Sustainability Hotspot Analysis for the Furniture Industry

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FIRA International Limited
Maxwell Road, Stevenage, Hertfordshire, SG1 2EW, United Kingdom

T: + 44(0)1438 777 700
E: info@fira.co.uk

Available to Furniture Industry Research Association Members only

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Executive Summary

This document is the second in a series of circular economy initiatives instigated by the Furniture Industry Research Association and presents the wide ranging aspects of a sustainability hotspot analysis by researching and contextualising the commercial, reputational and material source risks that exist within supply chains. It informs business leaders of practical methodologies that will mitigate these risks, which in turn enables data driven, sustainability decision making within organisations.

Historically, the business case for adopting a circular economy model has tended to be purely environmental, with organisations seeking to reduce their carbon footprints through energy efficiency and resource optimisation strategies. More recently the concept of sustainability hotspot analysis has emerged, advocating consideration of broader impacts on the supply chain, such as social and economic factors.

Sustainability hotspot analysis is a science based approach that assists in the identification of areas to be targeted for action. It takes large volumes of information, which are then analysed in order to prioritise stakeholder investigations and subsequent interventions throughout an organisation's supply chain. This is not always simple for a business to address as there is currently no common approach to hotspot analysis, nor is there any accepted guidance on how a business should translate the results of hotspot analysis into sustainability information for stakeholders.

Subsequent chapters detail the following key elements of hotspot analyses and provide background information, along with methodologies and examples, to assist with the collation of data and reporting:

- Price and Materials Volatility
- Social Hotspots
- Water Hotspots
- Life Cycle Assessment

The security of supply of raw materials is discussed in the context of resources becoming increasingly insecure due to a variety of converging factors that include commodity price volatility, protectionism and resource fragmentation. The production of furniture relies on raw materials such as timber, iron ore (in the form of steel), aluminium, nickel and in some cases copper where electronic components comprise a part of the furniture item. Volatility in the price of oil directly influences other material inputs such as plastics and chemicals used in the furniture production process. Price volatility is exacerbated through increased competition from emerging economies and falling product prices.

Changing consumer and sustainability procurement behaviours are presented in the context of socially responsible supply chains. Failure to address or alleviate social hotspots presents genuine risks to a company. In turn, positive action may provide opportunities to improve a brand's standing and its relationship with stakeholders in the supply chain.

Water hotspots are researched, highlighting the direct links that exist for the furniture industry between over abstraction of water for agriculture and increased water scarcity. Similarly, the potential for pollution caused by industrial processing of leather, chromium and nickel used in the furniture sector is addressed.

Water scarcity is identified as a significant emerging risk for the UK's supply chain. Financial organisations advocate that businesses treat water as a separate environmental risk, whilst NGOs highlight the important role UK business can play in improving water resources, by making good water management a standard element within supplier contracts.

Life Cycle Assessment is introduced as a technique to assess environmental impacts of consecutive and interlinked stages of a product. Different life cycle assessment approaches are examined including those within the ISO14000 suite of standards and the United Nations lifecycle initiative. These encompass a range of methodologies and tools for the evaluation of various stages of the life of a product or organization, from raw material acquisition to final disposal. A summary of the different lifecycle approaches available, and when they might be appropriately applied, is also summarised.

Lastly, in the most technical section of the paper, specific methodologies that are available for hotspot analysis and lifecycle analysis are explained. This section is most relevant to those involved in sustainable procurement, sustainable design and sustainability management.

The conclusion highlights that, for many organisations, the adoption of sustainability hotspot analysis is a significant challenge to existing orthodoxy. Many furniture manufacturers have no quantifiable measures of the environmental impacts of their direct and indirect resource consumption, material inefficiency, and waste generated within their supply chain.

The research goes further, highlighting that it is necessary for retailers and manufacturers with complex and often global supply chains (and customers) to adopt a more risk based approach to the supply of raw materials, components, services and products. Understanding where potential resource, water and social hotspots exist can help to minimise operational and reputational business risks and also influence business decision making and strategy.

Corporate social responsibility and sustainability legislation and procurement policies are also driving companies to re-evaluate their supply chains in order to meet legal, customer and shareholder requirements. Businesses that fail to address these challenge could see their brands and reputations compromised, putting their future economic successes at risk.

