

The image shows two spools of yarn made from vetiver grass, resting on a dark blue, weathered wooden surface. The spools are made of a dark reddish-brown material. The yarn is a mix of brown and light tan colors, appearing textured and fibrous. A single strand of the light tan yarn is loosely coiled on the wooden surface between the two spools. A semi-transparent white horizontal band is overlaid across the middle of the image, containing the text.

**FROM THE WORLD OF WEARABLE
GRASSES: VETIVER**

**VICTORIA UNIVERSITY OF WELLINGTON
2019**

**FROM THE WORLD OF WEARABLE
GRASSES: VETIVER**

(The use of local place-based knowledge to develop a scalable circular economy that enables positive social impact within the textile industry.)

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ABSTRACT

Progress is the first instinct for humans, with innovation and problem-solving driving forces within every generation. Sadly, as a part of this process, there has been a lack of recognition or interest in age-old, indigenous, local or place-based knowledge. In contrast to this belief of globalisation, this thesis advocates Indigenous Wisdom as a bridge to solving 'wicked problems' of our modern society. Horst Rittel describes wicked problems as interconnected and networked by nature, existing on multiple scales. This research identifies one such a wicked problem of textile pollution. One of the factors contributing to textile pollution is the resulting landfill. Connected to, contributing to or more abruptly put, causing this problem is fast fashion. In 2011 the United Nation Environment Program estimated that without intervention, the rate of consumption for fast fashion would continue to grow up to three-fold by the year 2050. The research explores the need for a durable, economical and more sustainable textile option that can both minimise production waste and is affordable for consumers. Paralleling Transition Design with local place-based knowledge this research identifies a raw material that is the vetiver grass, a sustainable and straightforward production method, a community that is the inmates of Bhopal Central Jail, and a scalable circular economic model and connect them to make fabric based items for their use or sale and trade beyond their community.

1 CHAPTER INTRODUCTION

What is it that drives humankind to put itself before the environment? While chasing the modernist edicts, seemingly we have forgotten to hold on to our roots, those roots that have in many instances and cultures have successfully sustained populations and communities many within the limited resources available to them. Progress is the first instinct for humans, with innovation and problem-solving driving forces within every generation. In recent decades, globalisation has connected the world beyond expectations thought possible, Sadly, as a part of this process, there has been a lack of recognition or interest in age-old, indigenous, local or place-based knowledge. The premise, simply put, being it fails to be universal. Therefore incongruent with a globalised approach. In contrast to this belief, this thesis advocates Indigenous Wisdom as a bridge to solving ‘wicked problems’ of our modern society. Wicked problems, a term coined by Horst Rittel describes a new order of social problems that are interconnected and networked by nature. They exist on multiple scales, making them difficult to solve (Rittel & Webber, 1973). This research identifies one such wicked problem and explores it. The problem is textile pollution. At the outset, it is clear that there is no direct solution to this problem, but as explained by Rittel, solutions are not straightforward or on one level because the problem itself engages multiple disciplines (Irwin, 2012). One of the factors contributing significantly to textile pollution is the resulting landfill. Connected to, contributing to or more abruptly put, causing this problem is fast fashion. Fast fashion is readily available clothing that is cheap and affordable to the masses but comes at a very high price to the environment as it uses unsustainable manufacture and production processes. It also, in many cases takes advantage of many extremely vulnerable people in vulnerable communities. While this research acknowledges it cannot solve the problem, it does seek to establish a model of supply, manufacture and production within a community that can better support that community’s needs. Paralleling Transition Design with local placed-based knowledge this research seeks to identify a raw material, a production method, a community, and economic model and connect them to make cloth based items for their use or sale and trade beyond their community.

Chapter two explores 'fashion' and different aspects within. It is important to understand the fast fashion industry in order to identify the areas and models that can be redesigned to be more sustainable. People, who choose 'fast fashion' still care about the environment, then what is it that drives them to embody the most unsustainable trend? It is the desire to have a distinct social status in the world by mimicking luxury brands through fast fashion in a world driven by capitalism (Joy, Sherry, Venkatesh, Wang, & Chan, 2012). This behaviour leads to a continually increasing gap between fashion and sustainability. Moon describes them as fundamental attitudes; Fashionism and Environmentalism. He states that there is a need to analyse the relationship between attitudes (Moon, Lai, Lam, & Chang, 2015). The researcher believes that the understanding between the relation of two is a crucial element to decrease the gap of supply and demand in fast fashion. As it appears, fast fashion increases the consumption rate of textiles, resulting in a higher rate of textile waste across the world. United Nations Environment Programme (UNEP) predicted that if there are no changes seen in the Fashion Industry, by 2050, it will use up to a quarter of the world's carbon budget ("Putting the brakes on fast fashion | UN Environment Assembly," n.d.). This chapter also compares the carbon footprints between different natural fabrics. Lastly, it discusses the importance and influence of textiles within Indian culture and lifestyle and correlates it to the influence of Maori world-view in the harakeke textiles of Aotearoa (New Zealand). The researcher fostered an understanding during the initial years of her design school that interdisciplinary collaborations are the future which can revolutionise the world. This

thesis extensively studies, experiments and observes the process of sustainable textile manufacturing using indispensable resources, making it accessible to the masses as well as the identifying and safeguarding interests of the environment for a holistic, sustainable design led systematic development.

In Chapter three, this research addresses the economic and societal impacts on the textile industry in modern and traditional society, its challenges and whether or not a new product development can be a viable alternative of the current range of fabrics available to the society. It also discusses the implementation model that stem from transition design and the limitation faced by this thesis.

Chapter four identifies the methodology of this research and its process and implementations. This research seeks answers and solutions for modern-day conscious textile choices through the lens of Transition Design. Transition Design acknowledges "we live in transitional times" (Irwin, Kossoff, & Tonkinwise, 2015) and encourages designers. Further, Transition Design also acknowledges interconnect-edness between societal, environmental and economic aspects into the research.

There is a need of more durable, economical and most importantly comfortable fabric that can benefit both manufacturers and consumers by sustaining the fashion requisites and in lieu not generate excessive waste or take a massive toll on the environment. The fabric is expected to serve society by creating a business model that encourages a sustainable and recurrent circular economy. This thesis brings forth the potential of Vetiver grass to be developed and opti-

mised as a fibre which can further be able to weave a fabric and how this hypothesis can turn out to be a successful direct tool to minimise the wicked problem of landfill waste generation by the fast fashion industry. Transition design guides the researcher to incorporate a system-level change through vetiver grass fabric.

The research develops an understanding of system level change that promotes Indigenous knowledge driven by the emergent design provocation Transition Design. In brief, the thesis proposes a community based economic model following the prison reform policies. This research offers a system that can provide workshops to these prison facilities in order to educate the prisoners with the craft of fibre extraction. The research further calibrates if this could be a viable skill-set for the inmates of Bhopal Central Jail located in the outskirts of Bhopal, Madhya Pradesh, India. It also discusses a model that can train these inmates to weave fabric from Vetiver grass and explore self-employment premises, which are expected to be long-term and stable. Along with the employment opportunity for the inmates, the system will ensure a sustainable textile production practice that will stabilize the current linear production process, progressing towards a model that grows together with the environment instead of jeopardising it.

Chapter five reviews the literature that has influenced this research. This thesis builds on Samarng Keunun's paper on vetiver grass where she researched and tried to develop vetiver grass yarn mixed with cotton and further developed a cotton-vetiver fabric. The thesis also reciprocates the idea of sustainability in fashion and ex-

plores various alternative eco-friendly natural fabrics. The thesis explores and draws inspiration from Mahatma Gandhi's Khadi Movement and further identifies a circular economic model within the movement, linking it with the Maori textile narrative as both share the same idea of inter-personal growth and development through the medium of art inter-weaved with living practices and spirituality.

In chapter six, the research discusses the origin and the chemical and physical properties of vetiver grass. Vetiver grass has been around for centuries, but its usage was limited to medicinal and cooling purposes. This chapter discusses the properties and how these properties can be applied to new purposes apart from medicinal uses. As the thesis is directed towards sustainable textiles, this chapter creates a clear image of the raw material, and its potential.

“If it can’t be reduced, reused, repaired, rebuilt, refurbished, refinished, resold, recycled, or composted, then it should be restricted, designed or removed from production.”

