Sustainability through Risk Assessment:
A Case Study of Resource Risk

Author: Gayathri Babarenda Gamage, PhD Candidate,
International Centre for Sustainability Engineering and Research,
Department of Civil and Environmental Engineering,
University of Auckland

Mailing address:
Formway Furniture Ltd. 176 Gracefield Road, Lower Hutt,
Wellington, NZ
Email: gayag@formway.com
Phone: 04 568 1835 or 021 167 6618 **Fax:** 04 568 1195

Co-author: Dr. Carol Boyle, Director and Senior Lecturer,
International Centre for Sustainability Engineering and Research,
Department of Civil and Environmental Engineering, University of Auckland
Mailing address:
International Centre for Sustainability Engineering and Research,
University of Auckland, Department of Civil and Environmental
Engineering, 20 Symonds Street, Auckland, New Zealand
Email: c.boyle@auckland.ac.nz
Phone: 09 373 7599 ext. 88210 **Fax:** 09 373 7462

ABSTRACT

In the past, and indeed the present, it has been difficult to operationalise sustainability since it is reasonably difficult to determine if in fact a system is functioning 'sustainably'. Literature shows that preventing unsustainability through focussing on sustainability as a concept is difficult because the only indication that the system is not sustainable is through failure. One way to overcome this is to determine when and how the system in question would become unsustainable thereby ultimately leading to failure. Assuming that any action that prevents the continued function of the system is unsustainable, appropriate actions can be taken to prevent failure. Hence we are essentially dealing with risk to the system and the management of this risk. This paper looks at some of the significant material resources in the manufacture of Formway Furniture's office furniture and evaluates the risk posed through them to continued manufacture and hence survival of the particular product. Life Cycle Assessment (LCA) previously carried out on Formway Furniture products; MCC and Grid 2 screens, helped determine significant material resources of each product. The resources include aluminium and steel sourced within New Zealand and internationally. The study evaluates the risk to the system through these resources as a first step in managing the short, medium and long term adverse consequences for the product manufacture and hence to the company itself. The development of a risk matrix for aluminium and steel will help prioritise the risks which can then assist in their management. Thus the research attempts to show that risk and the management of risk is an integral, if not inherent, part of sustainable development.

1. INTRODUCTION

Numerous scholars and authors (e.g. Tainter (1988), Diamond (2004), Wright (2005), Kunstler (2005), Lovelock (2006), etc.) have, for a long time, warned about collapse of society. While these well-intentioned doomsayers may be depicting the worst-case scenarios, they all make a valid point regarding the direction of human activity on the planet. Historical evidence from Easter Island, Acadian, Samarian, Babylonian, Assyrian, Persian, Incan, Aztec, Mayan, Greek, Roman, Mongol, Ottoman, British, Soviet and other societies give evidence that collapse of societies, with varying degrees of severity, is inevitable. However, while it is premature to blame collapse on a single cause, i.e. environmental degradation, the stresses on the environment have been known to play a significant role. For example, lack of food due to decrease in soil fertility brought on by deforestation, soil erosion and salinity, exacerbated by demand due to overpopulation and extravagance, runs a similar theme in history. Some of the other factors include: disease; invasion; climate change; that have interacted simultaneously or consequently with environmental degradation. Authors such as Diamond (2004) also identify how the human response to the factors is also a major factor in the collapse of society.

Nevertheless, past occurrences, while providing ample warning, are not necessarily transferable to our situation. Fossil fuels, an intangible economic system and technological advances, support current society and have enabled us to stay a step ahead of disaster. Other factors such as terrorism and war are also fuelled, if not created, by society’s need for equality, in the face of scarcity. However, as population continues to increase, the accumulated adverse impacts on the environment and society also increase. The likely conclusion to this scenario can be summarised by a statement made by Crosby (2004) - “Mother Nature always comes to the rescue of a society that is stricken with overpopulation, and her ministrations are never gentle”. There is much lament at society’s inability to learn from the past and while all seems lost, many have stated that this is in fact the point in time when mitigation measures may be implemented to divert the imminent collapse. The idea that all is not well is becoming clear to people, and in fact, this was the reason for the initiation of the World Commission for Environment and Development (WCED) in 1983 and the development of the popular definition of sustainable development in 1987.