1. Introduction

This 'hotspot analysis' paper forms part of the Furniture Industry Research Association's Circular Economy project, designed to inform and support the industry in response to the challenges of waste and consumption of finite resources.

Hotspot analysis is a science based approach that assists in the identification of areas to be targeted for action. It takes large volumes of information, which are then analysed in order to prioritise interventions and investigations by government, industry and other stakeholders.

Hotspot analysis is used to address sustainability issues such as resource use, access to rare materials, water supply, social and ethical issues. The traditional approach to hotspot analysis of products and services has been to focus solely on environmental impacts and setting of science based targets to drive improvements.

Recently a broader approach to sustainability hotspot analysis has emerged[1], considering social and economic aspects as well as environmental aspects. Currently there is no common approach to hotspot analysis, nor is there any accepted guidance on how a business should translate the results of hotspot analysis into product sustainability information for stakeholders.

Some product sustainability initiatives use Life cycle assessment (LCA) or carbon footprinting to determine the hotspots within product portfolios, product categories or individual products. Others include analysis of sales data to focus improvements on 'big impact' product categories. This report researches the context of sustainability hotspots for raw materials (commodities), social impacts, water and environmental impacts using life cycle assessments and other methodologies. These analyses will not only quantify product impacts but will also inform manufacturing and supply chain decisions as organisations work towards a circular economy.

1.1 The challenge of waste and resource depletion

Economic development on unsustainable levels of resource consumption, material inefficiency and waste cannot continue. Waste is not only a socio-environmental problem but also represents an economic loss. In excess of 600 tonnes of furniture and mattresses are sent to landfill[2] each year, with an estimated £760 million of recyclable and reusable resources from all waste materials lost to UK landfills annually[3].

Previous cross-sector estimates in 2005 suggest that over 90% of the raw materials used in manufacturing a product are lost to waste before the product departs the factor. In addition 80% of products are disposed of within the first six months of their lives[4]. Whilst recycling rates have improved since 2005, resource efficiency and product life is not expected to have significantly improved. Resource inefficiency, coupled with the rising costs of landfill, price volatility of raw materials and geopolitical pressures are increasing supply chain risks.

There is evidence of shifting political agendas towards circularity away from traditional linear economy models. For example, further legislation as part of the European Commission's 'Circular Economy package'[5] could see

[1] UNEP (2016) 'Global Principles and Practices for Hotspots Analysis'. http://www.lifecycleinitiative.org/activities/phase-iii/hotspots-analysis/
[2] UK Government Statistics on Waste (2016). https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/547427/UK_Statistics_on_Waste_statistical_notice_25_08_16_update__2_.pdf
[3] Friends of the Earth Europe (2009). https://www.foe.co.uk/sites/default/files/downloads/gone_to_waste.pdf
[4] Richard Girling (2005) 'Rubbish: Dirt on our hands and crisis ahead.' Published 1st June 2005 by Eden project books.
[5] An EU Action Plan for a Circular Economy. http://ec.europa.eu/environment/circular-economy/index_en.htm

the introduction of waste reduction and resource efficiency measures including extended producer responsibility requirements, such as the Waste Electrical Equipment (WEE) regulations.

1.2 United Kingdom Policy Response

The UK Government published their response to European Commission consultations[6] and the devolved Scottish and Welsh Governments have embraced the challenge of zero waste and resource efficiency policies.

In Scotland, Zero Waste Scotland[7] is funded to support delivery of the Scottish Government's circular economy strategy[8]. The strategy sets out Scottish government priorities, where products and materials are kept in high value use for as long as possible, building on progress to date in the zero waste and resource efficiency agendas. The Scottish Government identifies clear benefits in adopting a more circular economy;

Environmental – reduce waste, carbon emissions and reliance on scarce resources;
Economy – improving productivity, opening up new markets and improving resilience;
Communities – more, lower cost options to access the goods we need with opportunities for social enterprise.[9]

The Welsh Government published 'Towards Zero waste'[10] in 2010 and has subsequently launched an EU funded project to promote Circular Economy for Small and Medium sized Enterprises (CESMEs) that will "enable small and medium sized enterprises to turn environmental challenges into opportunities"[11].

An increasing number of organisations in the furniture industry are realising benefits from a positive commitment to Circular Economy practices. However, the challenges of implementing such a revolutionary economic and social model are significant and not without risk.