Pete Seeger, Folk Singer and Social Activist

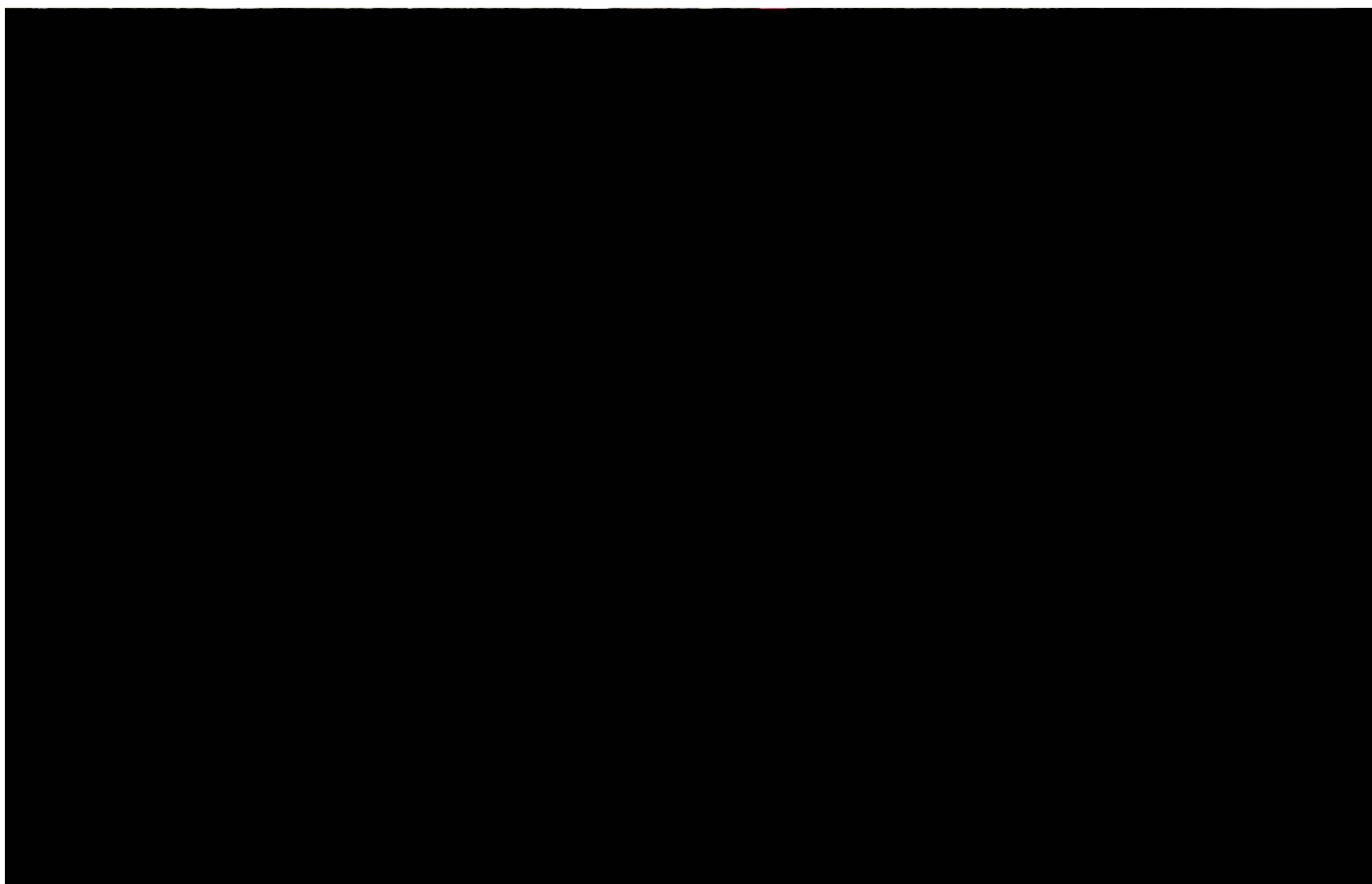


Figure 1- A scene from the ABC's war on waste

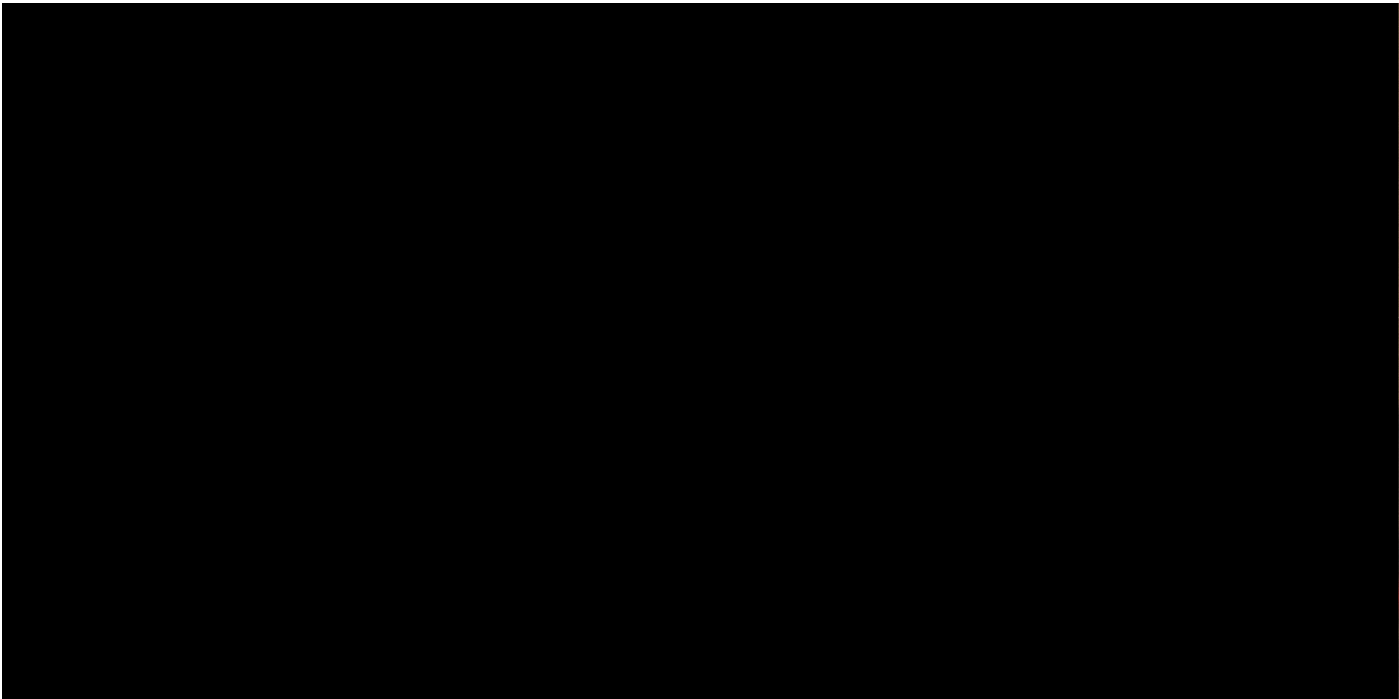


Figure 2- A representation of fast fashion (Cladwell,2015).

2 CHAPTER

SUSTAINABILITY IN FASHION

The basic idea of sustainability is to engage in a development process which is beneficial for the present without hindering the growth of the future (“What does sustainability mean?” n.d.). Textiles are one of the most significant production industry in the world. As a result, it is also one of the most prolific carbon-emitting industries. The primary environmental issues with textiles and fashion is over-consumption and resultantly, exploitation of resources and the environment (Bashar, n.d.). Over-consumption is rapidly increasing because of the popularisation of ‘fast fashion’ (Bau, n.d.).

2.1 What is Fast Fashion?

Fast fashion is the cycle of buying products “on trend” within a market where the trends change very quickly. Fast fashion ensures that consumers get the latest trends at an affordable price. As perfect as that sounds, there are many downsides to this cycle. Fast fashion promotes a short life span of fashion products. The shorter life cycle ensures that fashion items are not being utilised in their maximum capacity and hence generating waste which could be avoided otherwise (Bau, n.d.). In 2011, the United Nation Environment Program estimated that without intervention, the rate of consumption for fast fashion would continue to grow up to three-fold by the year 2050 (Vadicherla & Saravanan, 2014). As a result, there is an urgent need to deal with the solid waste disposal situation. One of the most popular ways to combat this is the application of 3R, (Reduce, Reuse and Recycle) (M & Development, n.d.). Even though the 3R policy is effective, the fashion and textile industry can not solely depend on it to solve the textile waste problem. There is a need to develop more solutions and to make them accessible and achievable to both the manufacturers and consumers. The production process needs to be eco-effective in order to develop and grow sustainably (Alkaya & Demirer, 2014).

2.2 The Emergence of Sustainable Fashion

There has been an emerging industry of Sustainable textiles made out of plant-based renewable resources. The key strategy to build a robust environmental hold on the textile industry is to extend the life cycle of textiles and fashion items ("Eco-friendly antimicrobials and sustainable solutions – Specialty Fabrics Review," n.d.). When most of the consumers are enchanted by Fast fashion, some choose to adopt an anti-consumerism mindset. These consumers discuss and reveal the potential of over-consumption to harm others and the environment (Joy et al., 2012).

2.3 Is Cotton Sustainable?

However, for a long time, Cotton was known to be one of the most organically sourced textiles. Cotton is produced over more than 100 countries, but the central production countries are China, USA, India, Pakistan, Brazil and Uzbekistan. Out of these, 80% of the cotton produced is with the help of pesticides and excessive use of water (Kooistra & Termorshuizen, n.d.). The production of cotton costs a lot more to the environment than how it is often perceived. The excessive use of water is causing these countries to face severe droughts (Leahy, 2015). So even though Cotton is a renewable resource, the production is not sustainable, and hence, it is not eco-efficient.

2.4 Cotton vs Hemp

From the time hemp cultivation is accessible, researchers continue to work on the physical and chemical properties of the plant and its fibres. Hemp has proven to be a great source to produce sustainable textiles ("The textile hemp chain," n.d.). In a comparative study by Averink, it shows that the water footprint of hemp is one third compared to that of cotton. In addition to that, the global blue water footprint for hemp in its cultivation stage is zero as there is not any need for irrigation for hemp crops (Averink, n.d.). These examples are living proof of utilising indigenous knowledge as a means to innovate solutions for the modern day 'wicked' problems.

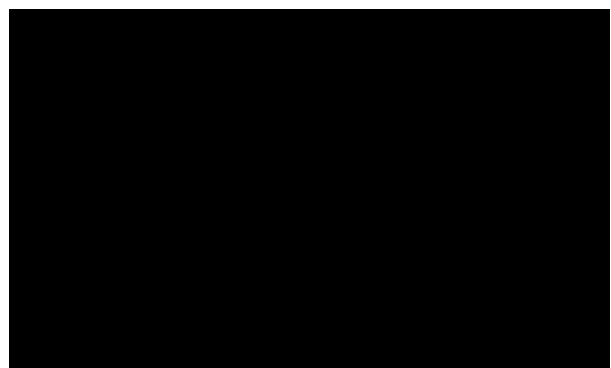


Figure 3- water crisis caused by cotton production (Mohammad Hussain Khan, 2018).

2.5 Bamboo Fabric

One of the emerging new-age sustainable textiles is bamboo fabric. It is a regenerated cellulosic fibre. Any natural cellulosic fibre is entirely biodegradable. Bamboo is the most massive grass which makes it a genius alternative to organic fabrics as it is a perennial grass. The physical and chemical properties are similar to viscose, which make it suitable for apparel purposes as well as other textile required products (C & Saravanan, 2008). Most of the naturally occurring resources, mainly grass, contain lignocellulose or cellulose. There are various chemical and physical treatments to remove lignin from the lignocellulose for it to be further developed into spinnable fibre (Afra, Yousefi, Hadilam, & Nishino, 2013). The thesis will explore the treatments in the next chapters.

The thesis is exploring a similar possibility of introducing a new fabric through Vetiver grass. The grass consists of all the required properties to engage in textile production. With the constant demand for textile in the Fashion Industry, it is almost unsustainable only to exploit their production. Cotton failed to be sustainable because it did not have enough alternative, and thus, cotton was significantly overused, resulting in its exploitation (Kooistra & Termorshuizen, n.d.). The mere availability of different fibres and fabrics brings out the opportunity to explore the industry without causing massive damage via exploitation of resources. The new product development of textiles also allows the production cycle to be eco-efficient since the beginning of production (Dangelico, Pontrandolfo, & Pujari, 2013).

2.6 Pineapple Fabric

Another such fabric that has been existing from a few centuries is PINA or pineapple fabric. Europeans first introduced pineapple tree to the Philippines in the 16th century, since then pineapple's cultivation has been an essential segment for Philippines economy (Carvalho, n.d.). The year of 1571 is the first recorded date of the production of Pina fibres (Lourdes R. Montinola, n.d.).

***“We never know the worth
of water till the well is dry.”
– Thomas Fuller, Historian***

2.7 What is eco-efficiency?

Eco-efficiency is the ability to provide goods and services that satisfy human needs and demands while continually reducing the ecological impacts on the environment. It is considered the best tool to change an unsustainable business model to a sustainable one. Eco-efficiency plays a vital role in creating a balance between ecology and economy ("The Concept Of Eco-Efficiency," n.d.). These are some elements to take into account for an eco-efficient product cycle.-

- 1.Reduction of material intensity
- 2.Reduction of energy intensity
- 3.Reduction and control in the dispersion of toxic substances
- 4.Improvement in the abilities and further possibilities of recycling
- 5.Use of renewable resources to its maximum potential
- 6.Extension of product durability
- 7.Growth in functionality (DeSimone, 2000).

The application of these principles/elements in a textile development process will initiate a channel of interaction around the innovation of new textiles.

2.8 Product Life Cycle

The advent of Fast fashion has abrupted the product cycle in place, which led to a high rise in demand of the customers. To fulfil the demand of the ever-changing trends, the new collections are always ready to replace the current. The problem is that this pre-stock cycle always has a massive leftover waste which then moves to clearance sale and eventually is thrown away. This excess production does not even go through a product life cycle. In Short, to fulfil a certain number of demands, the production is way higher than the actual products to be used. The figure below shows the life cycle of a product in Fast fashion.

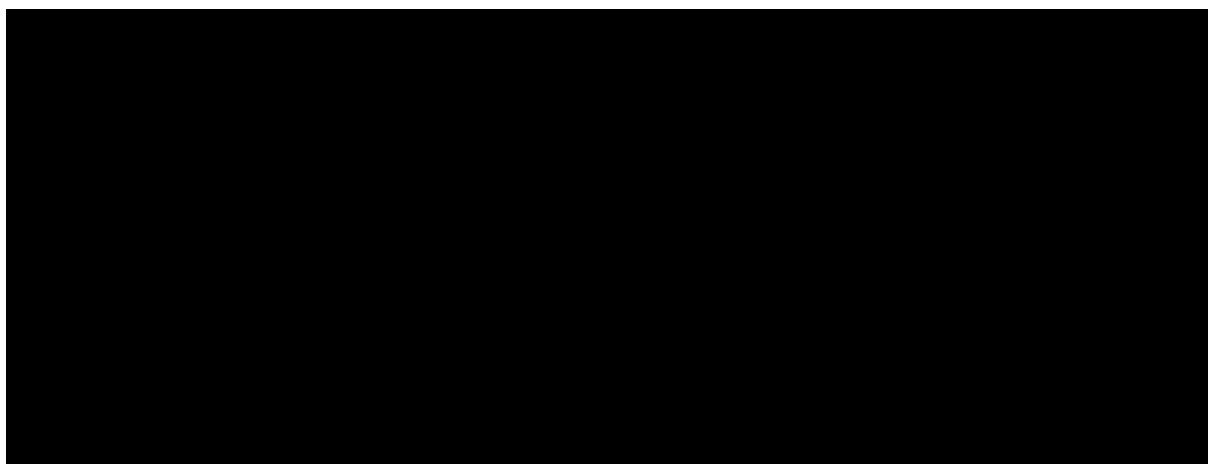


Figure 4- Life cycle of a fast fashion product (Sevilay Onal, 2017)

2.9 Traditional Textiles

There has been a global rise in ecological and sustainable awareness, which has led to an increasingly renewed interest in traditional textiles around the world. Kipoz believes that even though the traditional textiles play a small role in design cultures, concerning its designs and business potential, these textiles play a role as a local identity for their regions (Kipoz, n.d.). Kipoz says, "Traditional textiles are collective memory, social responsibility, intergenerational equity, and sustainable, as well as a contribution to the local economy."

2.10 The Role of Traditional Textiles in Society

According to Ezio Manzini, traditional materials are a tool to incorporate local knowledge, value and experience and hence, creating an idea or a socially responsible design process which is in synchronisation with the local economy. This process will ensure a steady source of income for the region (Manzini, n.d.). One of the most used traditional material is textiles. It has been a crucial part of human history and survival. Every region has a locally innovated and developed textiles as a primal human instinct in order to cope with the geographical and weather conditions of that region. It is impossible to cover all the textiles, and thus, this thesis will mainly focus on the textiles of India and New Zealand.

