level to understand what the machine required. Understanding the science behind the leaves helped me find the solutions to the challenges behind this technique. Has this been attempted before or failed?

[49] *M Farinas and T Alvarez-Arenas, "Ultrasonic Assessment of the Elastic Functional Design of Component Tissues of Phormium Tenax Leaves,"* Journal of the Mechanical Behavior of Biomedical Materials *39 (2019) 304–15. Accessed September 17. doi:10.1016/j.jmbbm.2014.07.018.*

[50] This is simply the ratio between stress and strain. Tensile elasticity is defined as the ratio of tensile stress to tensile strain and is often referred to simply as the elastic modulus.

*The following sub-chapters Tahi (One) through to Waru (Eight), provide descriptive text accompanied with visual images in the Appendices to further demonstrate this model. This process illuminates various intricacies of experimental key understandings required throughout each stage to produce a high quality continuous muka yarn.*

**Tahi (one) Harvesting harakeke**

2.9. Preparing the harakeke.

When harvesting, harakeke tikanga (customary practices)[51] is used to re-connect one with whenua (land) and to ensure respect towards the sacredness of this life-giving plant. These are based on a spiritual view pertaining of the natural world and can vary between Maori iwi, hapū and rohe. The weaver observes the appropriate customary practices pertaining to harakeke, specifically when harvesting and on completion of the final artefact.

> *The techniques employed for raranga used to this day in contemporary and traditional works are customary taonga (gifts) that are passed from generation to generation and again relate to the wharenui.*[52]

[51] D Campbell, "Weaving the Skin" (2005).
[52] Ibid., 2005. P, 13.

One example of harakeke tikanga I learnt and practice is quietly offering a karakia (prayer) of gratitude, respect and reverance before any cutting begins. It is a duality of the mind many weavers enter to link past and present with best practice moving forward when partaking of the plant in any art-form. It becomes a powerful communication system that allows me to visually see creative ways in my practise and how I can further apply them tangibly to my daily experiences.

> *In saying this maintaining the traditions of raranga does not impose any restrictions on the evolution of the processes, but rather it serves to elevate the exploration and innovation of the present day weaver*.[53]

Weaver and Artist, Ema Lyon (Auckland) was the catalyst in gently helping me reconnect with toi raranga. I quietly observed while I slowly built confidence as Ema attentively spent time teaching me how to harvest, extract and transplant harakeke all from her own special urban Pā Harakeke. The leaf is physically removed by hand from the outer base layers of the mature (grandparents) leaves, ensuring the continual life of the mother plant. Only older leaves are harvested leaving the younger middle three shoots untouched, to further grow. Ema was my inspiration behind having the confidence to start harvesting my own.

3. Harakeke tikanga. Offering of karakia before harvest.

[53] Ibid., 2005. P, 18.

3.1. Harvesting and Prepping Harakeke for extraction.

**Rua (Two) Haro - extracting muka fibre**

3.2. Extraction set-up.

Māori traditionally extracted muka from the harakeke leaf using a raw mussel shell which is still considered to be the most efficient way of producing the highest quality of fibre. I applied this technique to my extraction of muka. As in all fibres, there are different qualities of muka. Some is finer, some is coarser. There are also colour variations between leaves and these differences become more conspicuous after the muka has been spun into yarn. Fibre constituents found inside the leaf such as pectin, hemicellulose and waxes; are extracted using Māori haro in the extraction process.

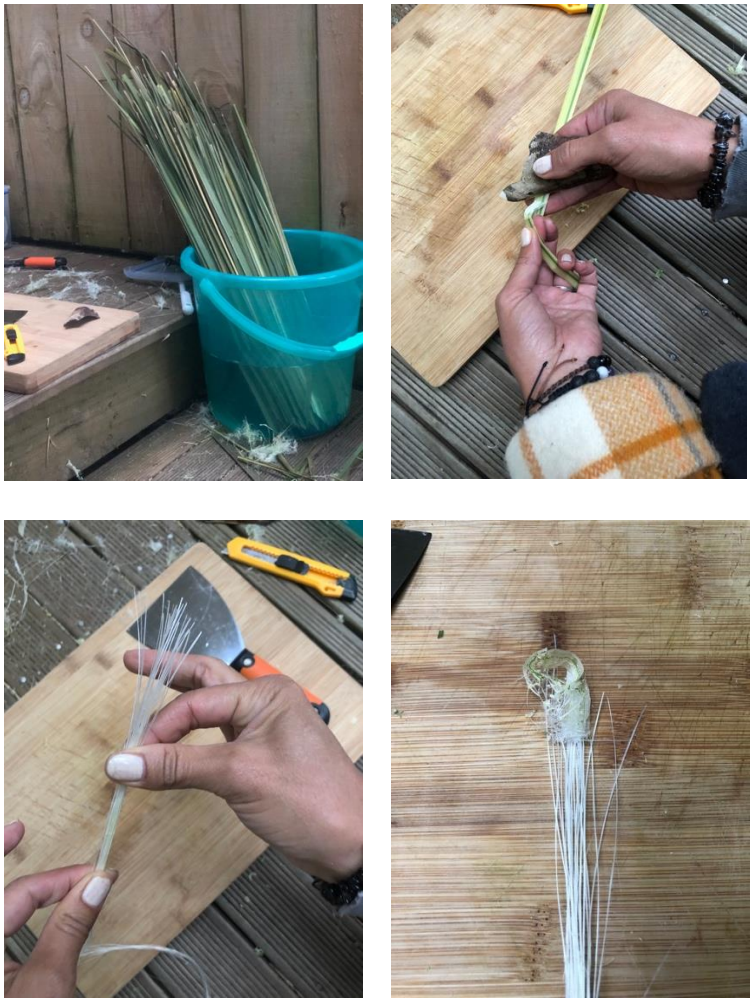
> *Different sections of the leaf are occupied by different tissues having different morphologies and features that are related with the different functions that these different tissues play in the leaf…sheath cells seems to be, from the mechanical point of view, a transition layer to efficiently connect the soft spongy mesophyll and the hard vascular bundle and to ensure leaf mechanical integrity in spite of the large deformations that can take place in the leaf produced during water content fluctuations.* [54]

These properties enhance the muka fibres properties and is what gives the leaf its superior strength, shine and flexible smooth exterior. This bonding that is extracted is what will need to be replaced at spinning process to meet the technology requirements. This made me think of the leaf epidermis qualities that align with the machine purpose, which are properties extracted to expose the muka. Understanding how to approach replacing the layers extracted between the muka

[54] M Farinas, and T Alvarez-Arenas, 2019.

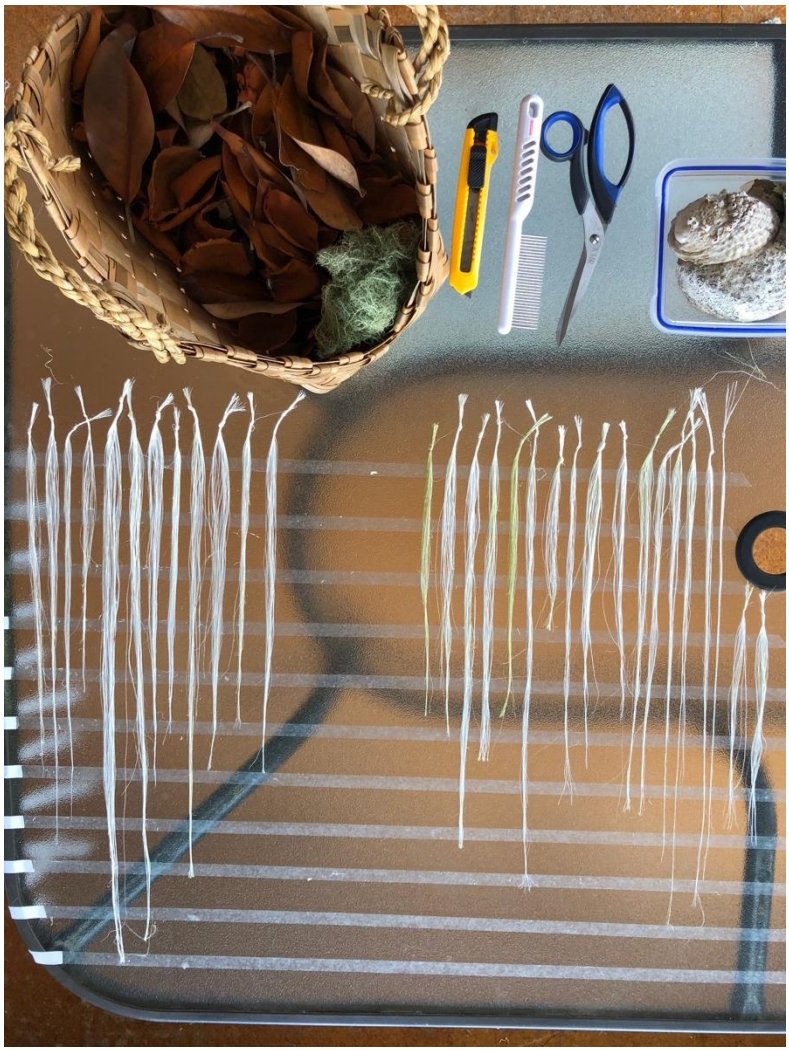
fibres that hold them together as a whole, initiated my first steps towards fabricating a binding agent to restore these properties the leaf epidermis provides. These qualities are needed to allow for a smooth process through the knitting technology.

After stripping, each bundle of muka, it is then knotted at the root end which keeps the fibres from becoming tangled between the stages it is prepared and spun. This is one of various methods explored for its efficiency in processing. I found that extracting muka then knotting the ends; 1: provided a faster process at the next step of the technique resulting in a superior quality of yarn, 2: created easier handling of fibres between stages and 3: storage of the bundles of fibre did not require special care of having to keep the fibres from rolling up on itself.



3.3. Extracting the leaf epidermis using a mussel shell to expose the muka fibres inside.

**Toru (Three) Drying the muka fibre**



3.4. Drying muka laid straight.

The still damp fibre is laid straight on a mat or flat surface to dry over-night. Brushing muka wet will tear and cause breakage to the fibre properties. During this drying stage, muka will naturally dry and curl in a Z direction onto itself. I experimented with two different drying methods. Pat Old dries muka straight, weighted down with wooden rods which works well. As I travelled a lot conducting this field research I turned my art drawing board into a portable drying station that is easy to transport. It is lined with double sided tape, roughly 5cm apart to adhere the muka as it dries.

3.5. Fibre twisting on itself as it drys.

3.6. Drying bundles of muka. *(un-knotted)*

As this technique has developed, I have found keeping the thicker ends of the fibre together by adding a knot prevents excessive fibre loss between processes. This keeps the fibres together within a big bundle which can then be untangled easier when combed later on. Drying muka flat weighted with wooden rods (Pat Old technique) or double-sided tape (exploratory) is to encourage the fibres to set straight to exercise minimal fibre loss. Drying the bundles of fibre removes trapped air between fibre cells before testing.[55]

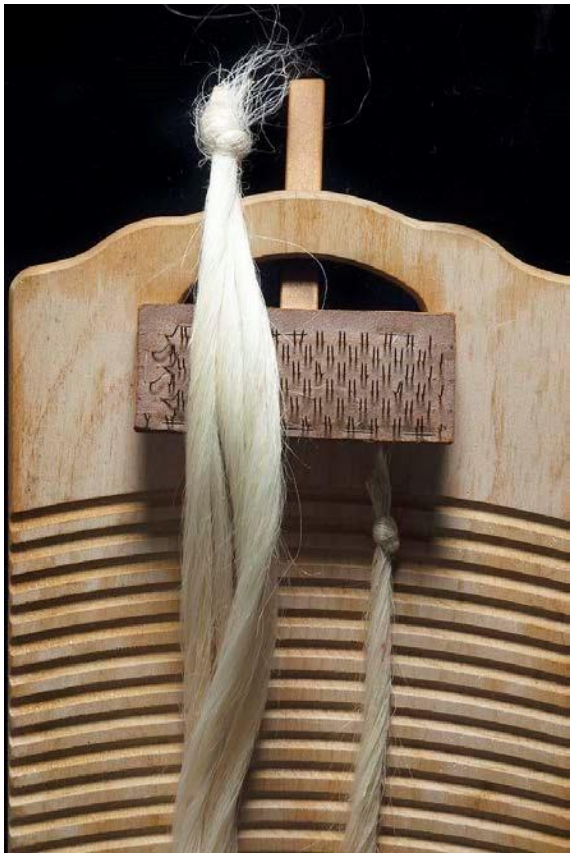
3.7. Portable drying box & rods.