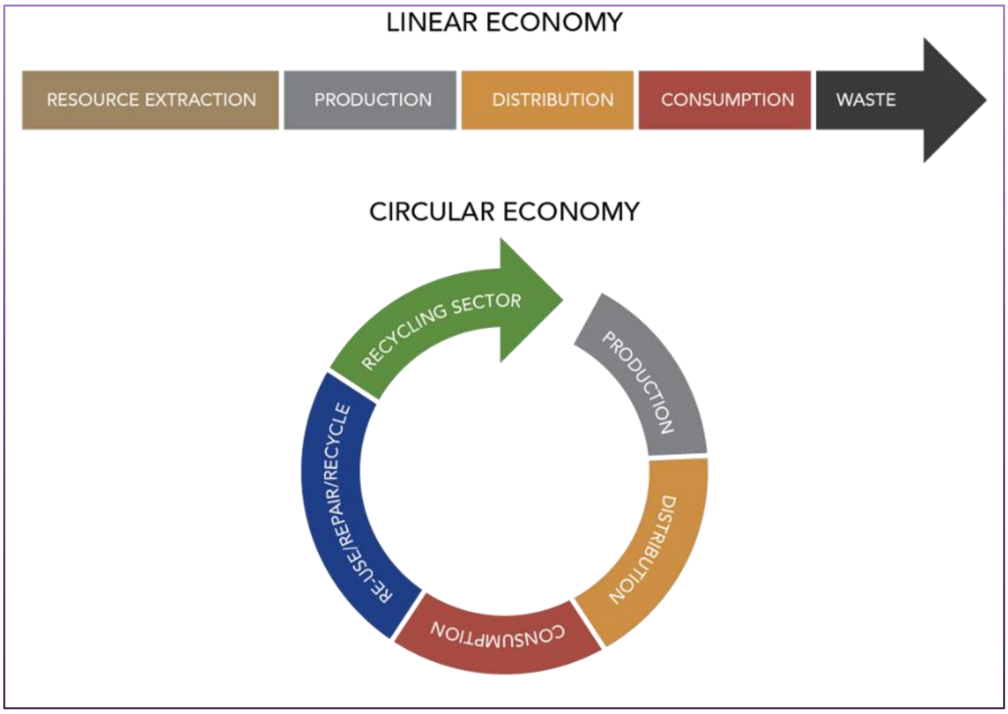
1.3 What is the Circular Economy?

In contrast to the historical Linear Economies the Circular Economy model (Figure 1) seeks to redress wastage and resource inefficiency. It promotes sustainable development by ensuring that existing materials and products are kept in productive use for as long as possible through a combination of; design, innovation, collaboration, reuse, remanufacturing and recycling.

In contrast to the prevailing 'take-make-consume-dispose' linear model that has applied to historical manufacturing models, the Circular Economy model advocates the conservation of finite raw materials and eradication of waste. This 'closed loop' conceptual model emulates the functioning of natural systems in which resources are efficiently cycled[12].

[6] UK Government Response to European Commission consultations on waste and circular economy (2015). https://www.gov.uk/government/publications/circular-economy-and-waste-markets-uk-government-response-to-european-commission-consultations
[7] Zero Waste Scotland (2016). http://www.zerowastescotland.org.uk/our-work/circular-economy
[8] The Scottish Government (2016) Making Things Last - A Circular Economy Strategy for Scotland. http://www.gov.scot/Publications/2016/02/1761
[9] The Scottish Government (2016) Making Things Last - A Circular Economy Strategy for Scotland. http://www.gov.scot/Publications/2016/02/1761
[10] The Welsh Government (2016) 'Towards Zero waste'. http://gov.wales/topics/environmentcountryside/epq/waste_recycling/zerowaste/?lang=en
[11] The Welsh Government (2016a) 'Interreg Europe CESME project'. http://gov.wales/topics/environmentcountryside/epq/waste_recycling/interreg-europe-cesme-project/?skip=1&lang=en
[12] Ellen MacArthur Foundation (2012), 'Towards a Circular Economy: Economic and business rationale for an accelerated transition' (Report Volume 1). http://www.ellenmacarthurfoundation.org/publications

Figure 1 - Linear and Circular Economies



The linear business model utilises biotic resources, which are inputs derived from living organisms and abiotic resources, which are inputs such as minerals and metals. These resources are extracted, processed, consumed and subsequently discarded[13]. This means that economic growth and development are directly linked to resource consumption, with an underlying assumption that abundant natural resources will remain inexpensive and easy to dispose of.