2.11 Importance of Textiles in India

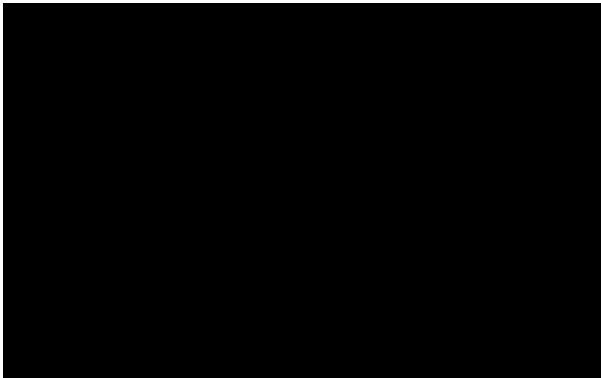


Figure 5- Mata ni Pachedi from Gujarat (Texteil Factorij)

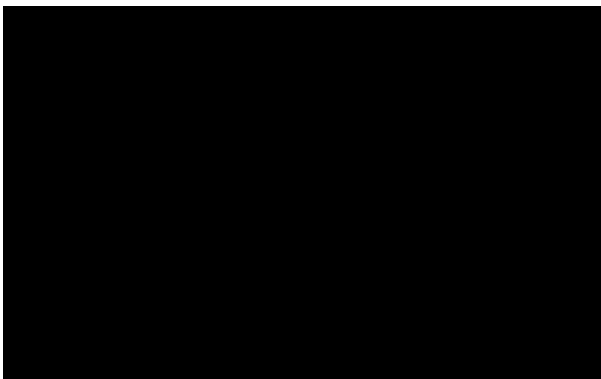


Figure 6- Pabuji ki Phad (Avinash Maurya)

Textiles have been an integral part throughout the history of India. India has 29 states, and every state has at least one kind of textile which is original and personal to that region. Although throughout history, the social, economic and political scenario has influenced textiles in India. The Mughal-era textiles were one of a kind that allured several regions and countries to initiate a trade exchange. To India, textiles are not just an essential amenity; it is an expression of art and values a particular culture holds. Textiles were as precious as gold and diamonds (“Why textiles have been the fabric of Indian society for centuries,” 2015). Textiles in India predominantly is used in clothing and home furnishings, as the Mughals started using handcrafted grandeur textiles as a means of luxury in their clothing. Textiles served a crucial role in the luxurious Mughal forts. Although it was not limited to clothing and furnishings, muslin and cotton cloths were used to depict and narrate the folklore and religious stories in villages through the medium of intricately handcrafted paintings on a piece of cloths. Mata ni Pachedi of Gujarat and Pabuji ki Phad of Rajasthan are two such cultural narrations bound by indigenous and place-based knowledge (Bhaskar & Tiwari, n.d.). In a lot of Indian cultures, textiles serve the purpose of heritage belongings, which are to be handed over to the next generation during the time of their weddings. Phulkari of Punjab is one such textile (“Phulkari and Bagh folk art of Punjab,” n.d.).

2.12 Importance of Harakeke weaving in New Zealand

Māori Harakeke weaving in New Zealand has been an essential life skill for the survival of the community. Harakeke grows throughout Aotearoa. Harakeke is still serving the purpose of medicinal usage, along with being a renewable resource for the development of day-to-day domestic living products (Scheele, n.d.). Māori communicated through the intergenerational practices and lifestyle that embedded the Māori heritage and culture. The art of weaving is known to be sacred and in congruence with 'mana, mauri and tapu.' (McRae-Tarei, n.d.). Mana, mauri and tapu are the vitals of Māori philosophy which resonates with both humans and the natural world ("Tapu, Mana, Mauri, Hau, Wairua," n.d.). Mana refers to an extraordinary power, essence or presence; Tapu refers to restrictions, disciplines and commitments; Mauri is the energy that binds all the physical things. (without mauri mana cannot flow) (Taonga, n.d.).

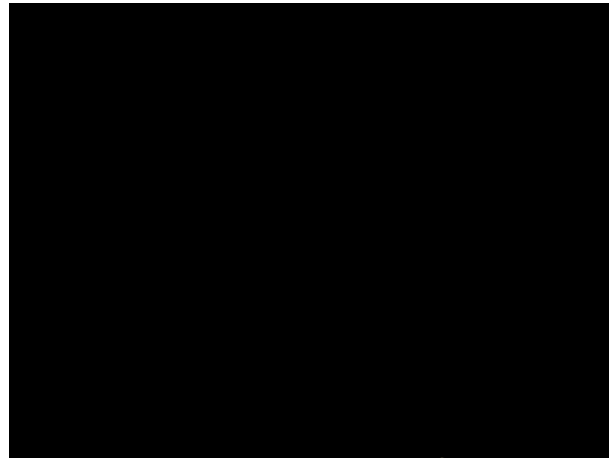


Figure 7- Māori kakahu (Miramoda Exhibition, 2011)

3 **CHAPTER** **ECONOMICAL AND SOCIETAL IMPACTS** **THROUGH TEXTILES**

3.1 Textiles as Physiological Need

Textiles is one of the major industries that have existed throughout history. According to Maslow, textile and clothing are one of the necessities of the human being as part of their physiological needs (Maslow, n.d.). These physiological needs consist of oxygen, food, water, shelter and constant and optimised body temperature. The fulfilment of needs is the first step toward personal satisfaction (Jerome, n.d.). As human civilisation grew, these needs became the primary obstacle to solve in a manner where the solutions involved peace among societies.

3.2 Challenges Faced by the Textile Industry

Textile Industry is one of the most unsustainable industries that exist in today's times; the prime reason is the resource-intensive supply chain being at the centre of the industry, producing a massive amount of waste and further releasing the toxic substances in the air, water and land (Gardetti, n.d.). Currently, at every stage of textile and fashion product life cycle, there is a considerable amount of waste generated as the fashion cycle promotes over-consumption (Vadicherla & Saravanan, 2014). Mass garment consumption entails a decision-making process of purchase, which is pushed to be shorter in a period rather than a conscious purchase. One of the biggest challenges the sustainable fashion brands are currently dealing with is to promote conscious consumption as well as sell as many products as possible (Han, Henninger, Apeagyei, & Tyler, 2017).

3.3 Modern societies vs Traditional Society

Looking at the “modern society” which refers to the economic system where the individuals make the choices as opposed to the “traditional society” (Horwitz, n.d.). Edward Shorter describes traditional societies as a collective decision making societies. These societies discourage the idea of individual choices as they were often at the verge of biological survival. These societies are based on community control and resource allocations (Vann, n.d.). Although these traditional societies are, in fact, the foundation of the indigenous knowledge that is still relevant in the 21st century. Indigenous communities in various geographical regions have devised methods and documented useful data and understandings through local philosophies to establish a connection between the local flora and fauna, land, water and supernatural forces. The data includes geographical, genealogical and biological knowledge and practices (Bruchac, 2014). The functioning of these indigenous societies is also a reflection of Karl Marx’s idea of the law of value. It talks about conscious economic planning during the distribution of resources based on the contribution level of individuals so that the social surplus goes back to the society hence making the economy circular (“Economic Manuscripts: Capital: Volume One,” Karl Marx pg 27).

3.4 Wallerstein’s Theory of World System

To implement a circular economy in modern times, it is essential to understand the global world economy at the place. One of the most famous sociologist and economic historian, Immanuel Wallerstein’s theory of world system discusses a world economy which is “integrated through the market rather than a political centre.”(Wallerstein, 2011b). In another word, the interdependency of different regions and states concerning food, fuel and protection alongside their competition of dominance, ensuring that no particular state will have their dominance forever (Goldfrank, 2000). Karl Marx profoundly influences Wallerstein’s theory (Wallerstein, 2011a).

3.5 The trickle-down Economy in Textiles

Through the lens of textiles and fashion industry, the trickle-down theory has a distinct and transparent approach for predicting fashion diffusion; It creates a hierarchy where the high-status individuals establish trends which can be followed by middle and low-income strata. Furthermore, these high-income individuals quickly move on to the next trend in order to differentiate their societal position (Kaiser, n.d.). The process of quickly moving on to the next trend is the starting point of fast fashion. This cycle of fast fashion ensures an unevenly distributed economy with an exemplary amount of residual waste in the form of clothing and textiles (Bau, n.d.). One of the most common examples of trickle-down fashion is runway designs. Considering the high prices of runway collections, it is not possible for middle or low-income individuals to own runway fashion. These designs are then simplified and manufactured for pret-a-porter fashion brands through cheap logistics and materials to serve and appeal to the masses.

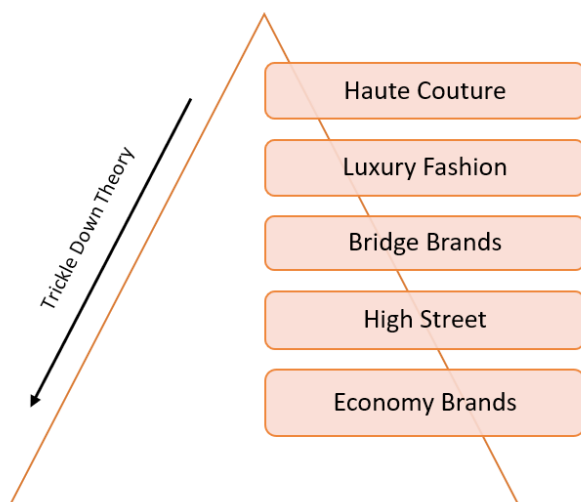


Figure 8- Trickle down Theory in Fashion Industry (own)

3.6 Linear economy- Take. Make. Dispose.

Over a century, the industrial economic model is dominated by a one-way production and consumption process. This process of linear industry cycle includes the manufacturing of goods dominantly from non-renewable resources; the product life cycle tends to be short as the most common economic structure is Trickle-down theory (Thibaut Wautelet, 2018). According to Ellen McArthur Foundation, the currently existing linear economic model has its root delved deep in historically unevenly divided resources. Since the consumer market was mainly among the developed countries, and so were the resources; the idea of 'take-make-dispose' became the norm (Ellen-McArthur-Foundation-Towards-the-Circular-Economy-vol.1.pdf, n.d.). As a result, the production was constantly motivated to adapt and reinforce the business models that were based on the exploitation of raw materials and thrived on economising human labour work. Consequently, the overemphasis on cheap material led to an economy which did not pay enough attention to reusing, recycling or waste management in general (Sariatli, 2017).

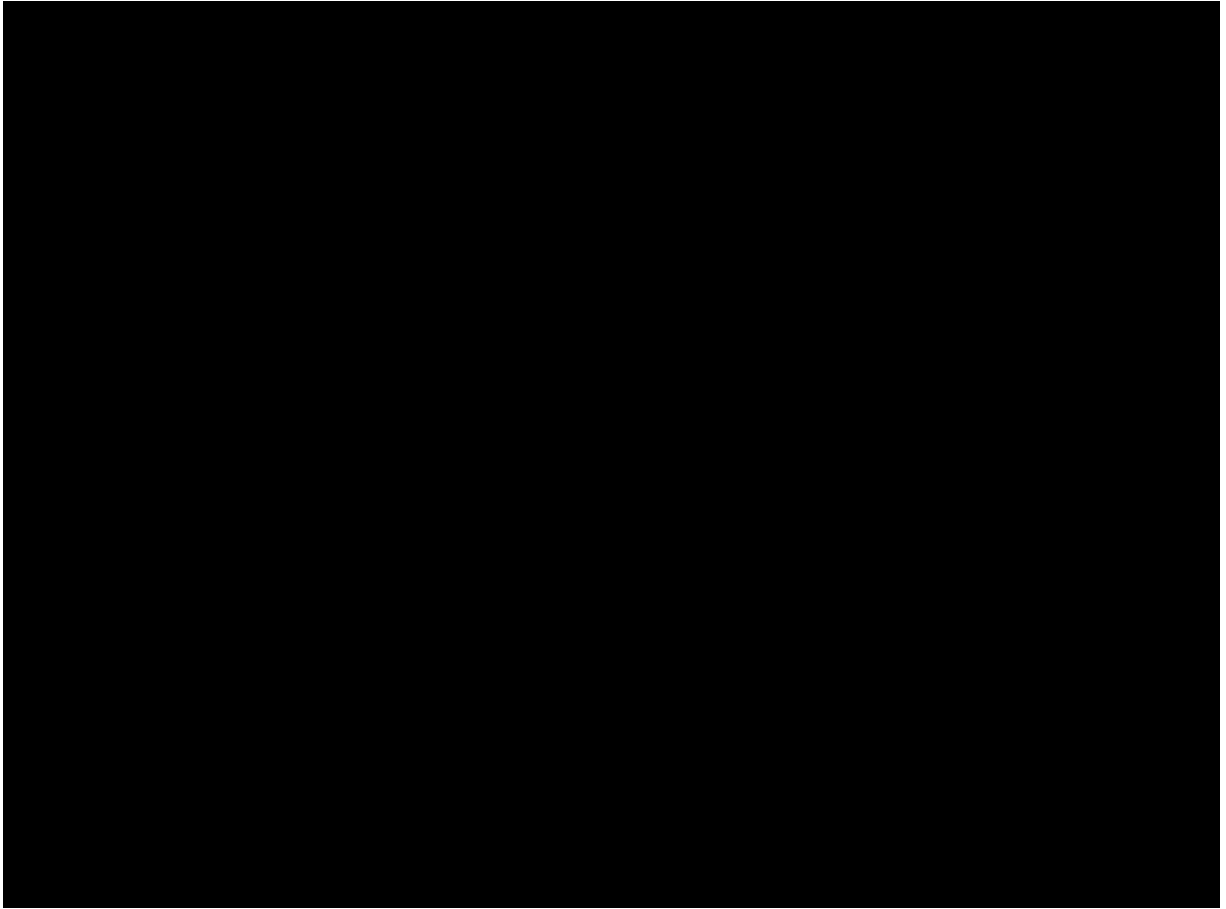


Figure 9- Gandhiji in sabarmati ashram (1925).