1.1 Sustainable Development Concept and Issues

While the concepts of sustainability and sustainable development have become embedded in industry and government alike, putting the concept into operation is yet problematic. The problems lie in converting the definitional concepts into practice. In relation to the traditional concept of sustainable development, the most accepted definition from “Our Common Future”, more popularly known as the Brundtland Report, is as follows:

> “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts:
>
> - The concept of needs, in particular the essential needs of the world's poor, to which overriding priority should be given; and
> - The idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs.”

(WCED, 1987, p. 43)

Furthermore, the Brundtland report outlines the requirements for sustainable development in terms of a number of system requirements including for example, “a production system that respects the obligation to preserve the ecological base for development”(WCED, 1987, p. 74). While the report outlines the systems and system requirements, there are still a number of key issues especially when it comes to the implementation of the concept in industry:

1. It is difficult to ‘operationalise’ sustainability in the real world;
2. It is difficult to determine if in fact a process, product or system is functioning ‘sustainably’;
3. It is difficult to prevent ‘unsustainability’ through focussing on sustainability unless the process, product or system fails, thereby showing that it was unsustainable; and
4. In practice, the concept has been compartmentalised into the environmental, societal and economic pillars, which disintegrates the holistic nature of the concept.

It should be noted however that many businesses are involved in some sort of sustainability program to enhance their operations as well as to safeguard the environment. There are numerous reasons for their involvement in sustainable development ranging from an ethical to purely financial incentives. Additionally, in Australasia, sustainability is slowly becoming a competition driver together with the more traditional core requirements such as quality, price, on-time delivery, etc. (Shahbazpour and Seidel, 2006).

1.2 Potential solution

This research looks at the sustainability of the economic, social and production systems as a combined system. Hence there are three basic requirements for the sustainability of the production system:

1. The provision of needs;
2. The ensured continuation of the system by allowing the supply of those needs to be met; and
3. The ethical responsibility to safeguard the environment and society.

One potential solution to this dilemma would be to assume that any action that ultimately *prevents the continuation* of the process, product or system is unsustainable, hence determine when and how the process, product or system would become unsustainable and take appropriate actions. This concept then integrates existing tools such as Life Cycle Assessment (LCA) and Risk Assessment (RA) as a tool to assess sustainability of a small yet complex system.

1.3 Life Cycle Assessment (LCA)

International Standards Organisation defines LCA as “a systematic tool of assessing the environmental impacts associated with a product or service system to build an inventory of inputs and outputs, make a qualitative and quantitative evaluation of those inputs and outputs and to identify the most significant aspects of the system relative to the objective of the study” (ISO 14040, 2006). The tool is popularly used to determine the environmental impact of products and processes. Integration of LCA into techniques such as risk assessment has also been investigated by the likes of Sonnemann et al., (2004). Numerous workshops as part of the European Union’s Environment and Climate programme, such as LCANET (1997) and CHAINET (Wrisberg, 2002) were dedicated for strategic LCA research and development. Additionally researchers (for example Cowell et al., (2002)) instigated research to create interfaces between LCA and other environmental tools including risk assessment for use in decision-making.

In the context of this research, LCA was used for two purposes: 1 – to determine the environmental impacts of the product lifecycle and 2 – to determine the Life Cycle Inventory (LCI), which can be considered equivalent to the needs of the system. The LCI is useful in tracing the resources back to their basic inputs.

1.4 Risk Assessment (RA)

Risk is unique in that every human venture, be it an individual crossing the road or governments implementing global initiatives, undergoes some sort of formal or informal RA. One of the earliest definitions of RA is “the combination of the sum of the probabilities of risk events and their consequences” (Burton and Pushchak, 1984). Today, a number of frameworks for risk assessment and management exist to aid in the process. The steps in risk management according to the Australian/ New Zealand risk management standard 4360: 2004 are given in the framework in Figure 2.