1.4 Natural Capital

The assumption of readily available and inexpensive raw materials is challenged through the idea of 'Natural Capital'[14]. Natural Capital can be defined as the world's stocks of natural assets which include geology, soil, air, water and all living things. It is from this Natural Capital that humans derive a wide range of services, often called ecosystem services, which make human life possible. Every business impacts, and to some extent depends, on natural capital and will therefore be subject to the risks and opportunities associated with these relationships. These impacts can be negative, for example pollution, or positive such as in the promotion of sustainable forestry.

Environmental impacts are more commonly measured in terms of carbon emissions or contribution to climate change, but many businesses have not traditionally recognized their natural capital dependencies, such as the need for water in production processes or the pollination of trees and crops that comprise an essential part of product supply chains. All of the impacts and dependencies that exist create costs and benefits not only for the business, but also for society (Figure 2). Understanding the connections between business and society and the associated risks and opportunities inform better, more timely and sustainable decision making.

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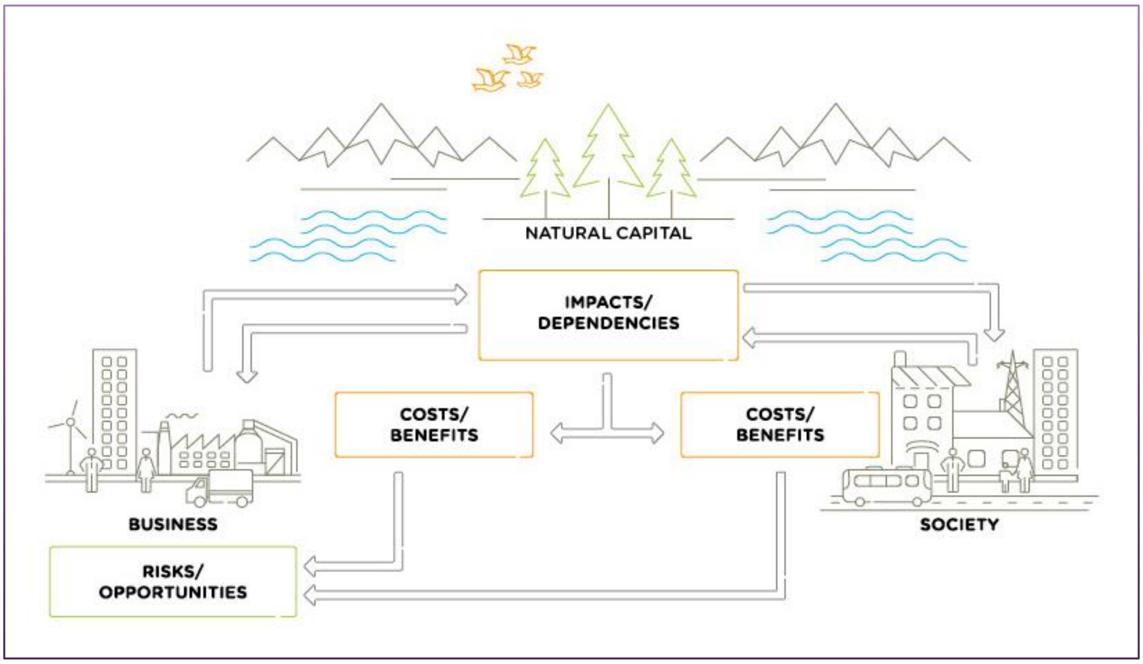
[13] Friends of the Earth (2009) 'Overconsumption? Our use of the World's Natural Resources.' http://www.foe.co.uk/sites/default/files/downloads/overconsumption.pdf
[14] Natural Capital Coalition (2016). http://naturalcapitalcoalition.org/protocol/

Figure 2 - Natural Capital impacts and dependencies [15]



This is pertinent for many of the raw materials and processes utilised in the furniture industry, which this report will explore in greater detail, by examining supply chain risks that exist within areas such as;

- commodity price;
- raw material volatility;
- water hotspots;
- social hotspots.