3.7 Circular Economy

On the contrary, Circular economy's structure revolves around reinforcing and strengthening the overall system health. It is crucial for the economy to run efficiently at all scales, including large and small businesses both globally and locally. A transitional shift from a linear economy to a circular economy not only aims at reducing the adverse effects of the linear economy, but It also demands a systematic change that leads to a long-lasting, self-sustaining resilient business and economic opportunities which aim to provide societal and environmental benefits ("What is a Circular Economy?" | Ellen MacArthur Foundation).

3.8 Benefits of Circular Economy

Nevertheless, some brands are acing circular economy, Patagonia being one of them. Patagonia teaches its customers to mend their clothes along with developing a system where the customer can return the clothes to the company, and the company can mend the product and bring it back to the market. Another such example is of Pratibha Syntax, an Indian textile company based in Indore, Madhya Pradesh. Pratibha has been recycling the textile waste and producing garment out of it; the company has not only increased its profits but also minimised their waste. This approach towards a circular economy has also helped change the mindset of people closely working with Pratibha Syntax hence giving away a vital ideology to people to ponder upon (Gardetti, n.d.).

3.9 Identifying a Circular Economic Model in Gandhi's Khadi Movement.

A glimpse of Circular Economy can be witnessed in Gandhi's model of Khadi Industry. According to him, The laws of the economy should be in synchronisation with the laws of nature, especially the ones that aim for material progress as well as social harmony and moral advancements. One such initiative was the production and promotion of Khadi Industry ("Economic Ideas of Mahatma Gandhi," 2016). It was estimated that every person in India required approximately 13 yards of fabric/cloth per year. Gandhi believed that increasing the number of mills is not the right solution to the problem and he insisted on building an economy through the Khadi Industry as "a symbol of Indian humanity of it is economic freedom and equality". Khadi production had the calibre for decentralising the textile Industry and redistributing the resources among Indians (Gandhi and the Mass Movements, n.d.). Khadi Industry was a significant part of "Swaraj" movement. Since Swaraj was focused on liberating India from the British, Khadi played an essential role in building up an economy that helped people supplement their earning and provided job to the unemployed. Khadi Industry was a well-planned initiative as it did not require a cumbersome set-up and could be organised with small capital. It became a source of steady income at the same time; It became a sustainable model in terms of economy, environment and social harmony ("Economic Ideas of Mahatma Gandhi," 2016).

“Our hopes and politics are largely the results of a given framework. It is particularly important that we reflect on this fact in times of profound transformations, such as today” -Arturo Escobar, Other Worlds are Already Possible (2009)

4 CHAPTER METHODOLOGY

4.1 Introduction

This chapter defines the different methods I have used throughout my research and the rationale behind its use. This research is both qualitative and quantitative. This investigation includes Indigenous Knowledge and previous research findings accumulated from past observations, arguments and studies within and outside the textile design and social innovation. With only limited previous research available on the opportunity to develop fabric from vetiver grass, it was very challenging to research the physical and chemical properties of the fibre, but this investigation never the less comprises of both primary and secondary research findings.

This research builds on the previous but limited work of Samarng Keunun into the uses of vetiver grass. The thesis incorporates the learnings and findings from the literature reviewed and undertakes a large number of quantitative physical experiments throughout the investigation.

This research is inspired by the Transition Design framework that is built on “four mutually reinforcing and co-existing areas of knowledge, action and self-reflection.” (Irwin, 2018). The investigation is divided into two main stages; Identifying current scenarios and future speculations of the problem solved. This process encourages the design of positive future focused interventions. The first stage maps research limitations and possibilities. The research in this stage includes the economic, social and environmental discourse about the Fashion and Textiles industry. Having achieved this, the information is collected and analysed. This stage impacted the decision of whether to design fabric from the grass.

4.2 Aims and Objectives

AIM 1

To identify, using Transition Design, a local place-based approach that can feed into a paradigm shift in the large-scale systems change required in the fashion industry.

•Objectives-

- To study Transition Design and identify it can contribute to this investigation
- To identify and study Indigenous Knowledge and its possible applications to the design of sustainable futures.

AIM 2

To identify processes and practices in which Vetiver Grass can be locally grown, processed into a durable but wearable material.

•Objectives-

- To study and identify the physical and chemical properties of Vetiver grass.
- To identify different kinds of sustainable pre-treatment to make the fibre soft and flexible.
- To explore weaving in the fabric with the processed fibre.

AIM 3

To identify a self-sustaining economic model that enables small rural communities autonomy and identity.

•Objectives-

- To identify and incorporate the local techniques and knowledge.
- To study the opportunity for establishing a small scale local operation that can offer community autonomy.
- To identify and study cosmopolitan localism for a self-sustaining economic through textiles.

4.3 Research Approaches

The section depicts the methods that are used in the research; Transition Design and Research Through Design.

Research approach-

The emergent design provocation Transition Design guided this research. The term Transition Design was introduced in 2015 by Gideon Kossoff, a social ecologist and Terry Irwin, the Head of the School of Design, Carnegie Mellon University, USA. Irwin and Kossoff, argue the need to implement a framework that can serve as a grounding to later build and create a sustainable society on (Kossoff, n.d.). As a consideration within the Transition Design framework the Everyday, as discussed by Ben Highmore, is considered an authentic and fundamental design context, and in the development of design solutions that can harness natural resources while prioritising the health and well being of future generations. (Irwin et al., 2015). The Transition Design framework is the most suitable approach to design solutions that have the potential to protect and restore both natural and social ecosystems (Irwin et al., 2015).

Guided by the Transition Design Framework, the thesis explores the socio-economic considerations within textile production and fast fashion industries. By using the Transition Design (TD) framework, it has helped build a vision for a shift in paradigm within the development of textiles. This investigation uses the medium of Vetiver grass fibres. Again influenced by TD this study adopts from the Theories of Change within TD the Stream of Thought, Indigenous Wisdom.

“Indigenous pre-industrial societies lived sustainably in place for generations, informed by ‘slow knowledge’ that was place-based and embedded within local cultures. Transition designers have much to learn from these approaches to designing and their symbiotic relationship with the natural environment.” - Transition Design, 2015

The recognition of Indigenous Knowledge and Wisdom provides a new approach to the research of sustainable and inclusive solutions. The TD framework enables and specifically addresses the need for a shift in mindsets and new voices to be heard. Research and the development of solutions from such studies become more authentically a symbiotic relationship and process. With the adoption of a new mindset, the next step is to design the new product or processes with an appreciation of more holistic approaches, the everyday life and how change can be introduced, managed and maintained within what are already transitional times.

Research Strategy- Research Through Design

Research strategies often support research frameworks. To achieve this, this study pairs Transition Design with Research Through Design. The approach of Transition Design is to enable research to be furthered through design (Irwin, 2018). Research Through Design is an over-arching term where the innovation or production of artefacts; in this case, fabric, is explicitly driven by the primal research question. Furthermore, the product is used for the theoretical development of the holistic idea or system (Selena Savic & Huang, 2014).

This thesis endeavours to identify the need to create new materials that battle specific problems that contribute to larger 'wicked problems.' This study addresses landfill textile pollution and unsustainable production practices in the sectors of textile and fashion and explores ways to redesign a model through new product development. The new product aims to help improve small social and economic paradigms but that, as framed in Transition design can be scaled up where appropriate and contribute to larger scaled concerns. The strategic component of this study is the development of a circular economy that benefits a local community and that can be adopted and networked in other communities or scaled up to a larger iteration.

There is a limited amount of resource available on vetiver grass fabric, but as vetiver grass is a natural cellulosic material, the existing literature on cellulosic natural resources forms the backbone of my study along with Samarng Keunun's research. The process involved much trial and error throughout the experiments with the removal of the cellulose from the grass for a residual fibre, proving very challenging and time-consuming.

***“To eliminate the concept of waste means to design things-products, packaging, and systems-from the very beginning on the understanding that waste does not exist.”
~ William McDonough, Architect, Designer,
Author***

4.4 Design Research and Structure

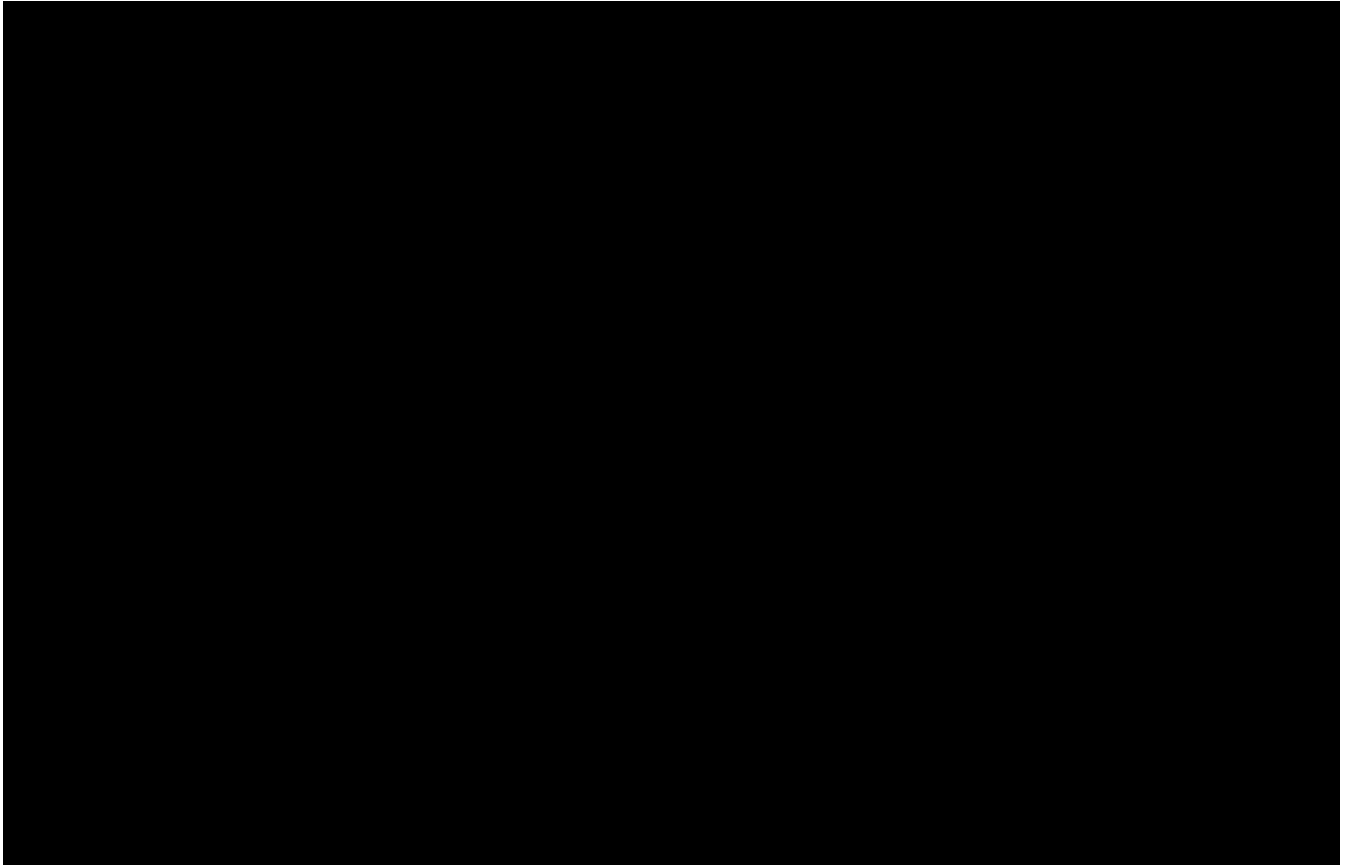


Figure 10- Transition Design Framework (Irwin et al., 2012)

Transition Design is a design-led methodology that aims to create system based change. The framework is mutually co-dependent on four key areas that help bring together a variety of interdisciplinary practices works as a catalyst to achieve the desired system-level change (Irwin, 2018). The interdisciplinary approach embedded in TD enabled engagement and deepened understandings with socio-economic issues. Design can also serve as a medium to manifest the results or communicate and facilitate the process considering system-level change does not happen overnight.