3.8. Straight set drying using double-sided tape.

[55] T Le and K Pickering, "The Potential of Harakeke Fibre as Reinforcement in Polymer Matrix Composites Including Modelling of Long Harakeke Fibre Composite Strength," Composites, Part A 76, (2015). 44-53.

3.9. Using various drying methods to suit harvesting locations.

**Wha (Four) Combing then wave-setting muka**



4. Combed *'silk like'* muka fibres.

**Combing the fibre**

Muka fibre is soft, lustrous, and flexible when delicately combed through. The separated fibres are combed using a hand carder which have small rows of steel set in a wooden base that splits and buffs the fibres while taking out the shorter *'tow'*[56] fibres from the mix. I take a handful of fibres by the root ends and gently pull down and flip just the very tips of the fibres onto the carder. Pulling the fibres down into the steel teeth will damage the fibres causing unnecessary wastage.

A breakthrough in my research came in an unexpected moment. One day, as I sat brushing my daughter's beautiful long brown curls, my mind drifted towards the memory of my Grandmother and Mother caring for me as a child in the same manner. As I slowly learnt to build a gentle touch to combing, my mind was processing in the background what treatments we require ourselves to restore natural balance to our own damaged hair. I had a striking realisation of how sacred (tapu) hair is in Māori tradition, then made the connection between caring for the harakeke fibre and

[56] A 'tow' is a short or broken coarse fibres removed during the processing of plant fibres like muka, flax, hemp, or jute.

human hair. Hirini Moko Mead discusses in detail the tikanga of hair[57] as it pertains to protecting one's personal tapu and hauora (well-being). This is further discussed throughout the research.

I gradually learnt how to draw the fibres lightly across the top of the steel comb and work my way up the centre of the fibres and reverse. The idea is to consider brushing someone else's hair. You need to cultivate a tender restraint to prevent the fibres tangling, yet a flexible grip in motion to help pull through any that may need a slight tug. Sweeping the fibres through the comb takes refined care to avoid damaging the muka. The knot-end may be removed here and reversed for combing lightly from root tips to center. Left over short fibres (tow) can be repurposed into other functional uses.

4.1. Excess fibre from combing that can be repurposed

Wave Set

Because of the smooth surface, muka can sometimes have a lack in cohesion of fibres which can make it difficult to spin. I came across a New Zealand National Film Unit documentary called NZ Flax from 1950 that shows how muka fibre was processed during the New Zealand flax trade.[58] A quick mention of setting a wave into the fibre alerted me to implement that here.

[57] Mead, H, M. Tikanga Māori (revised edition). Living By Maori Values. Wellington: Huia Publishers, 2016
[58] http://www.Māoritube.co.nz/how-to-and-diy/new-zealand-flax-1950-archives-film/. Fibre given a wave set. The documentary is also an example of the misnaming of harakeke: 'This film takes a look at the harvesting and milling of New Zealand flax – New Zealand's oldest industry. New Zealand flax is one of the country's most distinctive native plants.'

Because the fibres are long, the muka requires special handling to keep the fibres organised and avoid tangling during spinning and processing. I found an old home crimping iron and set waves into the fibres as if you would your own hair. I found this not only made the fibres easier to handle but it also kept the fibres from tangling on the distaff. I also discovered this simple method allowed me to be able to pick up fewer fibres between my fingers consistent for a finer yarn to be spun thin. I later found research in surface modification of Milkweed fibres to understand my own findings. Testing was made on milkweed fibre surfaces with a chemical modification of alkali treatment which produced structural differences between the fibre surfaces after treatment. The results found the presence of convolutions along the fibre showed an increase of fibre friction. They concluded the test improved the Milkweed fibres' spinability.[59]

4.2. NZ Flax Industry (1950) Wave setting.

- *Bundles of combed muka. Removing the pectin(epidermis of the leaf) before spinning begins.*

- *Exploring the efficiency of this technique was very important to me across every step made. It needed to meet real day to day operational targets that could service many while utilising tools and resources in new ways. It was also challenged to be adaptable to shift with location and its environments.*

[59] Sanaz Hassanzadeh and Hasani Hossein, 2019.


4.3. Exploring different techniques of combing the extracted fibres.

**Rima (Five) Spinning set-up and preparation**

Dressing the distaff[60]

Muka fiber can be a little challenging to work with at first for any beginner. It is important to take the time with setup and preparation to allow a smooth process moving forward. Following common flax spinning preparations, a distaff was utilised for single fibre pull-through when wet spinning. I made a simple cone attached to a long vertical pole that sits beside my spinning wheel from which the fibres are hung. This helps keep the fibres organised and prevents them getting tangled. The goal is to separate the fibres so there are no clumps, and to arrange them in thin layers that can draft smoothly and continuously with an even consistency. The fibres are then spread on a table, into a series of very thin layers, criss-crossing them like a spider's web and fanning them out from the knot root end. I then wrap the fan loosely around a distaff and tie a piece of fine ribbon around to keep the fibres in place. Other methods tested involved a strip of double sided mounted tape on the wall side to act as a distaff. Other tests involved multiple ways of using brown rice to act as a weight to keep fibre while spinning.

4.4. Exploratory practise.

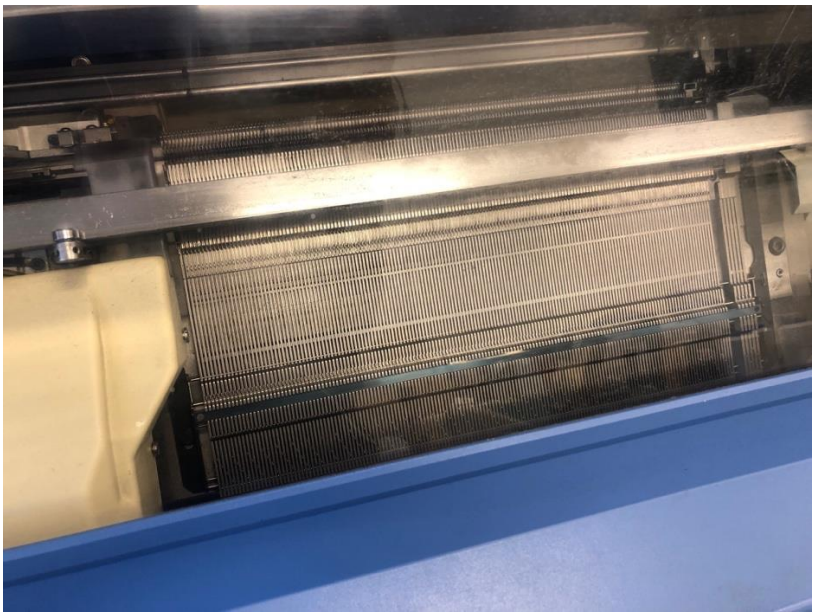
- Demonstrated above are methods explored to suit my learning in spinning. Implementing rice acted as a weight and aided the spinning process by decreasing fibers from becoming an entanglement and going back on itself. This further enabled me to pick up fewer fibres for a finner continuous thread.

[60] A distaff is a tool designed to hold the unspun fibres and keep them from becoming tangled. It is used to make the spinning process easier.

4.5. Coconut oil & linseeds.

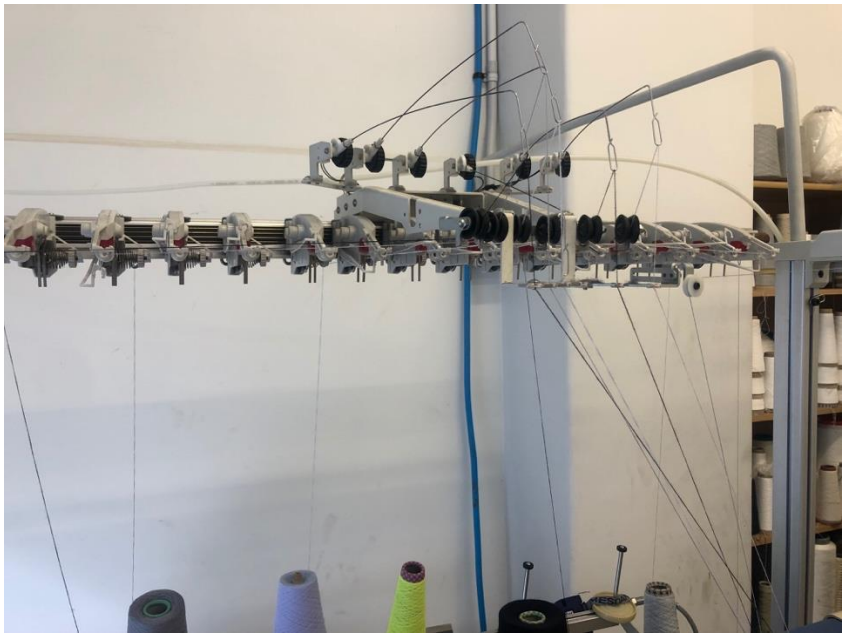
Muka Wrap Membrane - Aloe Vera, Linseed, Coconut oil & H2O

Whole garment knit form fabric by creating consecutive rows of loops that mechanically intertwine. Because muka yarn has no elasticity, it is important to use a membrane to enhance fibre properties that may've been lost through handling and hold the fibres together during spinning.



4.6. Knitting technology needles.

This binds and nourishes the fibres to reinforce strength and flexibility enough to be processed through the tensions of the knitting machine and needles at a high speed without breaking. The knit loop structures formed, will then allow the muka fibre to be manipulated to stretch 4 ways. Any fibre strands that may loosen after machine design are then further locked together due to the knit weft and warp structures formed, allowing for an even stronger yarn.



4.7. Knitting technology tensions.

Laboratory test shows a binder spraying method in order to investigate the efficiency of the treating method on Milkweed fibres cohesion.[61] Although Milk weed is from a completely different plant family, getting the fibres to join proved challenging. To make a strong, smooth, even yarn, muka must be wet-spun. The moisture sticks down the fibre ends. However, I found water alone used in traditional European flax spinning was not enough for the purpose of digital knitting technology.

To resolve this problem, I employed my past beauty career expertise by studying the science of caring for curly hair to develop a natural recipe to bind and adhere fibres once spun. This is to mimic the epicuticular wax morphology found on the exterior of harakeke leaves that provides its protective coating and flexibility before haro extraction. The membrane provides a coating to enable the yarn to glide through the mechanical tensions and knitting needles of the technology effortlessly at a fast speed, without snagging or breakage of the yarn.[62] One test I used beeswax, coconut oil, linseed and water. The beeswax was inspired by the traditional Māori Hieke (rain cape). I was attempting a simple water-resistant yarn.