The paper will summarise the findings of a literature review into the different components of sustainability hotspot analysis and will then introduce methodologies and approaches that companies can consider when seeking to assess social, water and environmental impacts of products.

Whilst there is no common approach to hotspot analysis, the purpose of the research is to provide information to companies that wish to better understand sustainability hotspots that exist within their products and business operations, then target areas for improvement as part of a continual improvement process.

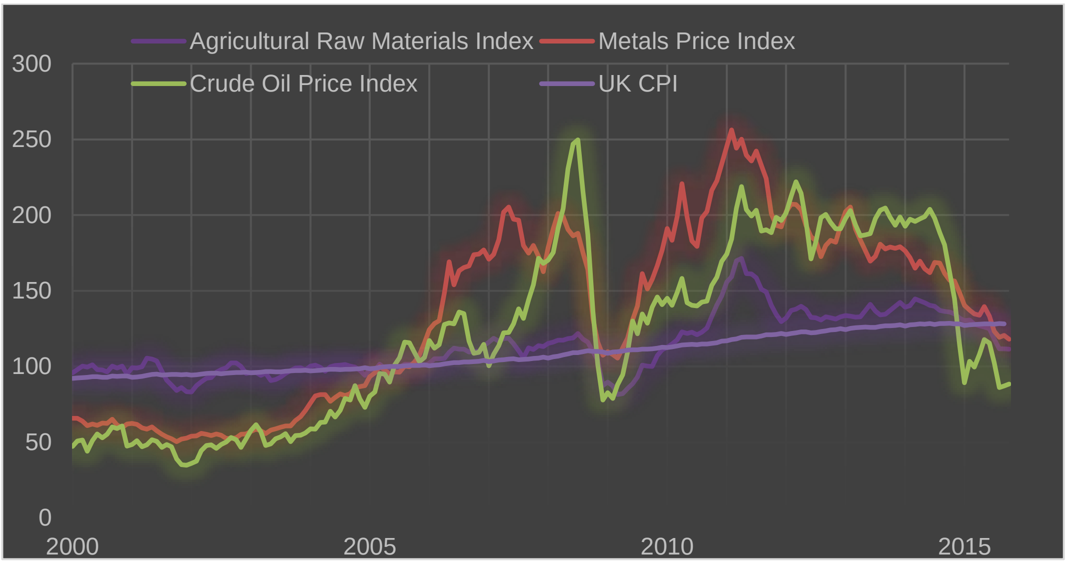
[15] Natural Capital Coalition (2016a). http://naturalcapitalcoalition.org/natural-capital/

2. Price and Materials Volatility

Simply put, raw materials and resource supplies are increasingly insecure due to a variety of converging factors. Of primary concern has been the remarkable increase in volatility of commodities prices since the early 2000s[16] as shown in Figure 3. This surge marked a reversal in the trend of declining commodity prices over the previous 30 years following the oil price shock of the early 1970s which resulted in relatively low commodity prices underpinning economic growth for the latter half of the 20th Century.

This post 2000 period, widely referred to by Economists as the 'Commodities Super Cycle'[17], saw the average price of four commodity sub-indices: food, non-food agricultural products, energy and metals increase to levels unseen since the 1910s.

Figure 3 Commodity Prices 2000-2015



Source: International Monetary Fund (IMF) Monthly Indices of Primary Commodity Data and UK Consumer Price Index

Whilst commodity prices do naturally undulate within economic cycles, and periods of boom and bust have been common throughout the 20th Century, these levels of price volatility are a recent phenomenon.

A United Nations report in 2012[18] highlighted the downside risks of excessive commodity price volatility and the macroeconomic effects on growth and policy. The magnitude and volatility of commodity prices over the period 2000 to 2015 has created policy challenges for both resource-based economies and the international community.