These four key areas are; Vision for Transition; Theories of Change; Posture and Mindset and New Ways of Designing. (fig 11) In this thesis, these are the four areas where critical thinking and brainstorming happened throughout the progress.

Vision for Transition

In this research, the Vision for Transition is to help small rural communities create a sustainable circular economy that they benefit from. The benefits are more than economic and consider more holistic values and relationships. These could include systems with zero waste that ensure no harm to the environment while eco-efficiently sustaining both business and social paradigms.

Theories of Change

This section of TD was deeply inspirational, and surprisingly holds a meaningful connection to my cultural roots in India. Transition design acknowledges the value in diverse and pre-industrial world views. Gandhi's socio-economic model of Khadi (explained in chapter 3) is one that has motivated this research and was established in an pre-independent India. The other worldview that has inspired this investigation is te ao Māori (the Māori world-view.) Te ao Māori acknowledges the interconnectedness and interrelationship of all living & non-living things (Ka'ai et al., 2004).

Te ao Māori also acknowledges the importance of craft in both personal life and social life within a community plus the inter-generational translations of knowledge throughout the ages. Apart from these two significant and personally relatable premises, the research also relates indigenous appreciations of circular economies and their application in a more contemporary environment.

Posture and Mindset

One's own experiences drive one's posture and mindset. TD challenge individuals and collectives to address and where needed challenge one's own approaches to impact change on a system-level. TD argues that by doing these new ways of designing solutions to the multi-layered problems can be undertaken. This thesis is exploring sustainable, eco-efficient and straightforward fibre extraction methods from Vetiver grass that can be executed by anybody, ensuring the conception of a process that can be acceptable by the masses to the transitional system-level change.

“In order to change an existing paradigm you do not struggle to try and change the problematic model. You create a new model and make the old one obsolete.”
~ R. Buckminster Fuller, Architect, System Theorist

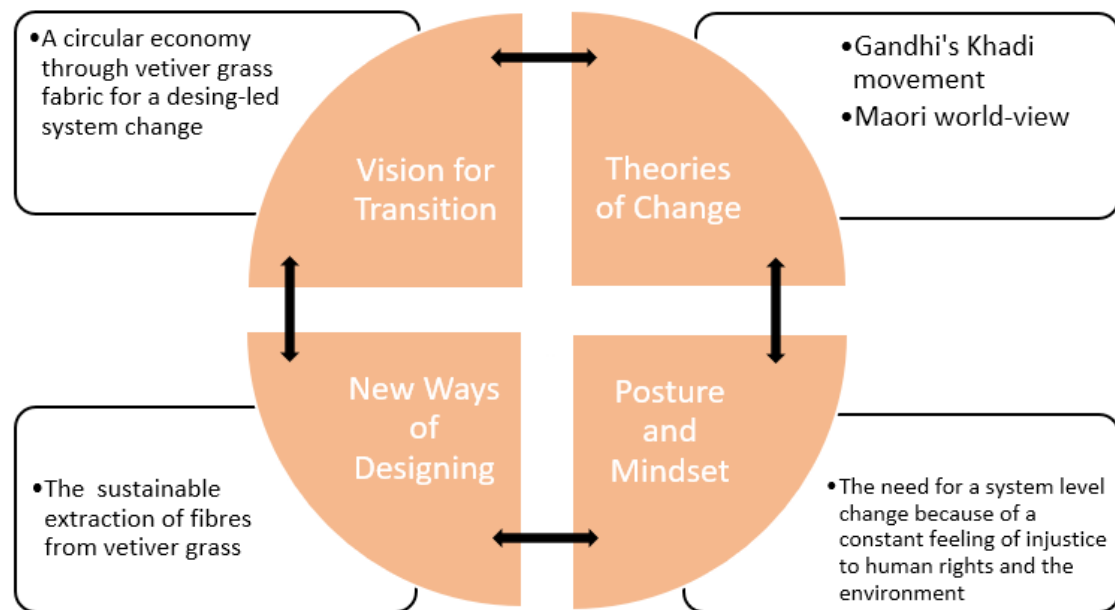


Figure 11- Transition Design Phased Approach (Author)

These phases are the next set of steps that follows the identification of the four areas of research. To start the process of 'creating', it is of utmost importance to lay out the current scenario and the desired future scenario. This process of identifying the present and future is not limited to the beginning of the process but is a part of the process throughout where any additional information can be introduced. A matrix assists this process, discussed in figure 13 (Irwin, 2018).

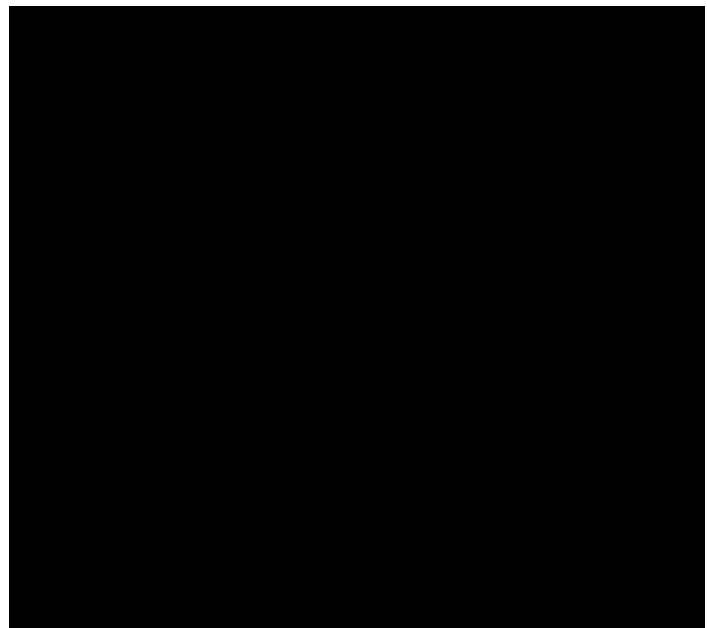


Figure 12- Transition Design Phases (Irwin,2015)

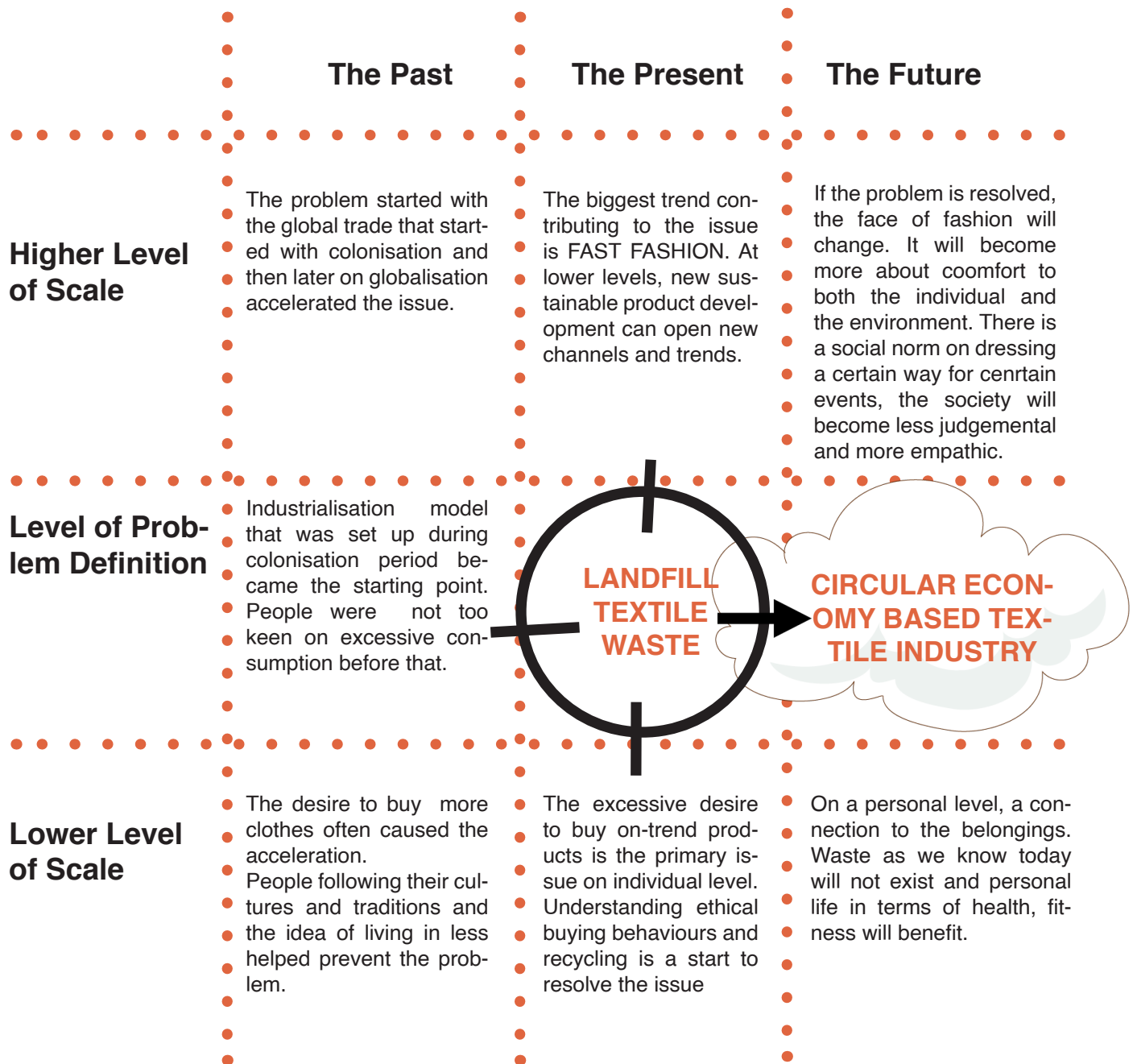


Figure 13- The Spatio-Temporal Matrix for the wicked problem of Landfill Textile Waste (Author).

Designing interventions require questions to be asked at every level of the problem, from lower system levels to the higher system levels. This process helps in the identification of problems and further helps to address these problems through the design of pathways into the future.

These questions are constructed to enable a contribution in designing the solution of wick-ed problems. In this research, the everyday problems of the textile industry expand across agriculture, production and eventually, the market places and consumption. The user is a central issue to this research.

The advent of 'fast fashion' has its roots in globalisation. Current discussions revolve around stabilising the fashion and textile industry. The problem is beyond individual control and demands a systematic change.

Once the design interventions are at place, on a system-level, it is beneficial to wait and observe the reactions of the design solutions. The observation and henceforth its understanding and analysis helps identify new issues and direct the researcher to develop new mindsets. There was a limited time allotted to the thesis because of which it was difficult to exercise the step of waiting and observing. This thesis is not just an academic routine for the researcher. As discussed previously, it is almost impossible to engage in a project like this and not involve personally. Even though the research does not go beyond the point of waiting and observing, it is a never-ending process to delve into a lifestyle moving towards a sustainable future.

“As a designer, you can’t accept whatever happens. You should do the revolution.”

– Ezio Manzini, Founder of DESIS (Design for Social Innovation and Sustainability)

5 CHAPTER LITERATURE REVIEW

This literature review discusses the most notable arguments and research that support this thesis. Along with serving the prime solution of soil erosion, vetiver grass has had many other functions (Kemper, 1993). In the Indian sub-continent, vetiver grass has always served medicinal purposes which were kept alive throughout the time with the help of the intergenerational transfer of local wisdom and knowledge of the respective communities (Gnansounou, Alves, & Raman, 2017). Samarng Keunun wrote the first paper on the development of vetiver grass fabric as a viable textile option. This was ground-breaking research that held possibilities for further exploration (Keunun, n.d.).