[61] Sanaz Hassanzadeh and Hasani Hossein, 2019.
[62] Seamless technology requires applying essential precision at exact technical parts when using this form of hybrid design.

4.8. Membrane emollient treatments.

- Left image is the membrane base. This consist of linseed, coconut oil and water.
- Right image: beeswax has been combined. Design focus, water resistant yarn.

I developed and tested various recipes purposeful for design application. My aim needed the membrane to add moisture to the fibers, stick like a gel during spinning and glide through the knitting needles. Ingredients were selected to meet these demands.

To make a simple but effective muka solution, I simmer 1 tablespoon of linseeds with 1 tablespoon of coconut oil and 2 cups of water for 10 minutes then strain. I add more or less water to get the desired consistency I'm looking for but found its best not to make it too thick. This is satisfactory enough, but upon harvesting one day I noticed a gel-like substance at the base of the leaf, similar to aloe vera gel. This gel or resin is called 'piaharakeke'. What if Harakeke could provide its own resource of protective balm?

4.9. Yolk membrane experimentation.

- Testing liquid consistency with spinning.  Adjustment to recipe made accordingly. Variation in spinning consistency may occur if it is too thick.
- Recipes were informed on desired future design outcomes and finding the best membrane to suit the end product. Example: water resistant or scent emitting yarn.
- Fresh binding agents are made in small portions before spinning begins.

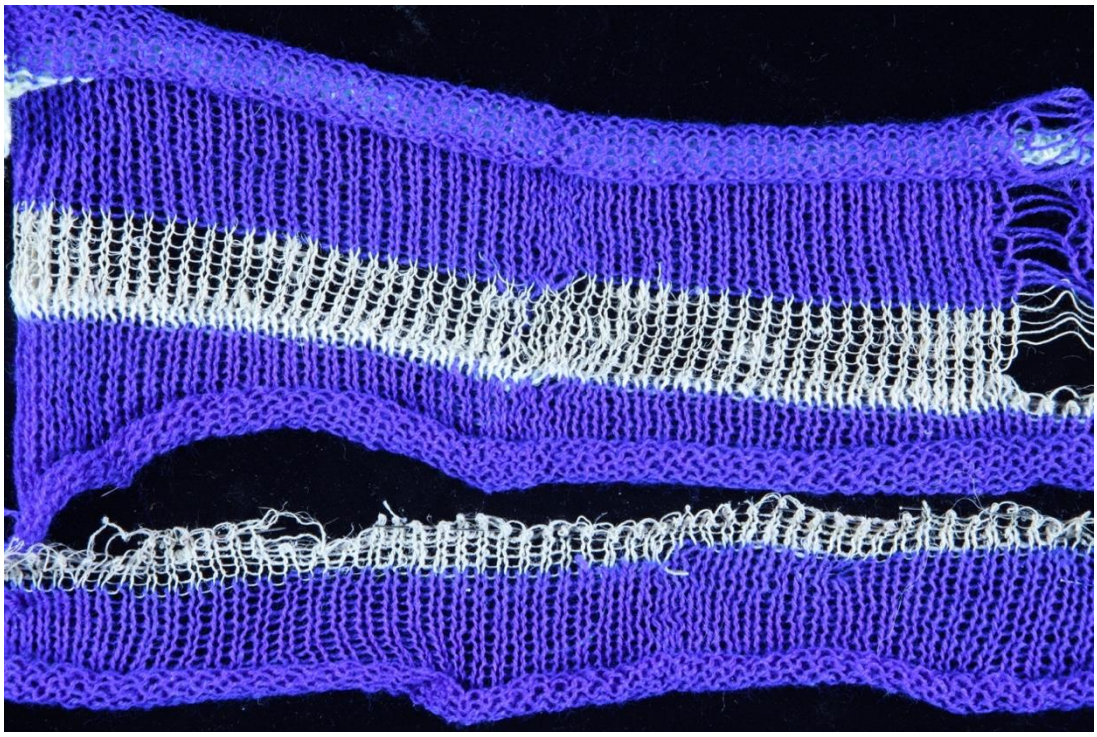
Design outcome example:

- Baby blanket infused with lavender.

  Recipe: After making the solution base (linseed, coconut oil and water), add 3 tablespoon runny honey, with 1-2 drops lavender oil.

Ingredients tried and tested:

- Linseeds
- Coconut oil
- H2O
- Aloe Vera
- Honey
- Beeswax
- Shea butter
- Vegetable glycerine
- Aromatherapy oils
- Hemp seed oil



5. Test 2 of knitted muka with beeswax dressing.(muka seen here represents the lighter knit)

- The purple knit is wool yarn acting as a support for the muka as it begins knitting through the technology. I question if using a more supportive yarn as linen with similar material characteristics would alter the tension of the knit weave? Does it make a difference? Further research needed.
- My skill in spinning still needed to be refined here. Holes due to an uneven consistency in the muka yarn.
- Experimenting with beeswax, linseed,

With more research, could Harakeke provide its own binding solution or blend better with other substitutes? One plant that is renowned for its healing properties is aloe vera, which is in the same broad Liliaceae (lily) family category as harakeke. As it produces a lot of gel and is easily accessible, I tested aloe vera gel, a humectant, or moisture-retaining substance. By adding other beneficial ingredients in finding an even consistency in membrane—in the manner we treat our own hair—assisted more in helping refine the continuous yarn. I aim to test piaharakeke when I next harvest.

**Ono (Six) Spinning muka fibre**

5.1. Spinning blind.

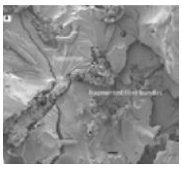
- I learnt to bring a gentle touch throughout spinning and feel the fibres within my hands. I found you can't rely on sight alone. Here I gained an appreciation for the skill of a Master Spinner and the importance of their role in the over-arching concept.
- Pressure applied between the fingers and hands is intuitive and can alter the yarn consistency during spinning. This also occurs during extraction. A constant switching between techniques due to the variations in the leaf and fibres.

Spinning proved challenging to get the fibres to adhere smoothly without crimping first and without implementing a membrane to protect the cohesion of fibres spun. To better understand the challenge I was facing around spinning the plant fibre, I researched science papers testing harakeke muka on a singular strand.

> *To prevent the generation of these defects, it is essential to understand the impact of the whole lignocellulosic processing procedure on the dimensional characteristics of the fibres intended to be used for mechanical reinforcement.*[63]

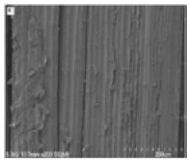
Understanding the fibre and plant as a whole allowed me to see the many variables that cause difficulty when spinning plant fibres. Phormium tenax has varying cross-sections along its length.

> *The tensile strength values of harakeke…shows a decrease of tensile strength as diameter increases. This trend has been reported for other natural fibres [15], [16], [17], [18]. The wide scatter of tensile values is a typical drawback of natural fibres which can result in variability of composite properties*[64]*…properties are influenced by a number of variables, including the fibre type, environmental conditions, processing methods, and modification of the fibre.*[65]



*Different cross sectional shapes of fibre bundles in composites.*

*Helical structure of vascular bundles seen on split as supplied fibre bundles.*

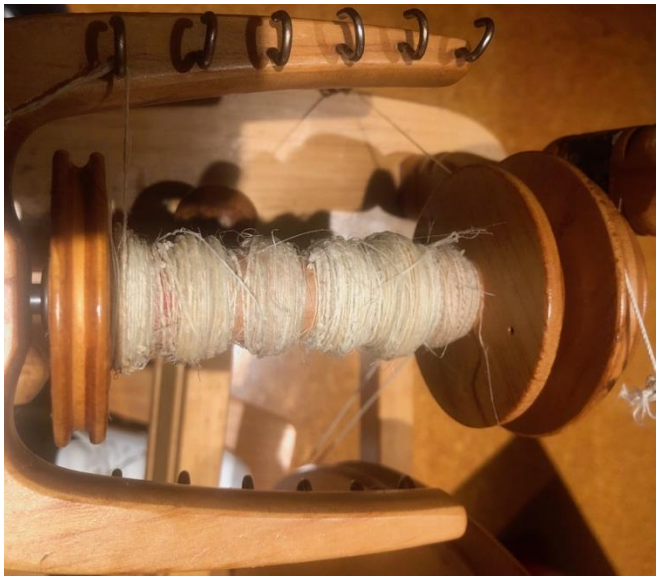


*Fibre bundle surface.*

5.2. Source, 'The Potential of Harakeke…' figure 4.

This reconfirmed to me restoring a protective epidermis-like layer while spinning will boost the processing requirements needed for the knitting.

[63] M Ramesh, K. Palanikumar and K. Hemachandra Reddy, 2019; Sanaz Hassanzadeh and Hasani Hossein, 2019.
[64] Tan Minh Le and Kim Pickering, 2019.
[65] M Ramesh, K.Palanikumar and K. Hemachandra Reddy, 2019.



- *If left to dry on bobbin, spray with water lightly first to dampen fibres before reeling onto a cone. This prevents the fibres from sticking and minimises excessive fraying of fibres.*

- *Muka spun fibre drying. This can be set using any device that allows the conditioning binder to set the fibres in place. I have also improvised using the bamboo outside my house, the 2 posts of a straight washing line or two pegs secure in the ground.*

- *Make sure the muka fibre is not set with too much tension. A good balance will allow for better elasticity in the yarn.*

5.3. Spinning process.

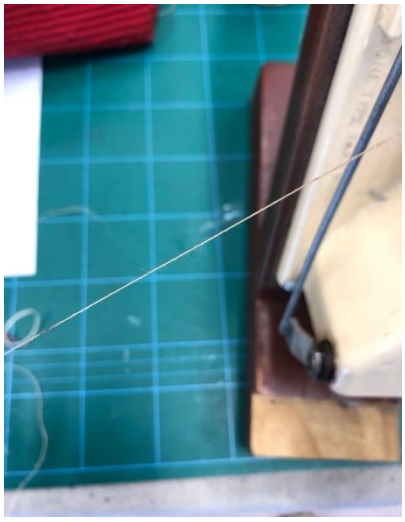
**Whitu (Seven) Muka yarn transfer to cone**

5.4. Muka continuous yarn.

After I have spun the muka into long enough continuous yarn, I loosely wrap it around two pegs to dry overnight.  From here the muka yarn is transferred to a cone, ready for processing through the knitting machine.