[16] International Monetary Fund (2016) IMF Primary Commodity Prices. http://www.imf.org/external/np/res/commod/index.aspx
[17] United Nations Department of Economic Affairs and Social Affairs (2016) 'Super-cycles of commodity prices since the mid nineteenth century.' http://www.un.org/esa/desa/papers/2012/wp110_2012.pdf
[18] United Nations Conference on Trade and Development 2012 Report on Excessive commodity price volatility: Macroeconomic effects on growth and policy options Contribution from the UNCTAD secretariat to the G20 Commodity Markets Working Group. http://unctad.org/en/Docs/gds_mdpb_G20_001_en.pdf

An example of this is the price of oil, which nearly doubled over the 15 year period from 2000 to 2015, but it is the underlying price volatility that was significant. The price of oil rose from under $25 per barrel in 2000 to almost $150 per barrel in July 2008. Rapidly increasing demand in emerging economies and production cuts by the Organization of Petroleum Exporting Countries (OPEC) in the Middle East drove the price of oil to its record heights.

Shortly thereafter, a deep global recession reduced demand for energy and sent oil and gas prices into free fall. By the end of 2008, the price of oil had bottomed out at $40. The economic recovery that began the following year sent the price of oil back over $100; it hovered between $100 and $125 until 2014, when it experienced another steep drop to $46 a barrel.

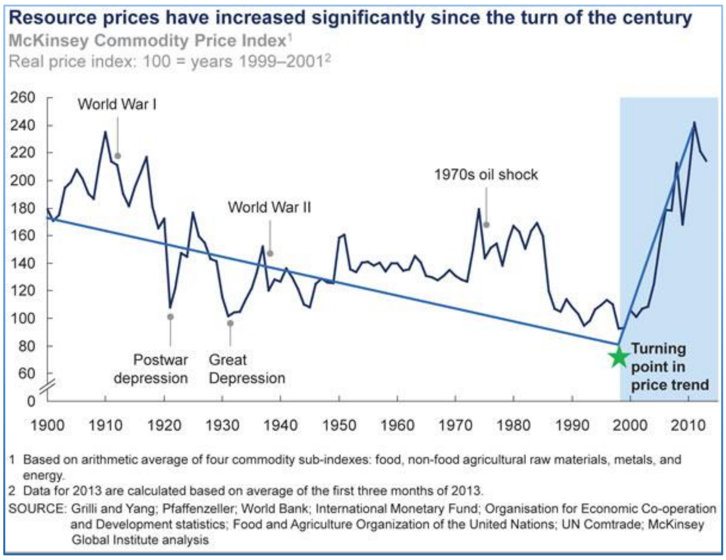
The nuance in this scenario is that whilst there has been a reversal in the trend of commodity prices, declining towards rising in the period 2000 to 2015, this movement in commodity prices has been accompanied by a global decline in prices for many manufactured products.

2.1 Globalisation and price volatility

Productivity gains in developed countries have lowered prices of manufactured goods relative to prices of services. A second and equally significant downward pressure on manufactured goods prices has been the growth in China and Southeast Asian economies, underpinned by relatively cheap labour-intensive manufacturing processes that have driven exports to the United States and European markets.

This inverse relationship between the price of commodities and manufactured goods existed throughout the period 2005 to 2015 with the exception of 2009 (Figure 4) when commodity prices crashed from record levels, following the 2008 global financial crisis. Commodity prices also fell again significantly in early 2014 as the global economy reacted to concerns about the stability of the Euro and the subsequent slowdown in growth of the Chinese economy as a result of lower demand from the Eurozone.

Figure 4 - Commodity prices in 20th Century.[19]



Source McKinsey Commodity Price Index

[19] McKinsey (2016) 'Resource Revolution: Tracking global commodity markets.' http://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/resource-revolution-tracking-global-commodity-markets

Some economic commentators, including Daniel Yergin,[20] founder of Cambridge Energy Research Associates believe that the current global economic downturn is signalling the demise of the latest commodity supercycle. Others offer the view that the latest price volatility is evidence that the global economy is simply doing its job.