The current ventures around Circular Fibre Initiative hold a compelling narrative that involves the creation of new products in the sector of textiles (Ellen-MacArthur-Foundation-Towards-the-Circular-Economy-vol.1.pdf, n.d.). The Ellen MacArthur Foundation (TEMF) focuses its interest in making fashion circular. The organisation advocates a circular economy as the base of a business structure that follows a holistic approach in the development of the business ("The Ellen MacArthur Foundation's Mission," n.d.). TEMF argues that the circular economy model is the most viable approach to battle fast fashion without losing both business and profit while maintaining a 'no waste' initiative within the fashion industry business model and the production cycles (Joy, Sherry, Venkatesh, Wang, & Chan, 2012). The implementation of any new model into a current scenario is challenging and requires several approaches and methods that enable systematic change (Anderson, 2014). A systematic change calls for an interdisciplinary design approach to engage with the 'wicked problems' (as explained in the 5.4- Transition Design) (Irwin, 2015a). Transition Design aims to create solutions that are "design-led social transitions and lead to more sustainable futures". This framework advocates different 'stream of thoughts' including Indigenous Wisdom. These allow the extension of the scope of research into more local-place based knowledge and encourage a transition into more sustainable futures (Irwin, 2015b).

Parallel to Transition Design, this research identifies Mahatma Gandhi's (2.10.1869 – 30.01.1948) Khadi movement as a model that incorporates circular economies as a solution to the two most dominant problems that faced a pre-independent India. First, the economic crisis that lasted a hundred years and crossed both the 19th and the 20th centuries, which was fueled by the cheap trade offered by the East India Company. The East India Company, simply put, were the British colonisers and their implementation of trade with India. Indian National Congress (INC) led by Gandhi had a strong political hold, the Khadi movement was a part of the 'Swaraj' movement that was focused on fighting the British for the independence of India. The Khadi movement served as a non-violent revolution led by Gandhi against the East India Company. They demanded an Independent India (Bean, 1989).

Perhaps unsubstantiated, but as an Indian citizen, it is evident to me that the Khadi movement is one of the most remarkable examples of establishment of a system-led change through design. This research makes the connection between India and New Zealand as both being colonised by the British and yet finding their voice through their indigenous art, craft and music. Maori textiles serve as a narrative of the local knowledge and Indigenous wisdom that have been curated throughout the ages ("Tapu, Mana, Mauri, Hau, Wairua," n.d.). Te ao Maori (Maori world-view) advocates a holistic approach that includes both people and place within rich local histories (Taituha, 2014). This Chapter explores and reviews the literature relevant to the research.

“If we could build an economy that would use things rather than use them up, we could build a future.” ~ Ellen MacArthur

5.1 Samarng Keunun- Vetiver grass fabric

The most prevalent research on vetiver grass fabric as a viable option for textile product development was led by Miss Samarng Keunun of The Pikun Thong Royal Development Study Centre in Thailand. Keunun studied the properties of vetiver grass and developed fibres using a chemical process that removes the chlorophyll from the grass, leaving only the fibre strands. (Keunun,” n.d.). The results displayed that the fibres were hirsute, shiny, non-sulky and inflexible. Keunun observed that the strength of the vetiver fibre was stronger than wool but not as strong as cotton. As the Vetiver grass fibre alone was not fit to spin, Keunun furthered her research by blending vetiver grass fabric with cotton in order to have a spinnable yarn. Keunun established that Vetiver grass could serve as a sustainably viable source to produce fibres and textiles. Subsequent studies show that it is possible to enhance the chemical and physical properties of vetiver grass fibre in order to increase the spinnability of the fibres (Vinayagamoorthy, 2017).

5.2 The Ellen MacArthur Foundation- Circular Fibre Initiative

One of the most notable organisations to achieve an accelerating transition towards a circular economy is The Ellen MacArthur Foundation (TEMF). It was founded in 2010 by Ellen MacArthur, Philip Sellwood and Peter Morgan. TEMF promotes awareness and implements a circular economy in decision making across government, business and academia (“The Ellen MacArthur Foundation’s Mission,” n.d.). Academically, the foundation’s approach to learning involves interdisciplinary projects and involvement of schools and colleges to encompass formal and informal learning about circular economies and to implement a systematic critical thinking approach to accelerate the transition away from current linear paradigms (“The Ellen MacArthur Foundation’s Mission,” n.d.). An initiative launched in 2017 called ‘Make Fashion Circular.’ focuses on radically redesigning the operational model of the fashion industry (“Circular Fibres Initiative,” n.d.). This encompassed a circular model where waste minimisation was a priority alongside encouraging all new raw materials introduced to the cycle be sustainably sourced (Gardetti, n.d.). Foundations such as TEMF enable and provide knowledge to build a system that can assist a sustainable model of design and business without hindering the growth of each other.

5.3 Circular Economy

The Ellen McArthur Foundation explains that a “Circular economy as a system that looks beyond the current take-make-waste extractive industrial model; a circular economy seeks to redefine growth by focusing on positive society-wide benefits.” (“What is a Circular Economy?” n.d.). The textile and fashion industry is renowned as being highly unsustainable, with a massive amount of pollution and residual waste generated every year (“Putting the brakes on fast fashion | UN Environment Assembly,” n.d.). A systematic change is required to solve the evergrowing problem of textile and fashion industry rather than individual efforts, though those individual efforts are not in vain (Mohanty, n.d.). One of the principal schools of thought for the circular economy is Cradle to Cradle (C2C), Walter Stahel, a Swiss architect, first introduced the term in opposition to the current linear economic system (Thibaut Wautelet 2018, pp.5-6). Following this, William McDonough and Dr Michael Braungart introduced the concept in their book *Cradle to Cradle: Remaking the way we make things* (William McDonough, Michael Braungart, 2002). Essentially, C2C is the amalgamation of design and science to create the most effective economic models that benefit the society as well as strive to eliminate the concept of waste (William McDonough, n.d.). It is evident from the narrative of much of what was read on circular economies that redesigning or reforming a business model is the key to achieve sustainable development goals provided by the United Nations (73rd UN General Assembly, n.d.). One of the most recent voices of this model is Kate Raworth, an economist; explicitly talks about a circular model in her book ‘*Doughnut Economies*’. Roworth argues the incorporation of planetary and social boundaries while developing any economic cycle (Raworth, 2017).

5.4 Transition Design

The implementation of the circular economy in modern times is an inter-disciplinary affair with an emphasis on redesigning processes and life cycle of materials (Murray, A., Skene, K., & Haynes, K. 2015). One emergent area of design research that demands a fundamental change at every level of society is Transition Design. Modern problems such as climate change, landfill waste, depletion of natural resources are just a few of the ‘wicked problems’ that transition design argues, require a design-led systematic change to solve problems like these (Manzini, 2015). Jon Kolko, a social design strategist and the founder of Austin Centre for Design, defines wicked problems as too problematic to solve because of the complexities embedded in the problems. The issues hold different opinions about how to solve the problems; inadequate or opposing knowledge; and adding to the issue is the interconnectedness of different problems (John Kolko, 2012). Transition Design acknowledges the current socio-economic model and acknowledges “we are in transitional times” (Manzini, 2015). The principal idea of Transition Design is to encourage societal transitions towards a more sustainable future. One of the most exciting arguments made by Transition Design is that design will play a crucial role in this transition. It advocates reformations that seek more sustainable lifestyles in harmony with nature (Sachs, 1999). Terry Irwin, Director of the Transition Design Institute at Carnegie Mellon University, USA, argues the need to have a ‘continuum of design approaches’. Building on Service Design and Social Innovation, Transition Design focuses on a more long-term vision and recognition of solutions through new and more sustainable socio-economic and political paradigms (Irwin, 2015b).

5.5 Gandhi's Khadi Movement- The Fabric of Independence

Within Indian history, Khadi is a benchmark movement that sought to restructure the economic model around textiles. Gandhi termed Khadi as a 'fabric of Independence'. Khadi served as a symbol of the potential of Indian Economic model to be self-sufficient as well as a message to the British in which India demanded equal rights (Bean, 1989). Textiles have always been a fundamental currency within India. Textiles served not only the clothing industry but also as a medium of cultural narrative through weaving and prints (Bhaskar & Tiwari, n.d.). Khadi was perceived as a profound and passionate fight in leading India beyond colonisation while developing and creating their stable economic structure for a circular economic flow within the community (Ekta Jain, n.d.).

It is safe to say that Khadi is the Volkswagon of textiles for India. This research makes the connection between Gandhi's Khadi and the 21st century's movement of slow fashion and recognises Khadi as being the 'fabric of the people' ("The Khadi Story – Because of Nature," n.d.).

"If we have the 'khadi spirit' in us, we would surround ourselves with simplicity in every walk of life. The 'khadi spirit' means infinite patience. For those who know anything about the production of khadi know how patiently the spinners and the weavers have to toil at their trade, and even so, must we have patience while we are spinning the thread of Swaraj." –

Mahatma Gandhi

5.6 Māori Textile Narrative

Te ao Māori (Māori world-view) is considered to be holistic and recurrent. Every person is considered to be connected with a living thing, environment and to the atua, i.e., ancestors. The interconnectedness of humans with the world around them is defined or expressed through whakapapa, i.e., genealogy (Ka'ai et al., 2004). Aotearoa (New Zealand), like many other countries, was colonised by the British. Starting in the early 19th century, reclaiming the cultural narratives and storytelling through the medium of art, sculptures, music and dance in the form of decolonisation. Pūrākau (ancient legends) has always been a self-sustaining method to protect the old-age wisdom and knowledge in the Māori community (Lee, 2009). One such wisdom is the art form of raranga and whatu. Raranga is 'to weave or to plait', and Whatu is 'to weave, fibre weaving'. According to a Pūrākau, Huna and Rukutia are the atua associated with the art of weaving. Rukutia is known as the originator of weaving and plaiting, and thus, her name signifies the bonding within the fibres (Taituha, 2014). With the understanding of the holistic Māori narrative, a weaver's life is entwined with raranga and the fibres and materials. The weaver aligns themselves to the atua of weaving and thus connect to the teachings of everyday life (Te Kanawa, 2006). As discussed in Transition Design, the long term vision and solutions have a pathway that is enabled by the use of indigenous wisdom and other collective knowledge (Manzini, 2015).

6 CHAPTER VETIVER GRASS

6.1 Origin

It is a common belief that vetiver grass is native to South India, which it is, but compelling enough Vetiver was introduced to the state of Karnataka by Mr John Greenfield and Richard Grimshaw. (Vetiveria, the genus vetiveria) John Greenfield was an agriculturist from New Zealand. He spent 40 years of his life developing a system for soil and moisture conservation around the world, which will be suitable for extreme climates(Council, 2001). Vetiver grass was grown in Fiji Islands to help control soil erosion, in 1957. Vetiver was introduced to India in the 1980s when the coastal area of south India was going through the same problem of soil erosion (Council, 2001). A huge nursery was set up in Bhopal, by John Greenfield. Bhopal also happens to be the place where I am from, hence a connection and interest in Vetiver grass. John's initiative of vetiver grass in India was to solve the issue of soil erosion. However, India has been growing vetiver grass from ancient times for ayurvedic medicinal purposes (Kemper, 1993). It highly is known across the country for its fragrant roots. The tribal and indigenous communities in India have been using vetiver grass to make baskets, fans and ornaments. The root of vetiver grass is made into a mat-like structure to hang from the window and a special make-shift Air conditioner called (cooler) which coverts the warm summer air into cold air. This can be found in every single household in India. I have grown up with Vetiver grass (khus), and that is what makes it intriguing and unique. There is a special home-made drink available in Indian households made from the roots to fight the scorching summer heat. With the versatility vetiver grass has, it compels one to wonder what the other parts can achieve when explored.



Figure 14- A portrait of the researcher with vetiver grass (own)

6.2 The Physical and Chemical Properties

The roots have been the prime focus for the researchers from decades. This research will explore the functionality of the grass leaves. Vetiver grass is made up of lignocellulosic biomass. Lignocellulosic biomass is mainly composed of three polymers; cellulose, hemicellulose and lignin along with little volumes of other components such as acetyl groups, minerals and phenolic substituents. Every naturally occurring plant or grass that consists of cellulose is a potential resource to extract fibres. Vetiver is a perennial and fast growing grass along with the above-discussed qualities, makes it a viable resource for fibre extraction. The extracted fibre has till now has been used as a reinforcement in the composite material. That is, the fibres help enhance the strength of other material for structural purposes (Marriott, Gómez, & McQueen-Mason, 2016). Even though this has been a new approach in composite reinforcement science, indigenous communities all across the globe have been using fibres and leaves for enforcing the mud for the mudhouses (Cihan, Blake, & Sobey, 2018).