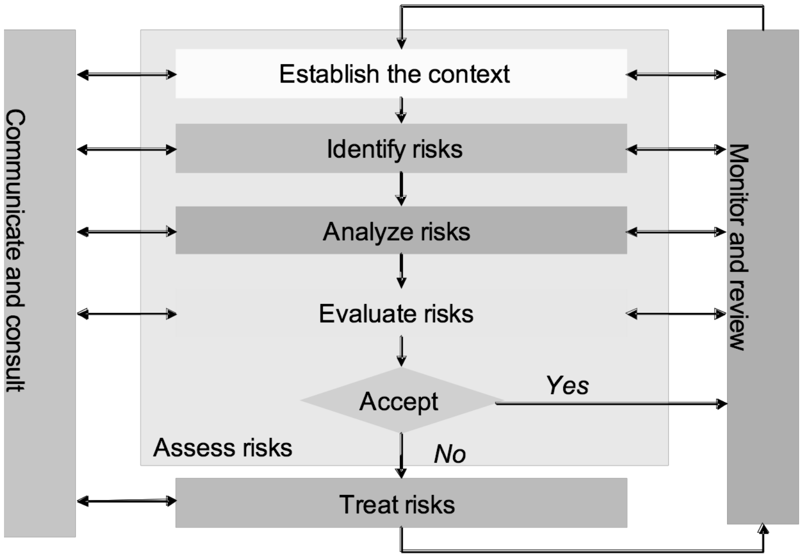

Figure 1: Risk Management framework (AS/NZS4360: 2004)

The aim of RA in the research context is to determine aspects of the system, in terms of resources, that can lead to disruptions of the overall process, either through impeding continuation through impacts to resources needed, or alternately through impacts from resources and final product.

1.5 Formway Furniture

Formway Furniture is an office furniture designer and manufacturer based in Wellington, New Zealand. Formway has recognized the need for sustainable development and has initiated a sustainability program to gain better understanding of sustainability issues specifically those pertaining to the environmental pillar. Due to recent competition in the environmentally preferable office furniture sector, moving towards the adoption of sustainability principles is seen as a competitive advantage, specifically in the Australian market.

1.6 Research

The objective of this study is to identify needs in terms of significant resources of a product system and investigate the risk posed by and through these resources. The overall research hypothesizes that assessing sustainability using risk as a measure can help identify and mitigate factors that lead to system failure (considered as 'unsustainability' in this case) thus ensuring system success (sustainability). Hence the overall research attempts to answer the question, 'can assessing sustainability, using risk as a measure, help plan for sustainability?' through the use of simple case studies based on production systems.

1.7 Research Scope and Parameters

The research scope is confined to a number of key product manufacturing systems. This paper discusses the research on two types of screen production systems: MCC; and Grid 2, which are used for separating workspaces so as to provide privacy. The material compositions of the two screens are given in Table 1.

Table 1: Material compositions of MCC and Grid 2 screens

Grid 2	
Material	**Weight (Kg)**
Aluminium	4.47
Polyester panel (PET)	3.55
Total	**8.22**

MCC	
Material	**Weight (Kg)**
Steel	13.35
Polyester panel (PET)	6.50
Total	**19.85**

The study focuses on resource aspects of the product; hence a number of assumptions were used resulting in a simplified inventory, for the purpose of this example:

- All materials considered are from virgin sources (i.e. no recycled content). Note that in reality, there would be some recycled content in materials and this is particularly true for metals such as aluminium and steel;
- The products contain a number of steel and plastic fasteners that were excluded from the study due to their negligible percentage weight as compared to the other materials;
- All component production processes were excluded from the study.
- Table 2 gives the processes for manufacturing components, and should these be considered in the study, significant changes to the final LCA results may be expected; and

Table 2: Manufacturing processes

MCC		Grid 2	
Material	**Process**	**Material**	**Process**
Steel	Cutting Welding Powder coating Grinding/ blasting	Aluminium	Casting Powder coating
		PET	Heat molding
PET	Heat molding		
Polycarbonate	Injection molding		

- Processes such as packaging and transport as well as end of life scenarios were excluded at this point. Note that these may also have significant impacts on the final LCA results.

With regard to risk, the scope of the research encompasses mainly the risk to the respective production system from an environmental point of view. Agenda 21 (UN, 1993) outlines some of the major issues with respect to environmental sustainability, however, when focusing on the production system, as the entity that must be sustained; the issues pertaining to resource consumption, climate change, environmental health, land use and biodiversity can be considered as significant. These environmental risks are contributed from two sources; the risks resulting from the impact of manufacturing the product (shown by LCA results) as well as the risks associated with particular significant resources along the supply chain.

2. METHODOLOGY

The basic steps in carrying out the research are to identify needs of the system; hence the most significant resource needs, through LCA. This is followed by identification, analysis and evaluation of risk from the identified resources. This assessment is expected to assist in planning for short, medium and long term mitigation actions.