5.5. AUT Textile Design Lab

- *Early testing of muka continuous yarn with a beeswax dressing. Design concept aim was to enhance the fibre properties to create a water resistant yarn and textile.*



- *Checking for consistency of muka thread. During spinning you are able to really experience the energies in your hands to discover how the fibres feel and perform under different pressures which can resemble and be applied to whatu (Maori handwoven textile methods).*

- ***Left:*** *Beeswax membrane (early prototype). Course consistency. Sand colouration caused from the beeswax.*
- ***Right:*** *Aloe vera honey and shea coconut conditioner binder. Developed prototype. Fine consistency. Silk like and white in appearance.*

- *Early testings of spun muka.*

- *Silk like spun muka on cone. This cone of fiber represents around 146grams of muka fiber. Approx 15mtres of fine thread. The skill is in the Master weavers hands where one becomes intrinsic to how the fibres perform under various processes.*

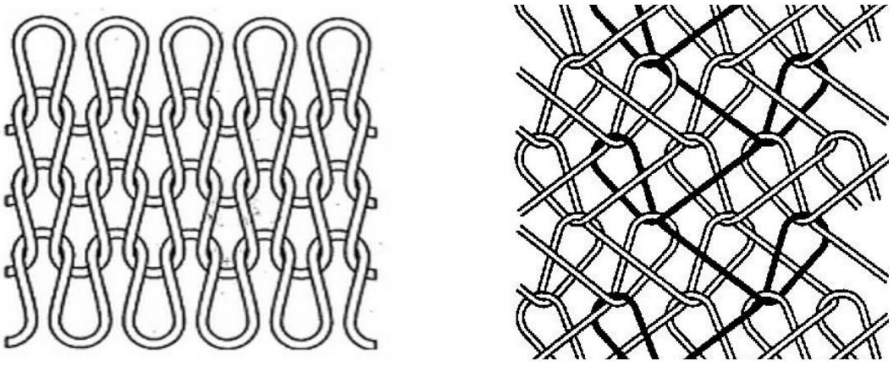
- *Early test of spun muka using water and coconut oil only. Required a faster spin ratio for a tighter twist to hold fibers in place.*

5.6. Transferring yarn to cone.

**Waru (Eight) Muka fibre to product - Commercial knitting - Shima Seiki Wholegarment® knitting machine**

5.7. Knitting technology, AUT.

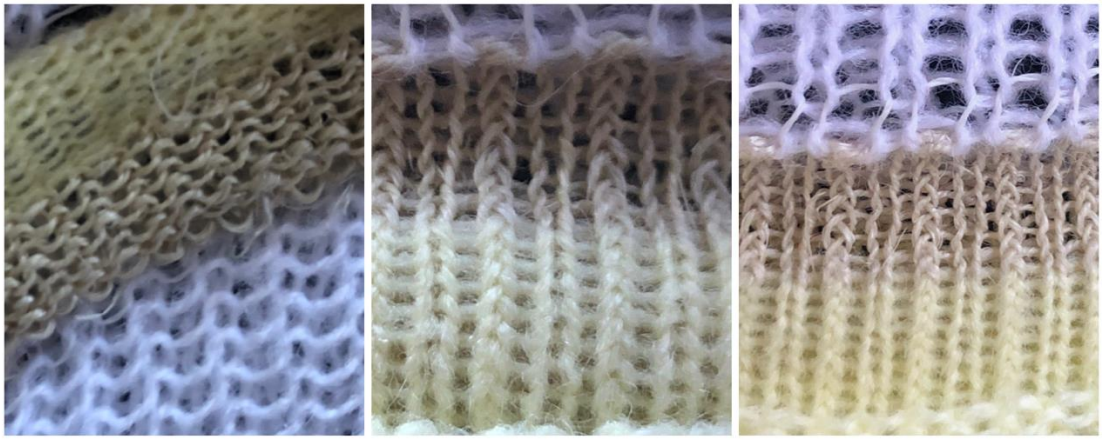
Wholegarment® knitting system is a process of translating design explorations into a software code the technology can understand to enable it to knit prototypes. It converts digital design applications to programme the machine to knit. The key advantages depend on the complexity of the design and varying properties of yarns.



**Weft** Knit Structure **Warp** Knit Structure

5.8. Knit structures.

Knitting techniques, properties and performance characteristics are distinct to weaving methods. Knitted structures are progressively made up of a weft[66] (horizontal) or warp[67] (vertical) construct where continuous yarns of fibres inter-loop together to form a cohesive and flexible textile surface. The knit structures inter-lock fibres of yarn in place creating versatility through a range of material and design explorations. A textile's appearance, properties and end use can be manipulated by the way it is constructed.

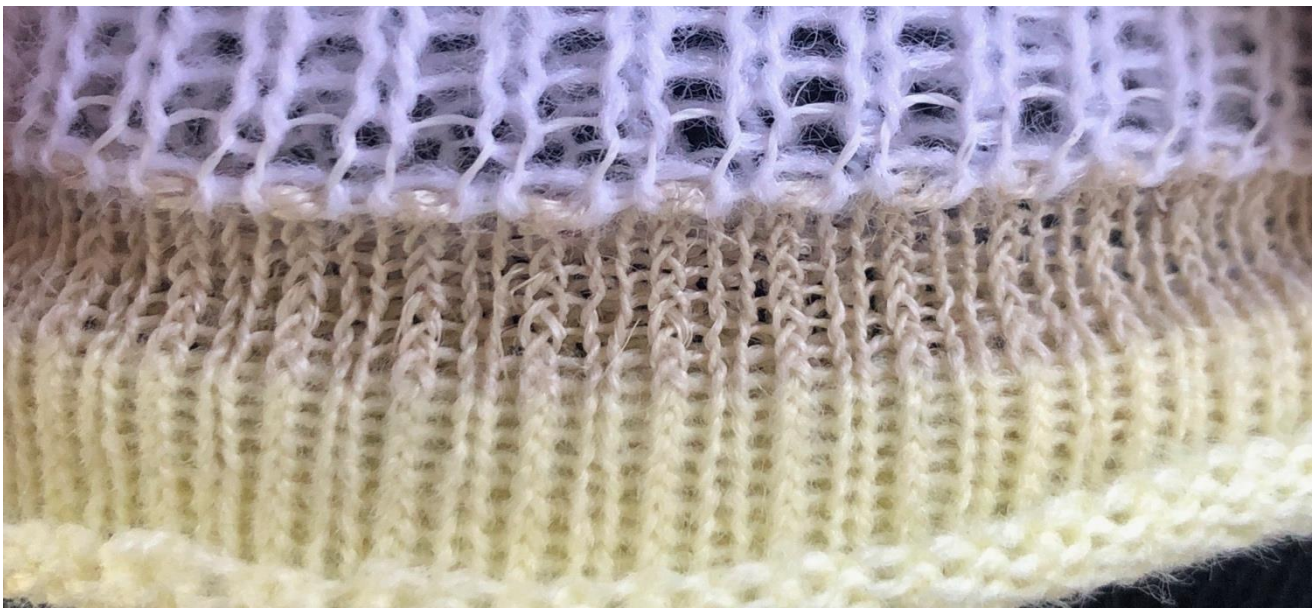


5.9. Muka textile – tight weave.

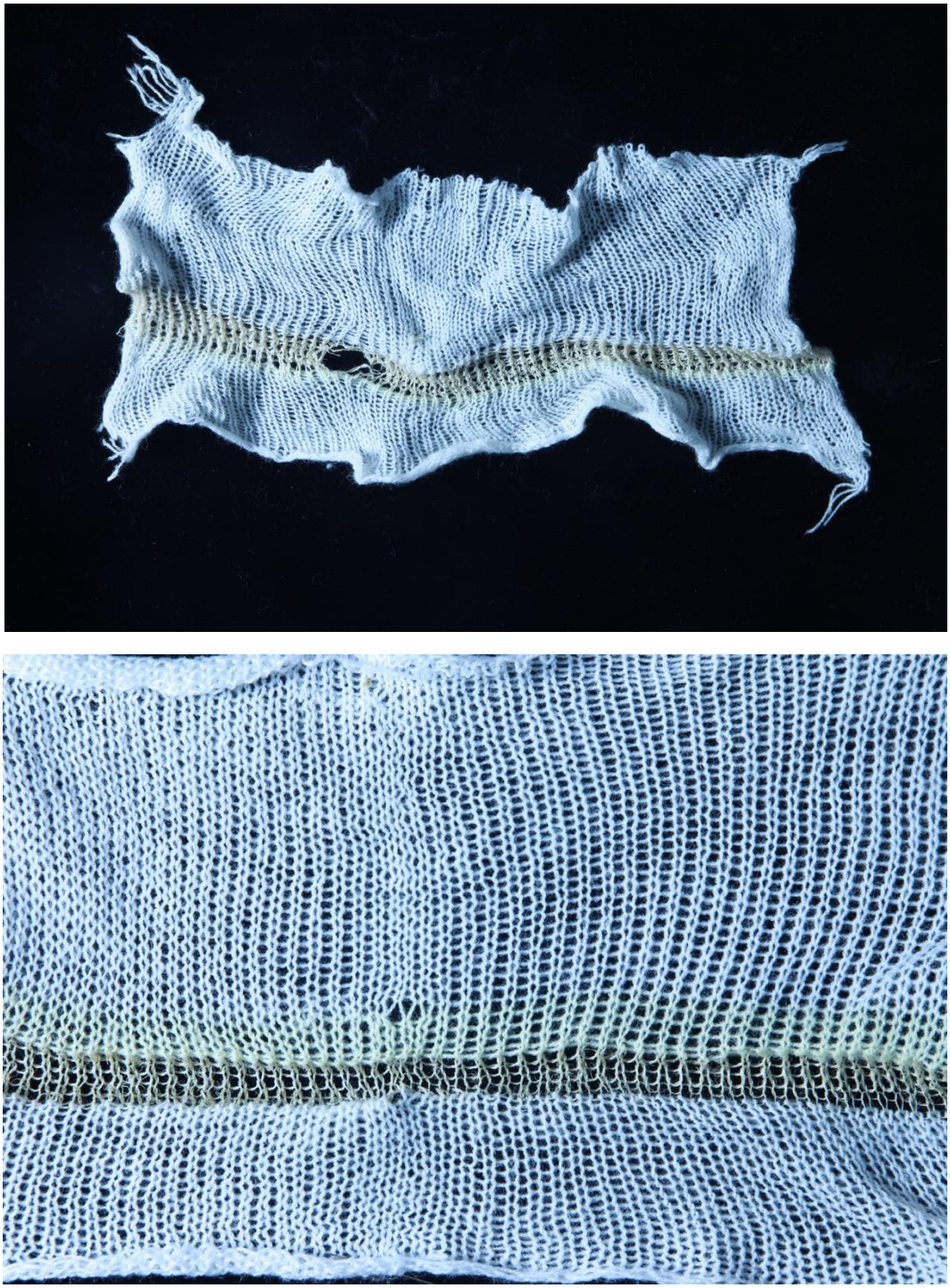
- Muka found centre place (between white and yellow knit). Colour: sand.

[66] *Weft* knitting consist of inter-looping yarns in a horizontal pattern.
[67] *Warp* knitting structures interlock vertically down the length of a textile.

6. Processing, spun muka yarn through Wholegarment® knitting system.



6.1. Knit Muka textile test.

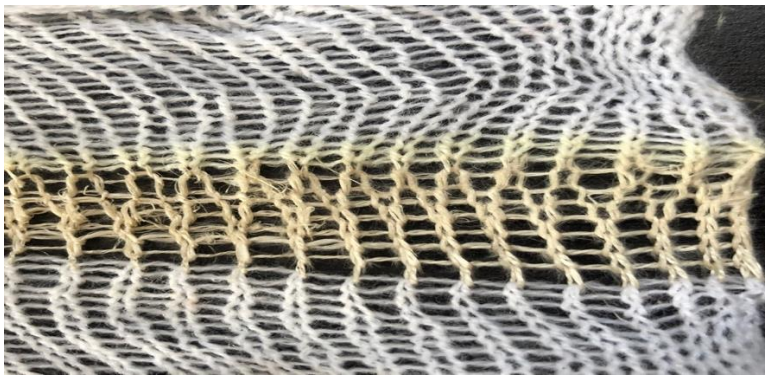


6.2. Testing scale of varying knitting stitches.
½ gauge, every ultimate needle.

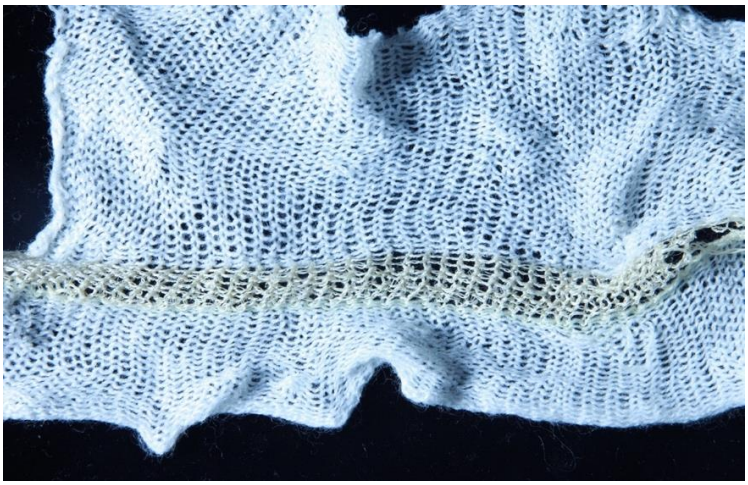
**Surface Finishing**

Here I examined and tested simple processes to soften the fibre after knitting. Muka characteristics is similar to ‘hemp’. The more you wear the fibre, the more it softens. Traditionally Māori would soften muka with a patu (club or pounder) in water. In one small section of a knit sample I simply rubbed the knit muka textile between my thumb and fingers. I was amazed how it softened further, enhancing its tensile strength without un-ravelling. Another test promising great results is through a hot water ‘soda ash’ wash.