6.3 Usage

Vetiver's abilities are not only limited to prevention of soil erosion and Ayurveda; it's deep- penetrating root system can survive almost any extreme weather such as rain, storm, heat, drought and more, except freezing. One of the unique qualities of vetiver is that it does not consume the water molecules and nutrients from the soil all for itself. This helps the nearby plants and crops prosper even after being in the close vicinity of vetiver roots. This quality makes vetiver a low maintenance crop. This quality is a crucial element of the following research demonstrated in this paper. The other striking quality of vetiver is that there are absolutely no insects or diseases that are as yet known to live on the grass. This allows exploring different aspects of a vetiver without causing any harm to flora and fauna around.

Vetiver grass has always existed around us, but it was the world bank who reintroduced vetiver to minimise the environmental disruption caused by soil erosion. The agriculturists have invented the vetiver systems. A vetiver system is a network of vetiver grass grown in hedges across the land because the roots of vetiver grow deep, this interconnects and stops the soil from massive movements.



Figure 15- Pre-Spinning Carding process (Author, 2019).

***“I’d rather fail at something important
than succeed at something trivial.” ~
Paul Hawken, Environmentalist***

7 CHAPTER

THE EXPERIMENTS AND IMPLEMENTATION

In this segment, the procedure of the research process will be discussed. The procedure accommodates the aims and objectives of the research. These steps show the relationship between each experiment and how the next experiment is derived from the findings.

7.1 Fibre Extraction Process-

Fibre extraction process consists of experiments conducted to get the most acceptable fibre that will be able to be spun ready for weaving. This investigation is executed with the consideration of minimum amounts of resources used for extraction and to engage in research that promotes sustainable approaches. This was done to ensure that the communities this research is aimed at can also engage in sustainable approaches. Although the correct way to extract any natural fibre is to leave the grass or the roots in the water for more than six months without any air contact, as mentioned earlier, due to research scope and time limitations, there was a need to use Sodium Hydroxide to accelerate the process. If and when this research moves out in the real world, the process of using Sodium could be eliminated.

In this segment, the procedure of the research process will be discussed. The procedure accommodates the aims and objectives of the research. The researcher shows these processes through design iterations, which are co-operated by textile chemical processing. These steps show the relationship between each experiment and how the next experiment is derived from the previous experiment's findings. The experiments and their analysis go hand in hand.



Figure 16- Textile processing for Experiment 1 (Author, 2018).

Experiment 1-

Aim- To extract the fibres from dried vetiver grass using Sodium Hydroxide (NaOH).

Material Required- Cooktop, 6l or above capacity pot, a spatula to stir, 250 grams of vetiver grass cut into 6-8 inches pieces, 15 grams of NaOH per litre, Thermometer.

Procedure-

- 1.Fill the pot with 2 litres of water and put in on the cooktop. Turn the cooktop on to the highest point.
- 2.Wait for the water to reach to 100 degree Celsius.
- 3.In the meantime, cut the vetiver grass into the length of 6-8 inches.
- 4.Once the temperature reaches to 100 degree Celsius, add 30-gram of Sodium hydroxide in the water. The water will experience a quick high rise boil because of the NaOH as it acts as a catalyst.
- 5.Add the 250 grams of vetiver grass into the water.
- 6.Boil the grasses for 1 hour while stirring occasionally.
- 7.Remove the excess water from the grass using a sieve.
- 8.Sundry the grass.

Analysis- *The fibres are rough, course and might give a feeling of itchiness. These fibres are not suitable to spin into a yarn.*

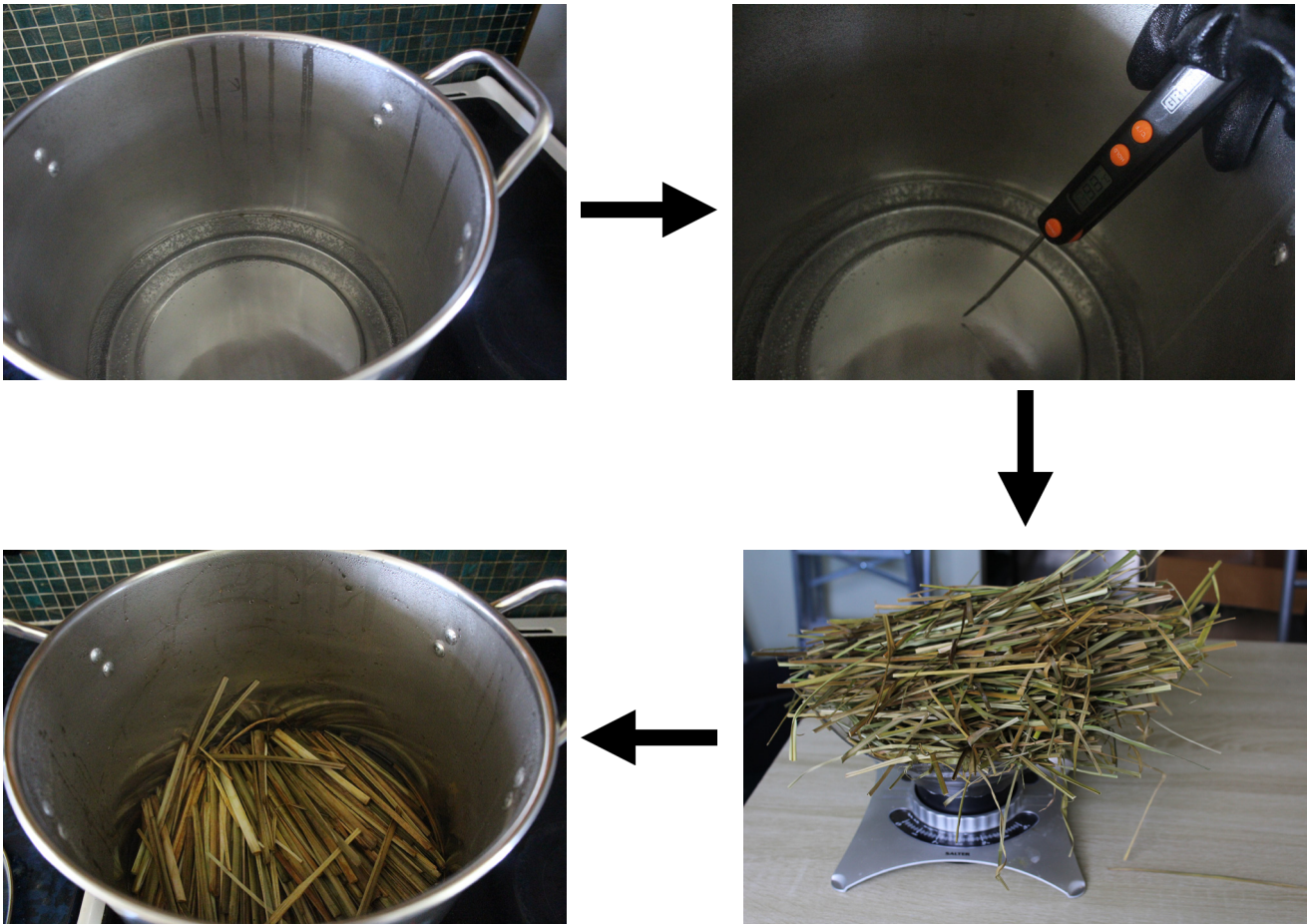


Figure 17- Textile processing for Experiment 2 (Author, 2018).

Experiment 2-

Aim- To extract the fibres from semi-dried vetiver grass using Sodium Hydroxide (NaOH).

Material Required- Cooktop, 6l or above capacity pot, a spatula to stir, 250 grams of vetiver grass cut into 6-8 inches pieces, 15 grams of NaOH per litre, Thermometer.

Procedure-

- 1.Fill the pot with 2 litres of water and put in on the cooktop. Turn the cooktop on to the highest point.
- 2.Wait for the water to reach to 100 degree Celsius.
- 3.In the meantime, cut the semi-dried vetiver grass into the length of 6-8 inches.
- 4.Once the temperature reaches to 100 degree Celsius, add 30-gram of Sodium hydroxide in the water. The water will experience a quick high rise boil because of the NaOH as it acts as a catalyst.
- 5.Add the 250 grams of vetiver grass into the water and cover the pot with a lid. (because the temperature was dropping to 97 degrees without the lid.)
- 6.Boil the grasses for 3 hours while stirring occasionally. (Boiling it for 1 hour was not enough, there was no visible fibre separation)
- 7.Remove the excess water from the grass using a sieve.
- 8.Sundry the grass.

Analysis- *The fibres are a bit rough but less than the previous experiment. The strength is lower compared to the first experiment. Since the grass was boiled for 3 hours, the fibre length has reduced to 2-3 inches.*

Note: The stirring needs to be one directional and slow. The grass length needs to be larger than 6-8 inches.

At this point, the fibre results were unsatisfactory, as it was not smooth or long enough to spin the fibres. With further research enquiry from the literature reviewed and the results from the previous two experiments, the researcher decided to use the original length of the vetiver grass. Also, as discussed earlier, it is best to use the grasses soaked in water for months; it was decided to soak the grass in the water nevertheless.



Figure 18- Textile processing for Experiment 3 (Author, 2019).

Experiment 3-

Aim- To extract the fibres from fresh vetiver grass soaked in water for a day using Sodium Hydroxide (NaOH).

Material Required- Cooktop, 6l or above capacity pot, a spatula to stir, 250 grams of vetiver grass, 15 grams of NaOH per litre, Thermometer.

Procedure-

- 1.Fill the pot with 4 litres of water and put in on the cooktop. Turn the cooktop on to the highest point.
- 2.Wait for the water to reach to 100 degree Celsius.
- 3.Once the temperature reaches to 100 degree Celsius, add 60-gram of Sodium hydroxide in the water. The water will experience a quick high rise boil because of the NaOH as it acts as a catalyst.
- 4.Add the 300 grams of vetiver grass into the water and cover the pot with a lid.
- 5.Boil the grasses for 6 hours while stirring occasionally. (Boiling it for 3 hours was not enough, there was no visible fibre separation)
- 6.Remove the excess water from the grass using a sieve.
- 7.Sundry the grass.

Analysis- *The fibres are a bit rough but way more spinnable compared to last experiments. The wet strength is lower than dry strength. The length looks spinnable. At this stage, it seems possible to soften the fibres.*



Figure 19- Fibre softening process (Author, 2019).

Experiment 4-

Aim- To soften the vetiver grass fibres extracted in experiment 3.

Material Required- Cooktop, 6l or above capacity pot, a spatula to stir, Vetiver grass fibres, three tablespoon coconut oil. Thermometer.

Procedure-

- 1.Fill the pot with 2 litres of water and put in on the cooktop. Turn the cooktop on to the highest point.
- 2.Wait for the water to reach to 100 degree Celsius.
- 3.Once the temperature reaches to 100 degree Celsius, add three tablespoon oil and stir it.
- 4.Add the vetiver fibres and cover with a lid.
- 5.Boil the grasses for 2 hours while stirring occasionally.
- 6.Remove the excess water from the grass using a sieve.
- 7.Sundry the grass.

Analysis- *The wet strength was the same as before. Although the dry strength reduced a little, fibres were much softer with a slight shine.*

Once the fibres were of desired properties, the researcher repeated experiment 3 and 4 to extract enough fibres for spinning.

While the fibres looked separated, it was still a bunch that was not fit to spin as it is. This lead to the next experiment.

***“I long so much to make beautiful things, but beautiful things
require effort and dissapointment and perseverance.”
~ Vincent Van Gogh***

Experiment 5-

Aim- To separate the vetiver fibres and prepare the fibres for spinning.

Material Required- A container with half-dried vetiver fibres, An empty container, hands.

Note: *The researcher tried to do this experiment with sun-dried vetiver fibres. It was difficult to separate the fibres because it was not soft enough to pull the fibres apart, and because of using extra strength, the fibre would break. The researcher then tried to do the same with wet vetiver fibres. It was too soft to hold onto the fibres, and because of the low wet resistance, vetiver fibres would break. The separation was possible in semi-dried fibres.*

Procedure-

1. Pick up strands of fibre that are sticking together.
2. Gently hold the strands from the centre.
3. With gentle hands, slowly squish the strands to separate the fibres within.
4. Gently, separate the fibres from the other hand and put it in the empty container.
5. Repeat the steps until all the fibres are separated.

Analysis- The separated fibres are soft, shiny, and when wet. The fibres are a bit coarse and strong when dry but spinnable.