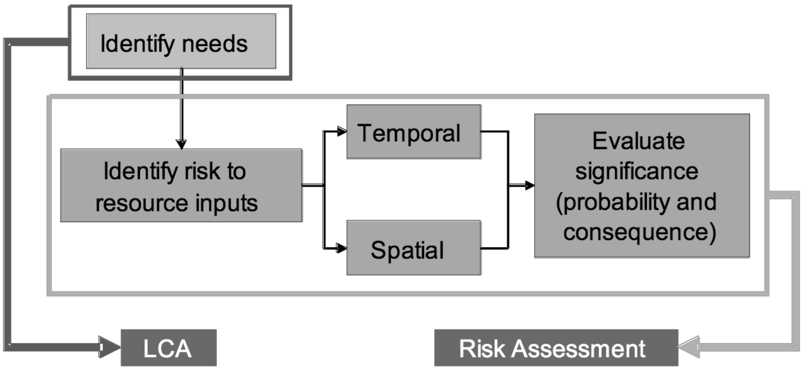

Figure 2: Research methodology

A quantitative approach to LCA with the use of SimaPro7 (PRé Consultants, 2006) and Eco-Indicator 99 (Goedkoop and Spriensma, 2001) methodology was taken to determine environmental impact and the LCI. Considering the materials that contributed to the highest total environmental impact as significant, these resources were then assessed qualitatively using matrixes to determine the risk to sustainability.

3. RESULTS

3.1 Life Cycle Assessment (LCA)

The streamlined LCA carried out showed that even though the MCC screen is by far more material intensive, it contributed to significantly less environmental impact than the Grid 2 screen (32% less in total) (Figure 3). The highest impact contributed from the MCC and Grid 2 screens came from PET and aluminium components respectively.

(a) Identification of significant impacts

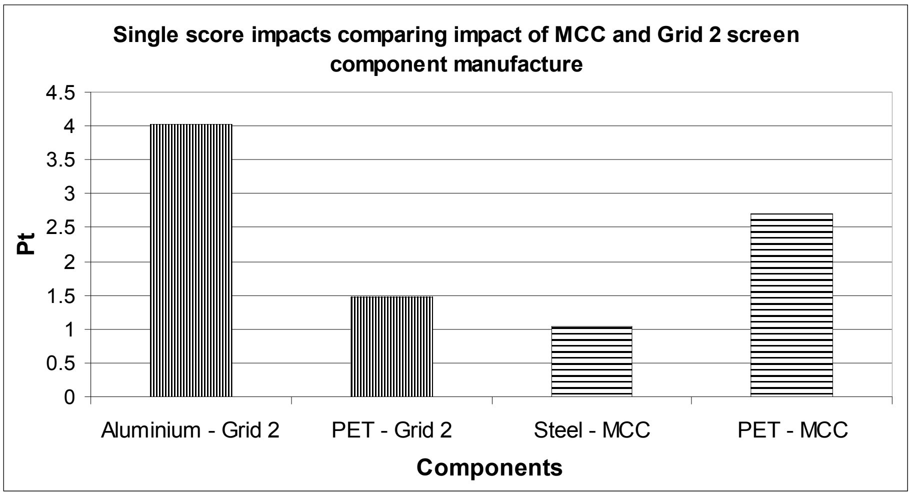

Figure 3: Impacts of component production

A number of conclusions can be reached from the LCA results:

- The aluminium components in Grid 2 exhibit the most environmental impact. By examining the impact indicators, the fossil fuel impact category was the most affected, depicting the high energy intensity of aluminium components; and

- The PET components of MCC exhibit the second highest environmental impact of all the components; however, this can be attributed to the fact that MCC uses more of the material than Grid 2. Again the impact category of importance is the fossil fuel category.

For the purpose of this example, aluminium, PET and steel are all examined further to determine the risk to sustainability of the production system.

(b) Identification of significant risk resources

The LCI considers a list of inputs and outputs for materials in the products. This excludes processes such as component manufacture, potential end of life, transport and packaging. The LCI indicates that quantity-wise, some raw materials are of higher significance and these should be assessed more carefully. It is interesting to note that the significant resources can be traced to the very basic resources that industry and indeed our whole civilization depends on. While there are numerous resources that pose significant risk to the production system, this paper focuses on three major needs: fossil fuel (coal for the production of steel, petroleum for the production of plastics and for energy); bauxite for aluminium; and iron for steel.