There are a multitude of exploratory options on finishing the textile to contribute to the end appearance and handle. An early industrial use of starch was implemented to ‘size’ and stiffen textiles. Today it is added to individual yarns to increase mechanical strength and resistance to friction wear while also resisting moisture penetration. Starch products are used in applications that are biodegradable, non-toxic and skin friendly. Further development in surface finishing for ‘muka’ can also provide new developments in water resistance or flame-retardant textiles.



6.3. Fast friction between fingers helps soften fibres after knitting.



6.4. Wash cycle to soften fibres test.

- *Silk feel to the touch. Soft quality.*

# Results

This research fabricates muka fibres into a continuous yarn for thread or woven and knit fabrics. There are many stages required to process ‘muka’ from fibre to fabric.  The fibres are extracted, cleaned, combed, spun into yarn, taken through a series of prepping processes before it is then knitted or woven into a textile.


6.5. Harakeke Navigations. Final Exploration outcome. 2019.

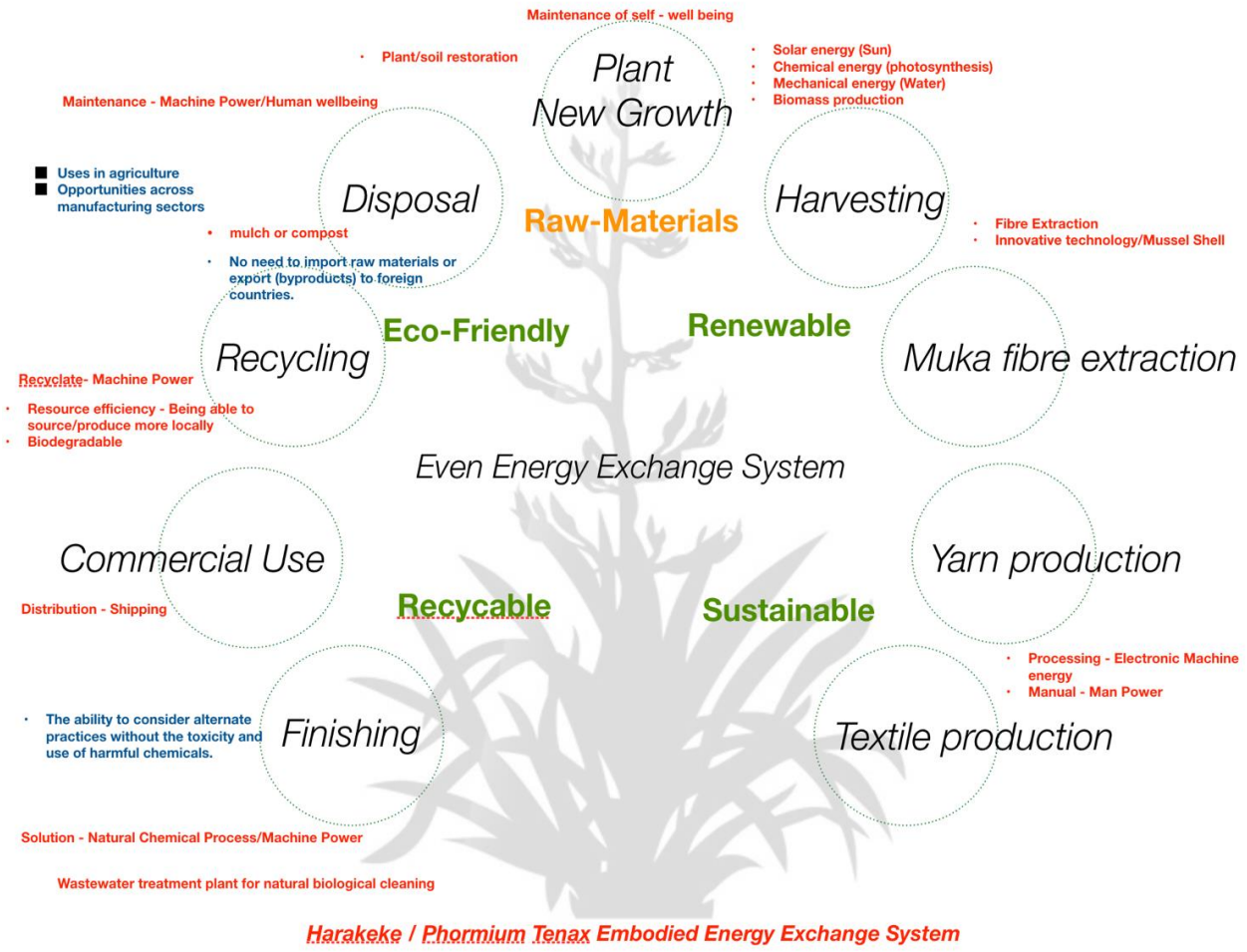
Because production is a laborious process; to achieve the finest muka textile requires a combination of handwork with machine processing. Enormous patience is required with a need to honour the space between how you truly feel and practice.

6.6. The infinite potential of Harakeke. 2019.

6.7.  Weaving of a new muka cloth.

This knit prototype shows muka fibres in its raw state (in between the yellow colour block above and below).  Using a honey

It is ready for further textile softening processing.  This opens new research pathways into finishing techniques or traditional dying methods to enhance its design potential.




6.8. My muka textile whakapapa road-map.

Growth and Expansion.

This research has aimed to realign with our environment and return to Papatūānuku (Earth Mother) natural plant resources. Observing tikanga is part of the ethic and exercise of kaitiakitanga throughout this methodology. The overall efficiency of the infrastructure and yarn quality will not contaminate or cause pollution to the environment, is harmless to the human body and friendly to our environment. Each step is actioned simultaneously to the next, in an even-energy exchange of reciprocity. The framework is economical and sustainable that can be adapted to meet current and potential future applications.

| *THE PURPOSE* | ***THE SHIFT*** <br> *Benefits of design Model* | *THE VALUE* |
|---|---|---|
| *Plant/New Growth* <br> *Harvesting* <br> *Muka Fibre extraction* <br> *Yarn Production* <br> *Textile Production* <br> *Finishing* <br> *Commercial Use* <br> *Recycling* <br> *Disposal* | *New Market Space -Textile Production* <br> *Labour, time, skill and craft is valued* <br> *Self-sustaining* <br> *Transverse* <br> *Efficient* <br> *Scalability* <br> *Experience is considered a skill* <br> *Overall well-being of the plant/people* | *Lifecycle - Embodied Energy System* <br> *Eco-friendly* <br> *Renewable* <br> *Sustainable* <br> *Recyclable* <br> *Biodegradable* <br> *Environmental Social Impact* |

**Materials**

**biological materials**
**technical materials**

**Agronomics - Soil Management + Crop Production**
seed-land-ammonium nitrate - water - triple superphosphate - potassium chloride

**Initial Processing**
leaves - machinery - hand tools

**Yarn & Fabric Production**
Harakeke plant fibre - machinery

**Finishing**
starch - fireproofing - soda mordant - natural dye - detergent

**Care & Use**
water - detergent

**Recycling**
used garments - hydrogen peroxide - water

6.9. Material Production Technology

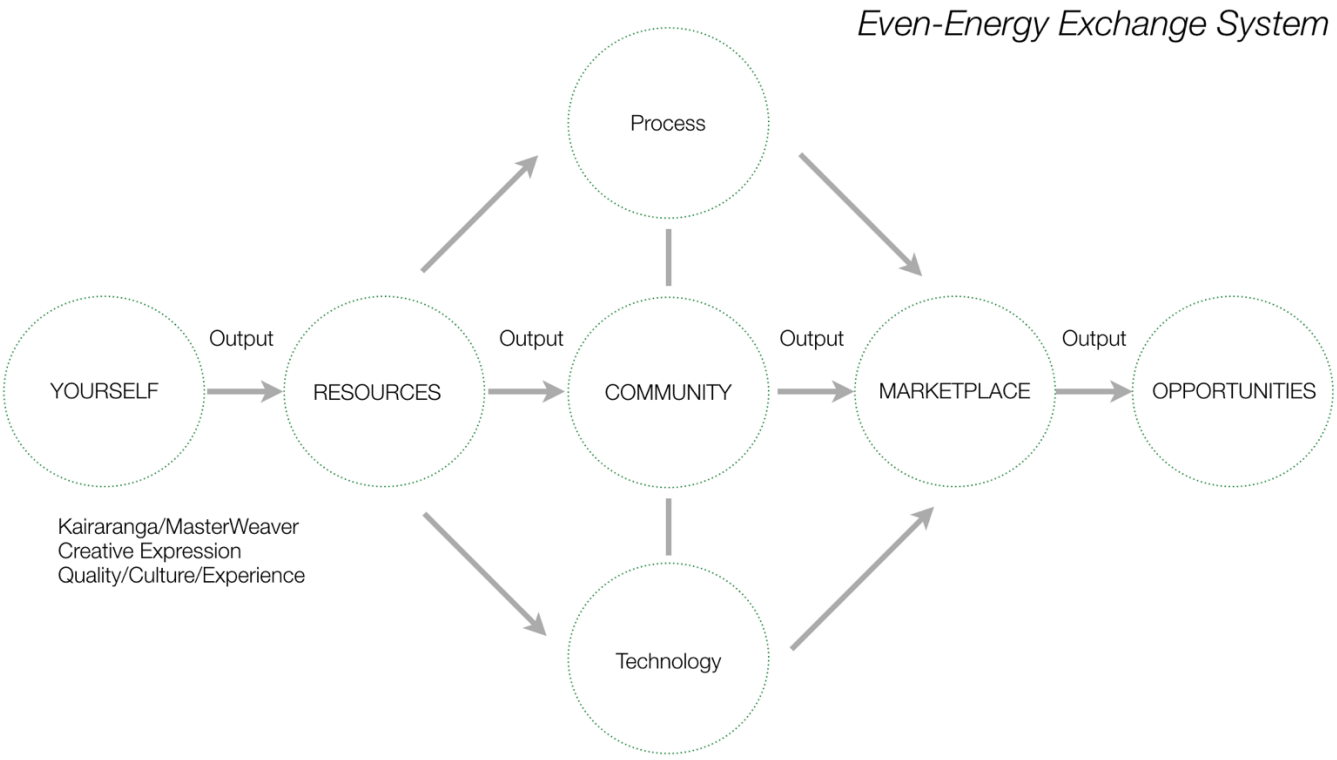
- Diffuse production of materials from which we build our surrounding environments.
- Quality rather than quantity.