7.2 Spinning-

The process of developing a spin-
nable fibre was the backbone of this
research. It was important to devel-
op a scalable fibre that was strong,
durable, and at the same the not too
itchy. The next step is to card the
vetiver fibres. Carding is a process
that helps separate the fibres within.
Once the vetiver fibres are carded,
they are ready to blend with other
fibres. In this research, I have used
Hemp Linen and Wool. For both the
samples, the percentage ration is of
70:30, vetiver fibres and the other
fibre respectively. Following are the
pictures of Spinning the yarn with a
spinning wheel.

Figure 20- Carding and blending (Author, 2019).



Figure 21- Preparing rolags for spinning (Author, 2019).



Figure 22-Continuation of rolags (Author, 2019).



Figure 23-A still image of the author spinning (Author, 2019).

7.3 Weaving-

Once the vetiver blend yarn is ready, the next step is to weave a fabric. I have used two-ply cotton yarn for warp and the vetiver-linen and vetiver-wool for the weft, separately. I have used a basic loom with a plain 1 x 1 weave for the fabrics. The pictures depict the weaving process.



Figure 24 -Threading the eyelets for 1x1 weave (Author, 2019).

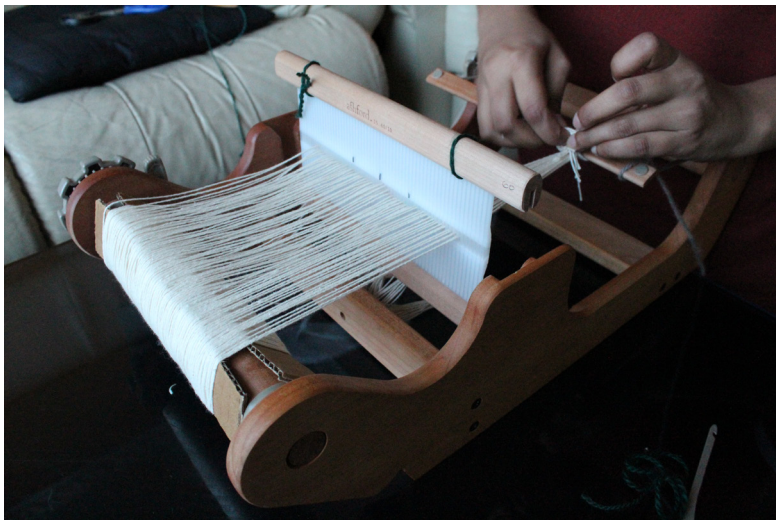


Figure 25 -Continuation of threading the eyelets for 1x1 weave (Author, 2019).

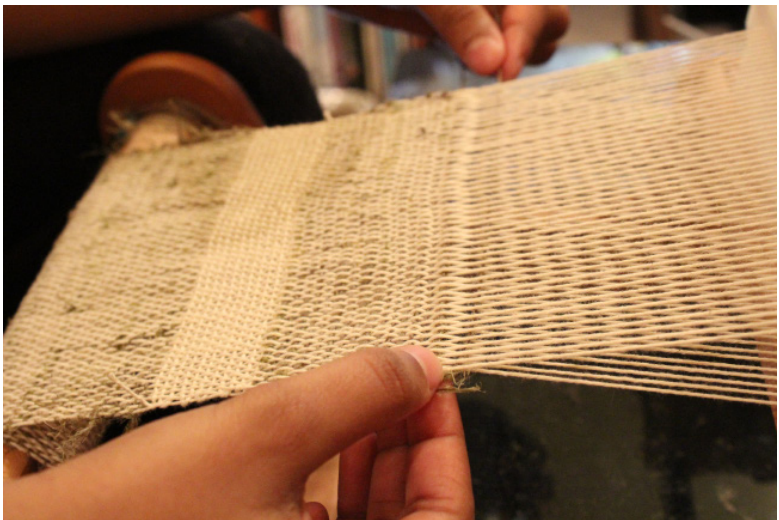
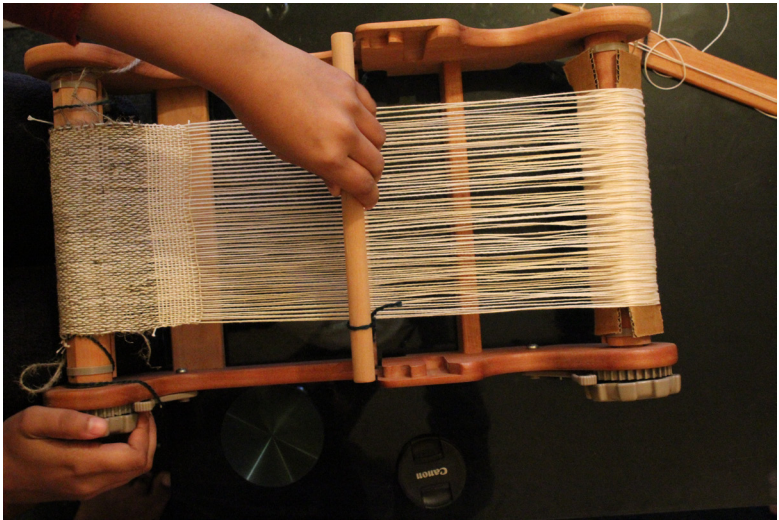
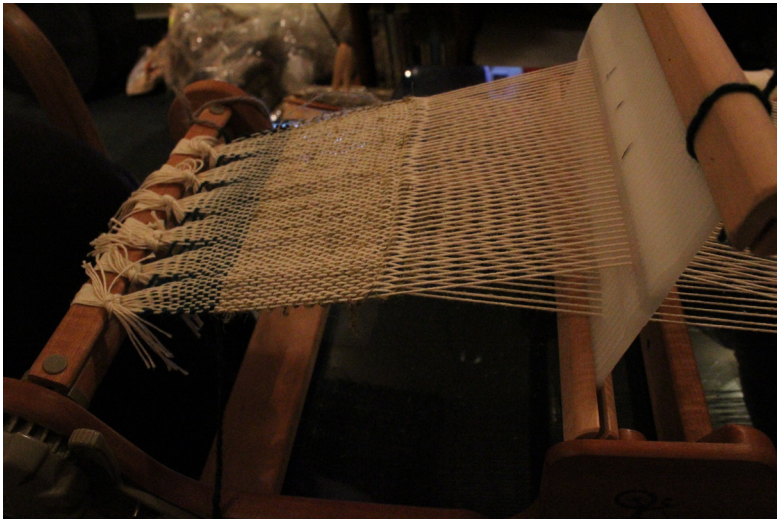


Figure 26 -The loom is ready to weave (Author, 2019).

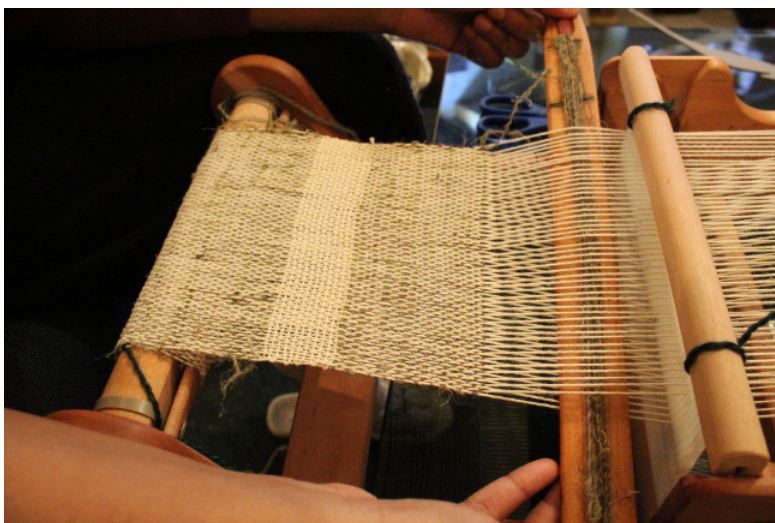


Figure 27 -Weaving. (Author, 2019).

7.4 Implementation

Transition Design advocates problem solving on a system-level. The development of vetiver grass fabric alone is not enough. In times like these, where the economy is premeditated to be linear and profitable, a transitional step towards building a new design-led economy can prove to do wonders. Vetiver grass fabric is planned to act as a core feature of an economy that is carved out to enhance the productivity of both a community and an individual.

The researcher has closely witnessed the proceeding of a prison facility. Along with the fundamental purpose of serving as a prison centre, there are numerous reformation policies at practice. In a close conversation with Ajay Khare, Deputy Superintendent of Central jail Bhopal, Madhya Pradesh, India, the conversation made it evident that the prison of Bhopal has the facility and infrastructure to pick up on this craft and create a craft cluster of their own. Prisons in India often associate themselves with art and handicraft clusters that have proven to be beneficial for the prisoners.

This thesis, driven by the emergent design provocation Transition Design, proposes a community based economic model following the prison reform policies. Prisons in India often associate themselves with art and handicraft clusters that have proven to be beneficial for the prisoners. This research offers a system that can provide workshops to these prison facilities in order to educate the prisoners with the craft of fibre extraction. Unlike their usual handicraft textile ventures, vetiver grass textiles processing will be affordable, sustainable and unique to the prison centres. This system will ensure a skill imparted to the prisoners along with a structure at a place to earn for themselves, ensuring a circular economy within the system building a craft cluster within the community.



Figure 28 -Inmates of Bhopal Prison preparing the warp threads (Khare, 2019).



Figure 29 -Inmates of Bhopal Prison weaving terry towels (Khare, 2019).



Figure 30 -Inmates of Bhopal Prison weaving on handlooms (Khare, 2019).



Figure 31 -Inmates of Bhopal Prison weaving Dhurries (Khare, 2019).



Figure 32 -Stitching workshop for female inmates (Khare, 2017).

8 CHAPTER CONCLUSION

This research explores the possibilities of developing new textile from Vetiver Grass. Samarng Keunun's paper on textile development sets precedence for this research. Apart from exploring the possibility of new product development, this thesis looks to circular economic model as a means of establishing a new economy at a scalable space. The research explores new product development through the lens of emergent design provocation, Transition Design. Transition Design framework helps identify the wicked problem within the textile industry.

As discussed previously, wicked problems are usually interconnected to each other and seldom have a single linear solution to the problem. This research identifies landfill textile waste as the central premise of the wicked problems faced within the industry. One of the integral bridge within the thesis that will help solve the wicked problem is the Indigenous, local place-based knowledge. Fast fashion acts a catalyst, increasing the problem of textile waste, the directly opposite approach to fast fashion is the slow inter-generational knowledge. This thesis applies the Indigenous knowledge in all the places where it can be applied. This not only helped build a sustainable process throughout the research but also helped the researcher develop a deep understanding of accepting and identifying links of this wicked problem in everyday life and intuitively brainstorming solutions to deal with them.

***“To do more and more with less and less until
eventually you can do everything with nothing.”
~ R. Buckminster Fuller***

The first chapter of the thesis is an introduction to the concepts that build towards the thesis. Moreover, chapter one identifies the aims and objectives of this research and explore methods in order to achieve them. Chapter two explored the notable research that inspired the thesis and discussed the relevant work developing a connection between the various concepts and theories. Since the research primarily revolves around vetiver grass, chapter three studies the origin of the grass and finds the link between India and New Zealand and their co-relation to vetiver grass. It also discusses the physical and chemical properties of vetiver grass and further its fibres. The research gradually moves towards fashion and textile industry and the role of sustainability within the industry. Chapter four explores fast fashion and its drawbacks. It also discusses the emerging sustainable textiles and a human empathic connection to textiles that human beings have had from the beginning of civilisation. The next section, chapter five, explores the economic and societal impacts textile have on society and visa-versa. This chapter compares linear economy to circular economy and the way they contribute to the society. This chapter identifies a need of circular economy in textile industry and thus going back to history, identifies a circular economic model with a social cause within Gandhi's model of Khadi. Further, chapter six, explores the methodology and design approach and strategy in this thesis.

Using transition design framework, this research identifies the problem and the present, past and future associated to the problem to visualise a holistic more sustainable systems within an Industry. This chapter also explored the primary research through the experiments conducted throughout the research period and eventually developed a fabric.

This thesis identifies a scalable economic model that can be implemented within the communities of inmates in an Indian Prison. While this research acknowledges it cannot solve the problem, it establishes a model of supply, and production within the inmates community that can better support that needs of those people specially when they finish doing their time and eventually move into the real world. There is a huge potential of research and development within vetiver grass and someday, it could be able to stand along with hemp, bamboo or linen.

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(The use of local place-based knowledge to develop a scalable circular economy that enables positive social impact within the textile industry.)

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