3.2 Risk Assessment (RA) initiation

The risk assessment carried out includes qualitative analysis on aluminium and steel. The assessment was carried out according to the AS/NZS 4360: 2004. The study resulted in a number of basic risk matrices outlining the risks that the production system face from a spatial and well as temporal scale. Interviews of managers within Formway highlighted the temporal scales involved as follows:

- Short term: 6months – 1 year
- Medium term: 1 year – 5 years
- Long term: beyond 5 years

Note that these are typical planning timeframes for many commercial organizations. There is however a disparity when the sustainability aspect is taken into account for civilization as opposed to businesses, where timeframes extending to a thousand years have been considered (Boyle, 2005). Since the production system is an integral part of the economy, via revenue of the company, it plays an important role in sustaining society. Thus planning for sustainability depends on how long we would want the company to be in existence. The spatial scales for the study involved the local environment – New Zealand, and the global environment, comprising of numerous countries from where resources are supplied.

3.3 Identification of risk (upstream and downstream)

The generic risks to the supply of the selected resources, hence the risks to the production system are given in Table 3. This does not take into account the specific business risks (e.g. market trends) into consideration.

Table 3: Classification of generic risk to production system from selected resources

Resource	Short term (6months - 1 year)	Medium term (5 years)	Long term (Beyond 5 years up to 100 years)
Fossil Fuel	Emission regulation forcing less use of fuels	Impacts from greenhouse gas emissions leading to global warming	Impacts from enhanced global warming leading to drastic climate change

	Cost due to fluctuations in global market	Slight increase in price due to actual or perceptive scarcity (e.g. war or increased demand)	Scarcity due to intense global demand/ decreasing supply
	Health effects due to combustion	Long term health effects due to combustion	High impact health effects from combustion (chronic: cancer)
	Employee health effects due to toxic/hazardous exposure (during plastic manufacture)	High impact health effects from exposure (cancer)	High impact health effects from exposure (chronic: cancer)
		Regulation of selected plastic production	Availability of fossil fuels for purposes other than energy/transport
		Increased dependency on coal	Increased dependency on coal exacerbating global warming and health effects
Aluminium and steel	Fluctuation in price effecting supply	Resource scarcity due to high demand	Competitive pricing where rich countries monopolize on supply
	Waste generation and disposal	Availability and technology to access and make use of scrap	Local supply scarcity including scarcity due to intense demand
	Immediate health impacts of exposure to processing chemicals	Long term health effects associated with processing	Chronic accumulated health impacts
	High energy requirements	Energy requirements affected by potential fossil fuel prices/depletion	Energy requirements affected by potential fossil fuel prices/depletion
		Increase price due to actual or perceptive scarcity	Availability and technology to access and make use of scrap
Common	Logistics for NZ: Transportation costs	Logistics for NZ: Increased transportation costs	Logistics for NZ: Extreme transportation costs
	Soil contamination	Soil contamination	Soil contamination
	Water contamination	Water contamination	Water contamination

4. DISCUSSION

4.1 Sustainability as continuation vs. sustainability as an ethical construct

Prior to discussing the results, the context to which they apply must first be addressed. Sustainability as continuity and as an ethical construct is considered synonymous here in that unethical action will eventually force discontinuation. However, it is this 'eventual' timeframe that is of concern, especially with respect to businesses. There are external forces (e.g. lack of demand, competition, etc.) that can just as easily cause discontinuation and this means that while individuals will act within ethical boundaries, the system as a whole (i.e. company) may not necessarily be compelled to do so as more immediate concerns relating to the day-to-day survival may prevail over those of long term well being. Hence examination of upstream and downstream risks, on a temporal and spatial scale, is necessary to influence decisions to ensure the demand for continuation and ethical consideration are balanced.

4.2 Results

Table 4 categorizes some of the imminent risks to the continued supply of fossil fuel, bauxite, and aluminium, which are significant resources for the production systems concerned. The short-term risks are those that affect the day-to-day operations of the production system. With the relatively short timeframe considered, most impacts (especially environmental impacts) are not obviously seen. The short-term significant risks relate to health and safety as well as economic aspects of the resource procurement. The medium and long term categories allow a more converged outlook on potential risks to the system, where resource scarcity, health and environmental degradation are a common theme.

(a) Resource Scarcity

Fossil fuels are fundamental to all industry and this is also true for the production system considered herein. Considering that increased world demand is likely to drive prices higher, NZ might find overseas resource procurement somewhat difficult in the long-term, especially in the event of fossil fuel scarcity. Geopolitical risk can also affect the supply and price of resources in general, and again, this is specifically true for fossil fuels.