This project opens up a plethora of opportunities in diversified regions to increase its productivity and growth across an array of infrastructures and multiple industrial sectors such as;

Production Overview:

**Benefits.**

- Knit Manufacturer
- Apparel Company
- The Consumer
- The Environment



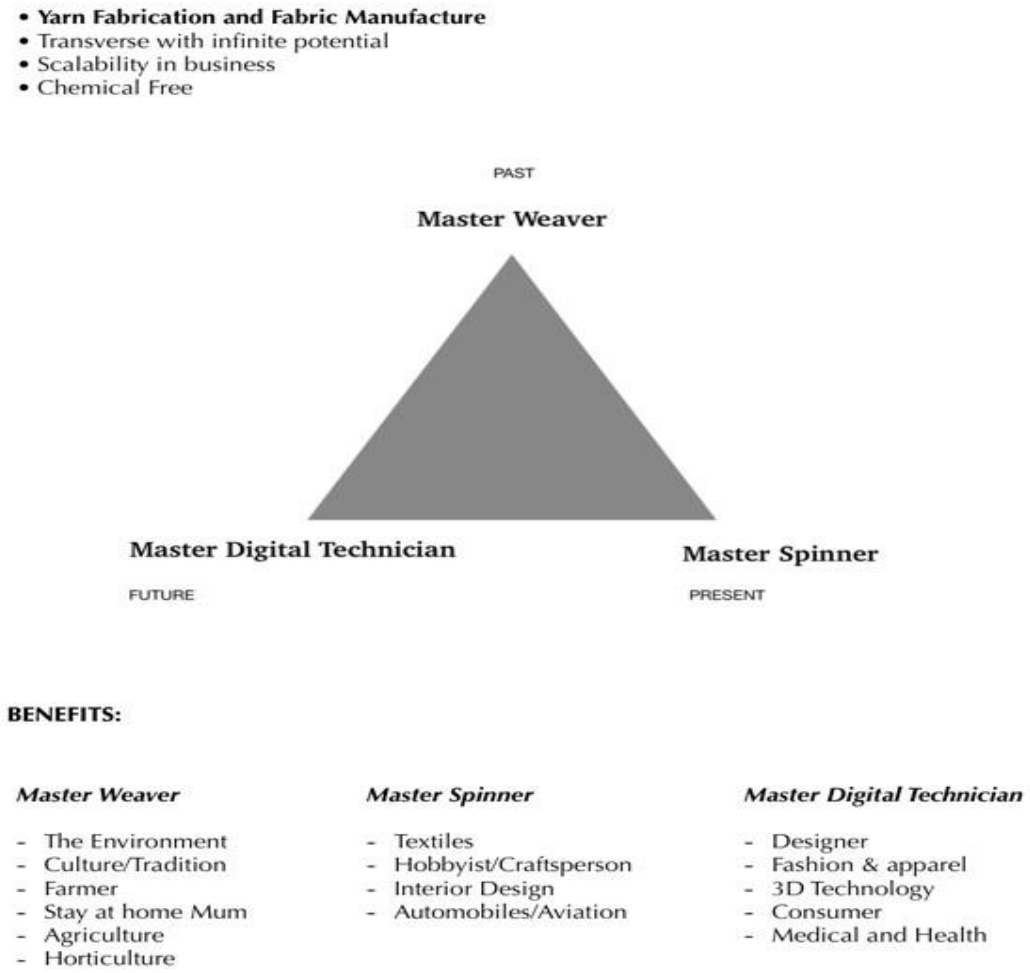

7. My Value system model.

- ‘Value’ driven initiative, with the intent of creating economic wealth across New Zealand.
- I tried to identify areas that could contribute to provincial growth. By spreading the wealth you are better able to spread the costs evenly amongst economic disparities.

The success of cultivating a commercial industry using harakeke into a reality will take a collaborative effort. The ‘Even-Energy’ exchange system roadmaps with the ‘yarn fabrication & textile manufacture’ frameworks I have provided here are to help navigate a transparent general understanding of how harakeke can be utilised throughout communities so that everyone may benefit from its growth.

This is a ‘value’ driven initiative, strategic in applying textile design knowledge with Maori tikanga. Sharing of resources encompasses the essence of manaakitanga through acts of respect, responsibility and reciprocity. Applying harakeke tikanga enriches the quality and value of the end products and contributes to finding technological solutions while maintaining integrity. Everybody plays a responsible role in the overall production, maintenance and sustenance of the plant. The quality of the end product is determined by the quality of ‘energetic service’ provided by those between stages. For example, a farmers relevance in supporting the health of the soil is just as meaningful as the performance of a weaver, digital technician, or designer.

Harakeke / Phormium Tenax Production Life-Cycle




7.1. My yarn fabrication & textile manufacture model.

The primary function is to fabricate ‘muka’ fibres into a continuous yarn for thread or woven and knit fabrics that is 100% NZ made using local suppliers and is unique to New Zealanders. Textile manufacturing entails conversion of fibre to yarn, and then to fabric.

The following are a few creative ways how harakeke can support diverse ventures in the development in new ways to increase economic output and indigenous development.

1. Iwi, hapu, rohe, local community groups, and whanau lifestyle blocks provides opportunities to re-establish Pa harakeke throughout the regions for sustainable economic return. Productivity will see a restoration of polluted water-ways, soil management and crop protection of the sacredness and sustainability of the plant.
2. New employment across a diverse range of sectors such as the arts, design, agriculture, science, commercial business and education but not limited to.
3. Remote communities, residents, businesses and visitors to the regions will benefit from improved technological infrastructures put in place within and between regions that focus on a new build.
4. Development of new roads or the improvement of existing between production processes within regions will support transport infrastructure with a focus on efficient transport methods.
5. Natural assets benefit, contributing to reducing energy demand by increasing energy efficiency.
6. A circular design framework supports the sustainable use of soil management, crop production, and using scarce water resources more efficiently.
7. Maori development through collaborative partnerships and sustained local employment, creating community unity.
8. Preservation of traditions and renewal of Te Whare Pora (The Ancient House of the Art of Weaving). Providing support and teaching correct tikanga and protocols when harvesting etc
9. Personal well-being. Connecting youth to issues of identity, place, spiritual relationships and community pride. Guidance towards how their skills and talent can be applied through the transition of knowledge into the real world around us.

**Extraction:**

7.2. Mussel shells collected from the beach as a tool for stripping muka fibre.

*"This is my future, finding magical things in the world and beach"*
*– Khora Charley* [68]

Mussel shells are truly priceless and gold for a weaver. The traditional Māori haro method for extracting the fibres from the leaf blades is still the best technique today for obtaining the highest quality of muka over machine processing. You cannot buy commercial farmed mussels from the supermarket-these are weak, brittle and break. I was gifted one when I embarked on this journey.

[68] Seeing through the eyes of my daughter.

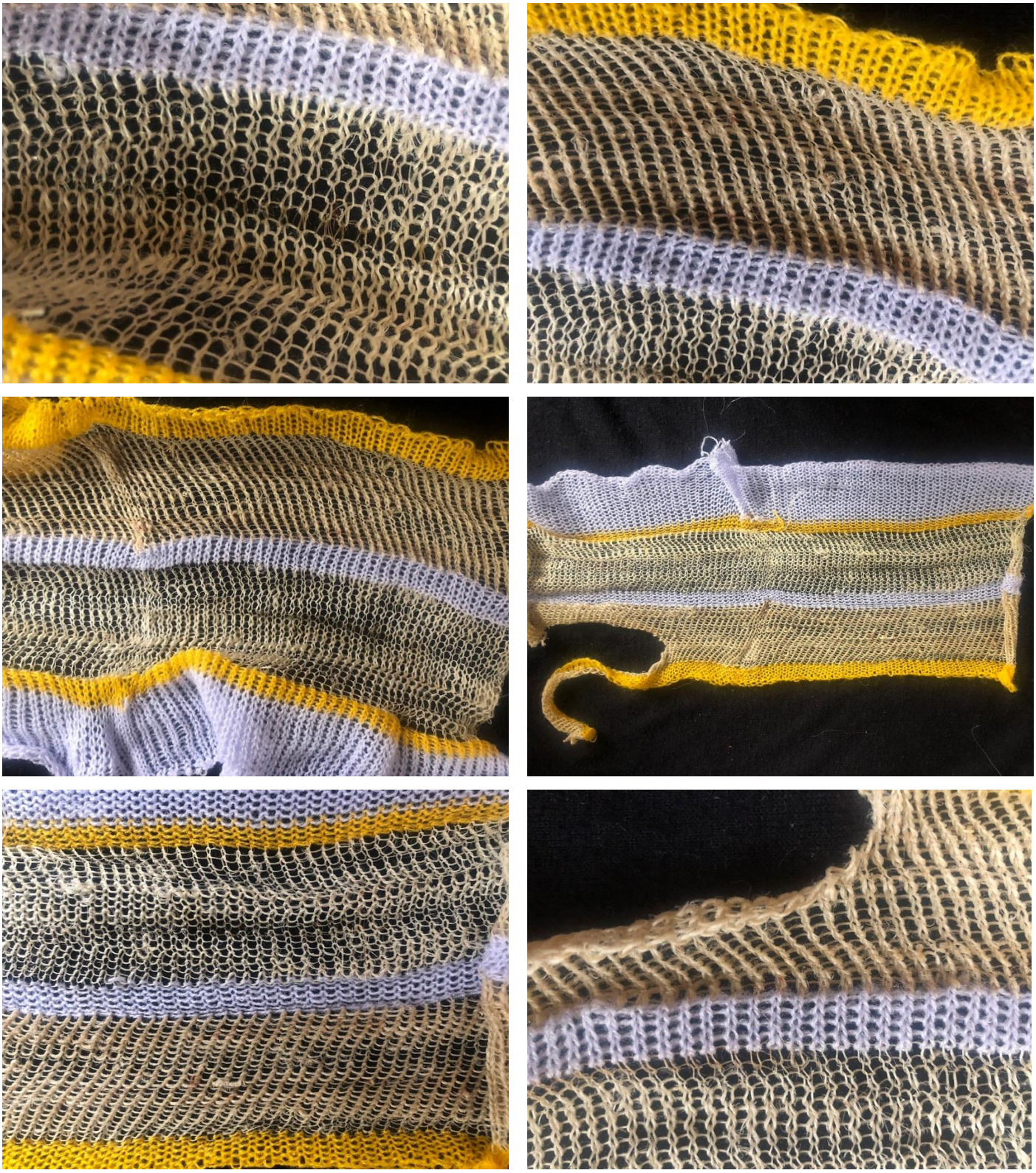
**Binding Solution:**

The use of a binding solution adheres the fibers into a more pliable and stronger yarn which is less likely to break under tension through the technology. The membrane acts as a replacement of the pectin removed at extraction production. Traditional flax spinning of using water (H2O) is not enough for harakeke cohesion. Adding other humectant properties remains to nourish the fibres once the water is evaporated.

Because the solution is also a conditioning treatment, once washed it will continue to nourish and soften the fibres. Further research into Harakeke Rongoā (traditional Maori medicine) could find ways harakeke seed oil or piaharakeke (gel) could provide its own emollient for fibre cohesion as Harakeke is rich in phytosterols and omega acids.

Use of Aloe Vera gel / or adding other humectants to the emollient binder was consistent in achieving the best results through technology. This is probably one of the most important steps to fibre cohesion. By adding other beneficial ingredients in the membrane similar to treating our own hair, assisted more in helping refine a smooth and continuous yarn.

7.3. ‘piaharakeke’. What if Harakeke could provide its own resource of protective balm?



7.4. Muka knit textile test samples.

7.5. Dressed fibre with binding solution.

**Post Finishing Process:** The fibre is enhanced the more you work with it. The conditioning membrane will soften the fibres further once washed.