From a NZ-based production system perspective, the proximity of resources is of major concern. For example, all plastic resins, approximately 260 million Kg in 2005, are imported (Plastics New Zealand, 2006); this means NZ is highly dependent on global supply and prices. Any shortages in resin, brought on by potential scarcity of fossil fuel would have adverse impacts on NZ plastic-based production systems, unless drastic changes to design can be quickly implemented. Hence, the proximity issue could potentially exacerbate the economic impacts created by resource scarcity. The export of goods (as opposed to intellectual property and services) is a significant source of revenue for NZ and the proximity issues that apply for exports are unavoidable. However, the costs involved in imports may be greatly reduced via locally sourced resources.

When considering the temporal scales with respect to resource scarcity, the issues are fairly minor in the short-term. The significant risks in the short-term are of economic nature where resource pricing result from global market conditions. These conditions have little to do with the actual amount of resource available. However, when the long-term is considered, especially for fossil fuels, the availability or lack thereof, is likely to have greater impacts on resource pricing as competition for remaining resources escalate. In terms of spatial risks, the short-term and long-term risks are locally concentrated. For example, fluctuation in price, a short-term risk, affects the production system directly while scarcity, a long-term risk while having global implications, would still affect the production system, although with potentially higher impacts.

(b) Health and environmental degradation

Risks contributed from the spatial scale highlight waste, emissions, health of workers and general public, and environmental degradation, as potential risk factors to the production system. The risks involved are aligned with the procurement of minerals such as aluminium and bauxite, where resources are mined and processed locally. Hence most of the local risks also carry economic risks in terms of regulatory compliance and in the event of failure, legal and risks to reputation are also of concern. With respect to electrical energy, NZ's use of renewable energy sources is favorable, where approximately 71% of electricity generated in 2005 was from renewable sources (hydro, geothermal and wind) (Ministry of Economic Development, 2006). Hence the risks from electrical energy related issues are less significant for the short to medium term, but increasing consumption beyond renewable capacity is increasing reliance on fossil fuels for electricity production. Additionally the advantage from renewable electrical energy can be affected by climate change in the long-term.

From a temporal perspective, there is significant risk to health and environment when considering all temporal scales. The health risks from short to long term scales range from acute to chronic effects respectively, while more serious conditions such as cancer are potential risks in the long-term. Likewise, environmental risk increases with time, where accumulation of impacts may seriously undermine the ability of the environment to regenerate itself. On a spatial scale, health risks are of significance both locally and globally, regardless of the temporal scale. However, the higher impact risks for the environment are likely to have global significance.

It should also be noted that other aspects such as quality, market requirements, etc. are also important for the sustainability of the production system. In fact, they are more significant for the day-to-day continuation of the system. The concentration of resources for planning for these risks may be the reason that businesses only consider planning only up to five years. Additionally, while examining the generic risks to the selected resources, the potential opportunities must also be taken into account. More efficient sources of energy and transport, emergence of new high performance materials that are not fossil fuel based, etc. may result from the need to sustain the production system. Thus attempts at ensuring sustainability of the production system should also go hand in hand with evolution within the system.

5. CONCLUSIONS

The research conducted so far gives an insight to the various perspectives of sustainability (ethical and continuation) that must be taken into account when considering the production system. With direct respect to the selected resources, the short-term risk to supply of resources is mainly logistic and financial pertaining to human health and environmental degradation. As the temporal scale is extended, the risks become global and relate to issues on resource scarcity and climate conditions. The importance of fossil fuels for production systems cannot be stressed enough and hence any shortage of such fuels poses huge risks for future sustainability. Use of local resources coupled with innovation towards renewable materials is one way to maintain the NZ based production system in the long term. Planning for some of these risks would assist in the sustainability of the production system; however, it should be noted that a broader risk assessment incorporating the business-market-social-environmental trends might be required for sustainability.

6. FUTURE WORK

Future work will entail the development of the matrix that would allow risk to be qualitatively expressed and identify those risks that must be dealt with for sustainability. This requires the evaluation of timeframes with respect to occurrence (probability) and the potential consequences to the production system to be undertaken. This would be followed by the development of a sustainability scoring system to evaluate the significance of the risk assessment results with respect to sustainability issues. This is expected to link the two fields; risk and sustainability.

ACKNOWLEDGEMENTS

This research was conducted at the International Centre for Sustainability Engineering and Research, University of Auckland. It was financially supported by Technology New Zealand (Technology Industry Fellowship grant no. FMYX0506). Additionally, we extend our sincere thanks to Formway Furniture Ltd. for its support and participation.

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