**Comb & Wave set:** Before spinning can begin, the muka fibre is prepped through a combination of combing and wave-set to help keep and adhere any loose fibres tighter together during spinning. This also prevents the fibres tangling up, providing an easier pick during spinning for a finer quality of muka yarn.

- *The crimped muka shown is wave-set using a domestic hand held hair crimping iron prior to spinning. The curl helps hold the fibers together during spinning and minimising it from tangling causing excess product waste. It also assist with the stretch tension/retraction of the material properties.*

7.6. Image (top): Combed/Wave-set muka. Image (bottom): Brush with muka tow.

**Knotting fibre ends:** The quality of yarn with the less amount of wastage is dependent on the overall efficiency in steps taken from step one to production stage. This technique found knotting muka ends, makes for easier handling between processing with minimal wastage.

7.7. Workplace efficiency.

- Initially, I explored finding techniques to dry the muka straight to prevent the fibre from twisting back on itself. 6.1 Left pic implemented double sided tape and knot ends. Center pic displays 2 gathered muka bundles that are knotted. A portable clothes wire stand was up-cycled to allow for air flow. Right pic, demonstrates drying two collected bundles straight. Light wooden rods are tested with muka, to the right. Both are without knots.
- I was curious to see if one reason muka fibres have yet to be produced in a fine cloth had to do at extraction, before it reached the spinning process? Through this I recognised the value of a simple knot.

7.8. Knotted un-dressed muka.

7.9. Knotted combed muka.

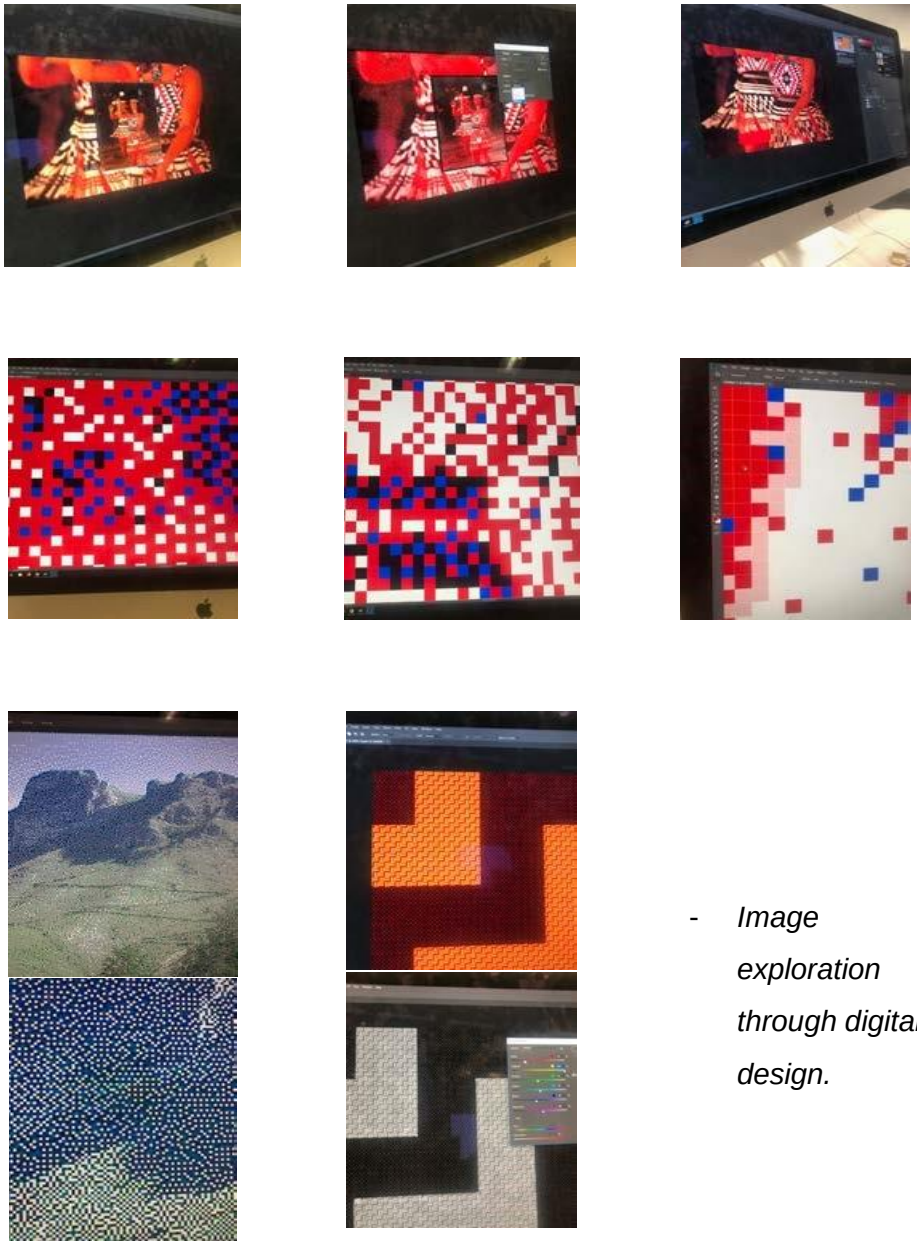
**Fibre Length:** The fibre length is critical in the processing through the knitting technology. The amount produced from six harakeke leaves or 146grams of muka fibre will produce roughly 15metres of quality yarn. However, depending on the skill level of the weaver or spinners hands, a teacher (Master of their craft) will enhance product even further.


8. Testing units of fibre measurement.

## Design Outcome - Applied Textile Design

### Summary of innovations & final samples

The following examples are areas of exploration I see possible in the future applications of digital technologies using knitted muka. Using my Mothers image[69] through digital colour technique[70] design processes to explore through knit.



- *Image exploration through digital design.*

8.1. Future Applications in Digital Technology.

69 Page 9. Te Kāuru Hou—a new leaf.
70 Finn Godbolt. Knitted Paintings: Exploring the Potential of Colour in Knit. AUT Masters thesis. 2019.


8.2. Nga Kete Wananga (Sacred Baskets of Knowledge).

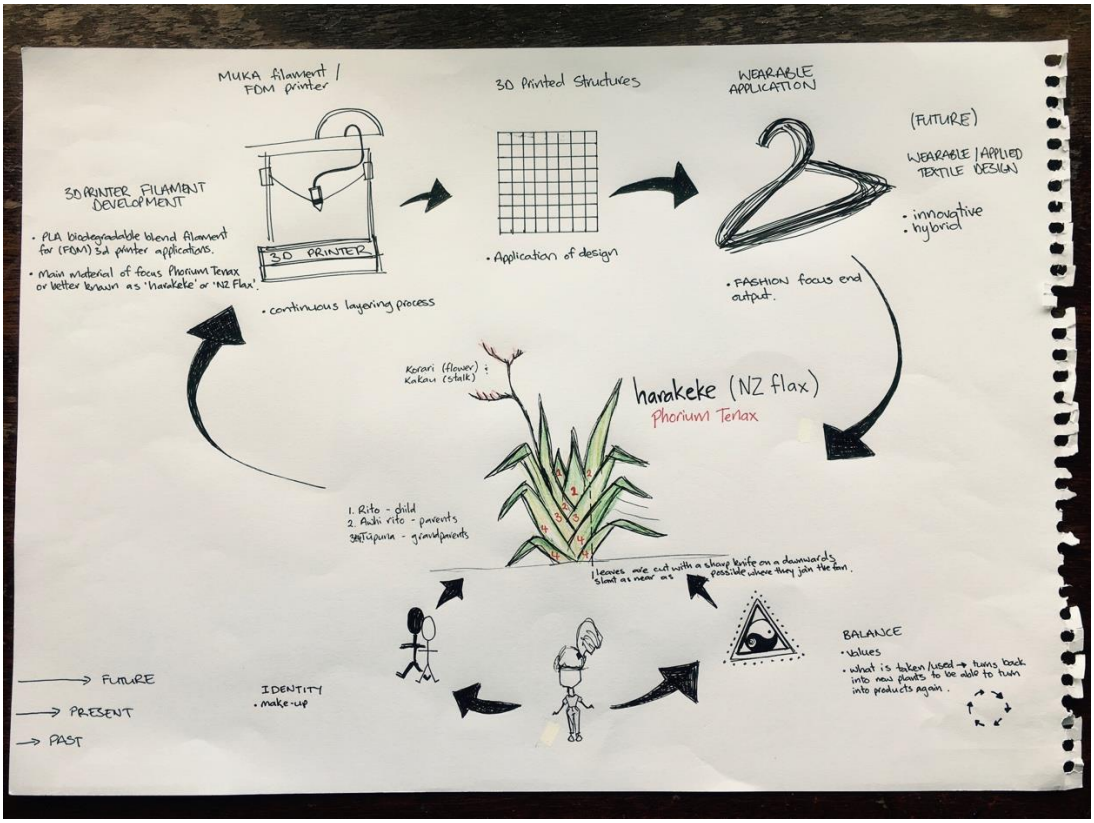
- As Indigenous Maori, many of us have different raranga (weaving) patterns that relate specifically of stories to iwi (tribes). These kete are my own personal contemporary design interpretations of the whenua (land) I whakapapa (descent) and identify back to. Using a yarn blend[71] of 60% cotton, 40% linen to illuminate the infinite potential of Harakeke (Phormium tenax) when applied to digital textiles.
- Muka characteristics and material properties are similar to linen and hemp. This provides potential in new fibre blends towards product development.
- Exploring linen and cotton blend fibers through digital knitting technologies. (14 gauge SES WG machine

[71] DEA Yarns. Linen Cotton blend yarn. 60% cotton, 40% Linen. Count 2/8Nm=2Ply. Colours: Gold, Tango, Black, Cream, Cauliflower, Airforce.

**The Infinite Potential of Harakeke through Digital Technologies.**

***Former development phase outcomes***

As an indigenous designer it is important to me that my work reflects a piece of the present time and what is inspiring me to move my practice forward. Below are examples of my past design exploration outcomes where I envision muka textiles may be developed for future applications within the digital technologies.




8.3. 2017 Mind-mapping: muka filament for Digital 3D technology. FDM printing.

- This project began researching a viable muka filament for 3D printing.

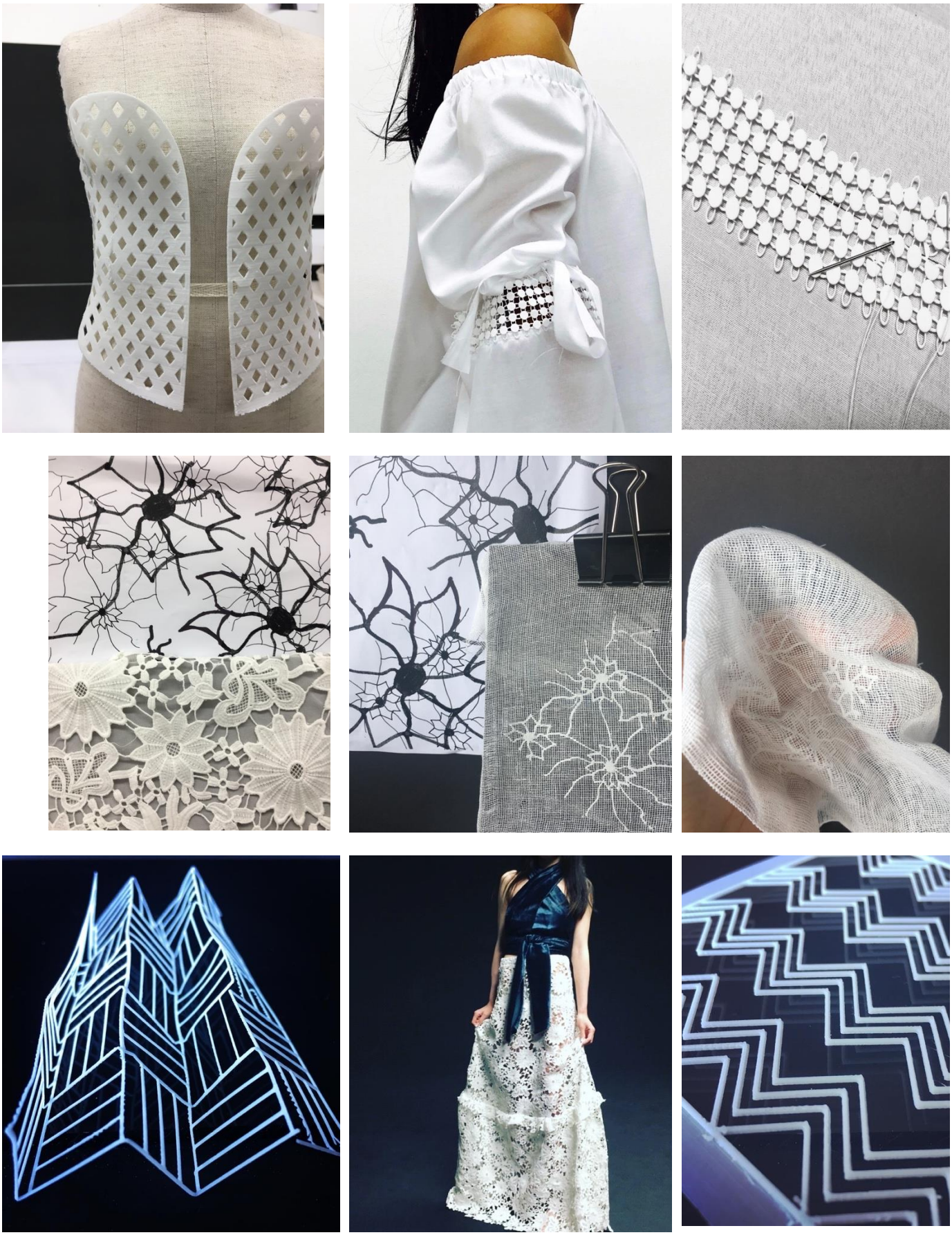
8.4 ''Nomad' Flat bed knitting collection. 2016.

- Muka has the potential to supply a new luxury textile in the design sector.

8.5. ‘Nomad’ Flat bed knitting collection. 2016.

8.6. Cubism Collection. 2015. Linen.

- Muka has the potential to explore woven materials and produce a linen like textile.



8.7. Exploration of muka through 3D Digital Fabrication Technologies.



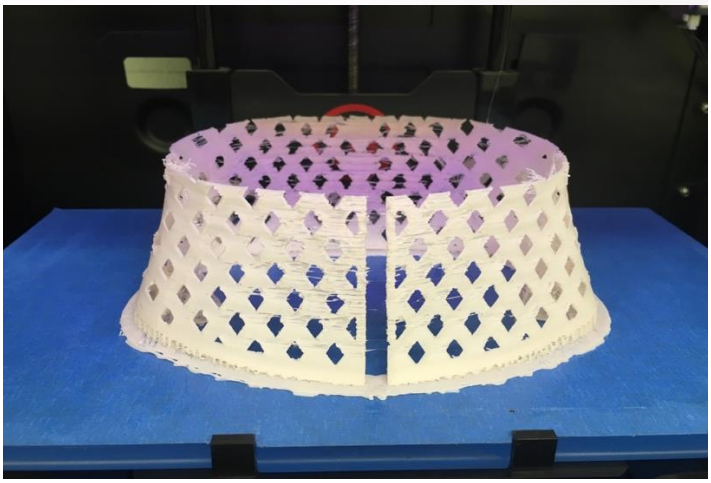
8.8. Product Design. (2016).

- Hand-crafted clog. (top). 3D print (FDM) PLA flexible sandal (below). Laser cut leather straps. Collab, 2016**.**

- *The ‘Habit’ dress. 2015. Linen woven material.*

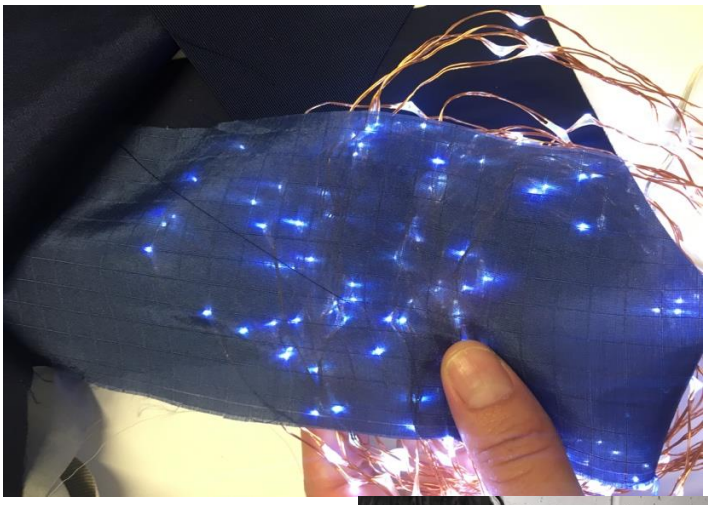
Future application for muka textiles.

- *The Waihou Jacket. 2015. Inspired by NZ farmers. The potential of muka in use with other materials.*



- *3D print exploration into flexible PLA filaments in design apparel.*

8.9. The Infinite Potential of Harakeke through Digital Technologies.

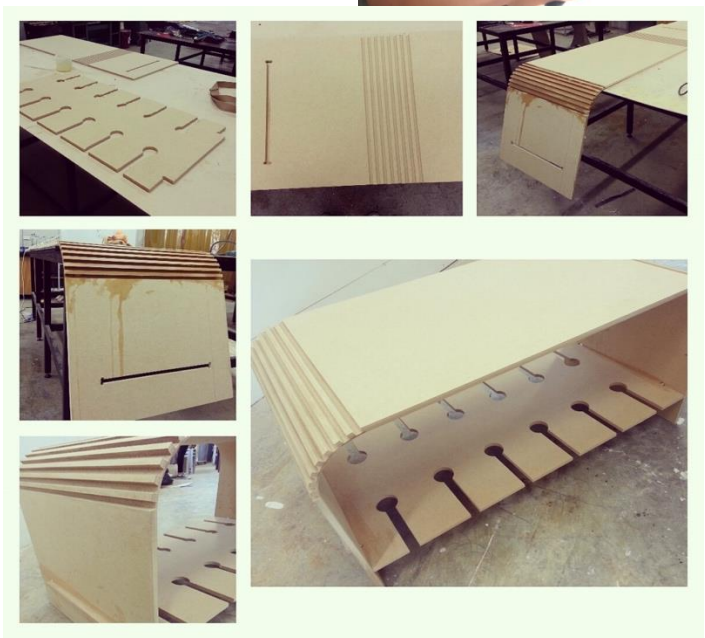


- *E-textile research exploration.*

*Muka can provide new pathways through smart technology as an alternative material.*

- *FeltLOOM® exploration. 2017.*

*I would like to see if there was potential for muka tow to be repurposed through felting.*



- *Digital Fabrication design collab 2014.*

*Harakeke by-product can be utilised in other design projects.*

9. The Infinite Potential of Harakeke through Digital Technologies.

9.1. Contemporary mini ‘kete’.

*A genesis of knowledge and wisdom*

This contemporary interpretation of a modernised ‘kete’ (traditional basket) was processed from plant to fibre to a textile prototype using Shima Seiki new knitting technologies. It is then hand crafted using Harakeke paper gifted by Pakohe Papers Ltd in Whanganui and filled with tow. Everything is perceived valuable and reimagined through the intrinsic art of toi raranga. Transcended into new life to symbolise this record of learning and it’s sacred commitments in transmitting past and present experiences that may support us with the tools needed for our futures. This is a representation of Indigenous Māori Ngā Kete Wānanga (*sacred baskets of knowledge)*[72], sacred by evidence of divine origins which can only be achieved through various rites of passage. The 3 baskets of knowledge obtained by Tane were named Tua-uri, Aro-Nui and Tua-Atea.

Rev Maori Marsden wrote of a fourth basket: “The World of Symbol”[73] as being a deliberate creation of the human mind to depict other perceived realities through formulated words of visual art forms, ritualistic ceremonies, legend, myth etc to act as maps, models, and prototypes and paradigms by which our minds can grasp to better understand the world around us.

[72] Marsden, M, & Royal. *The Woven Universe : Selected Writings of Rev. Māori Marsden. Estate of Rev. Māori Marsden.* Retrieved from http://search.ebscohost.com.ezproxy.aut.ac.nz/login.aspx?direct=true&db=cat05020a&AN=aut.b1082098x&site=eds-live. P, 60. The Baskets of Knowledge.
[73] Ibid., 1992. P, 62. The World of Symbol.

## Conclusion*: Seamless cloths of woven 'identities'*

> *The research began as a 'rito', a new shoot nurtured by the matua rito and awhi rito, the leaves that protect the inner leaf of the harakeke plant. It also began with my belief that there is a lack of understanding in university education regarding the fibre properties of textiles materials, and the impacts of textile manufacturing on the environment.*[74]

Through this research, and my own personal journey, I have been able to demonstrate that indigenous Māori knowledges can build on science perspectives to create new techniques and innovations that can transform harakeke from harvest, through to a highly refined muka' fibre yarn that can be processed with WholeGarment® knitting technologies to create knitted structures. This is something that has not been achieved before and its grounds in commercial weaving technologies is also expected. Furthermore I have also been able to demonstrate that there are close interconnections between Raranga (basketry textile weaving), whatu (weaving of muka fibres through the spinning and knitting process) and the contemporary textile design and manufacturing sectors through kaitiakitanga. This is accompanied along with analogue and digital design processes.

Innovations have included, new techniques for the processing and spinning of '*Muka'* using innovative binding solutions, innovative combing and wave set processes, ways of knotting of muka fibre ends to create fine yarn, and simple but effective processes to soften the material structures after knitting. This new raw textile material, together with a holistic systematic and integrated process that I present here, implements a respectful partnership of Māori and Western customs, and without the use of harmful chemicals that are often found rampant throughout the textile manufacturing industry. It also positions harakeke strongly as a 'new' fibre competitor to other common natural fibres; cotton, hemp, wool, and to artificial fibres, in the knitting technologies textiles sector.

Importantly, this research lays the foundation for new opportunities to re-establish a once thriving New Zealand flax industry with prosperous potential within indigenous cultures, communities, land use, design and sustainable practices that help ensure the integrity of the land. It also builds on, and respects the methods of whakapapa. Retracing whakapapa was essential in my journey to locate truths and to collectively understand the links between our past and present environmental issues. I believe that further research and development will only lead to a high performance muka-based textiles for apparel, luxury products, the integration of wearable technologies, new business concepts and future opportunities available for everyone.

Harakeke, like many other indigenous plants found world-wide, is a universally available resource (as it was to our tupuna) that we have access available to enhance more sustainable and self-reliant practices.

[74] Te Kauru Hou; Preface. P,3.

This work symbolises the relationships and principles that we keep with Atua and Papatūānuku to safeguard our future legacies.

My Grandfather Graham Alexander taught his children how to care for our natural resources and laid the foundation for his legacy, if any needed to return home we would have the whenua available to provide for our families.  My hope is that this research will create infinite opportunities to those seeking support in their own spiritual journeys ‘home’.

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