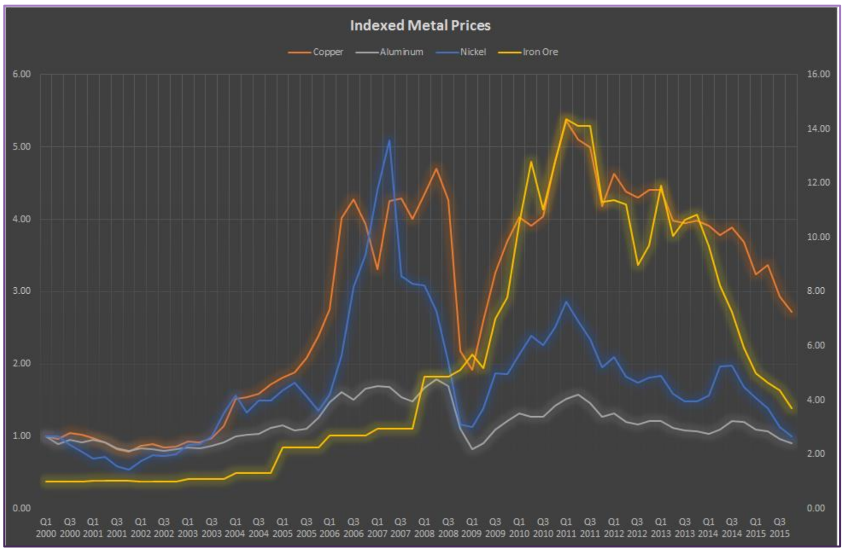
Rising prices make it commercially viable to extract materials from more difficult sites, but also drive manufacturers to innovate and use the materials more efficiently. This reduction in demand leads to lower prices, allowing the cycle to begin again[21]. Nevertheless the economics of 'globalisation' appear to be exacerbating the volatility within commodities and future price behaviour is widely accepted as hard to predict.

2.2 Commodity indices and futures trading

The typical annual variance in the price of primary commodities between 1994-2004 and 2004-2014 has been striking. With timber as a notable exception, the price of commodities has increased by a minimum of 50%. Most notably price rises for oil of 241%, copper 276% and iron ore 4211%[22] exemplify this volatility. Whilst timber prices do fluctuate, the marginal costs of increasing timber supply differ markedly from other raw materials which involve expensive extraction and processing. Other challenges exist with timber, namely that supply chains must mitigate the risk associated with illegal timber harvesting.

Figure 5 shows the volatility for metals commodity prices, indexed to the start of the period 2000 to 2015. From an economic perspective iron ore is the most important base metal, worth $225 billion to the global economy in 2015. Steel is produced from iron ore and is used extensively in construction and manufacturing. The production of iron is very sensitive to the level of investment activity in the sector, which has been on the decline in the past few years, reflecting rapidly dropping iron prices. This could have ramifications for iron ore prices should global demand for steel increase.

Figure 5 - Metals commodity price indices 2000 – 2015



Source IMF Primary Commodity Price System, IMF

[20] Financial Times (2015) article by Daniel Yergin 24th September 2015 'Commodity nations must deal with the demise of a supercycle.' https://www.ft.com/content/944e347a-5d2f-11e5-9846-de406ccb37f2
[21] The Economist (2015) article by Buttonwood 21st July 2015 'The great bear market.' http://www.economist.com/blogs/buttonwood/2015/07/commodities
[22] International Monetary Fund 2016 IMF Primary Commodity Prices. http://www.imf.org/external/np/res/commod/index.aspx

Copper is used in construction, wiring, motor coils and manufacturing and is the second most important base metal by value worth c$130 billion annually. Chile is the largest producer, followed by China and Peru, with China consuming about half of the world's refined copper.

Worth $90 billion to the global economy, large producers of aluminium are located where electricity is cheap, abundant and regulated. Aluminium prices have therefore been the most stable among metals because of the predictability of production costs. Recycling is an increasingly important part of aluminium production, it is much less energy intensive than the production of primary aluminium. China consumes about half of global primary aluminium production, in contrast to developed economies which rely more on recycling.

The fourth most important base metal is nickel, which is used for the production of alloys such as stainless steel. All four of these metals are used extensively in the manufacture of sub frames and components that are used in the furniture industry.

Commodity prices volatility has significant macroeconomic effects. Price uncertainty dampens investment and ultimately inhibits growth. When considered in the context of the UK's import dependency, with an annual trade in goods deficit of £33.2bn in the second quarter of 2016[23], commodity futures trading and currency exchange rate volatility, this raises the risk of even small increases in the price of commodities having lasting effects on UK businesses.

There are many contributory factors to price volatility but in recent years much of this volatility has been attributed to the influence of futures trading. This in turn has attracted regulatory scrutiny from the UN, US Government and European Commission in an effort to mitigate the effects of excessive speculation[24].

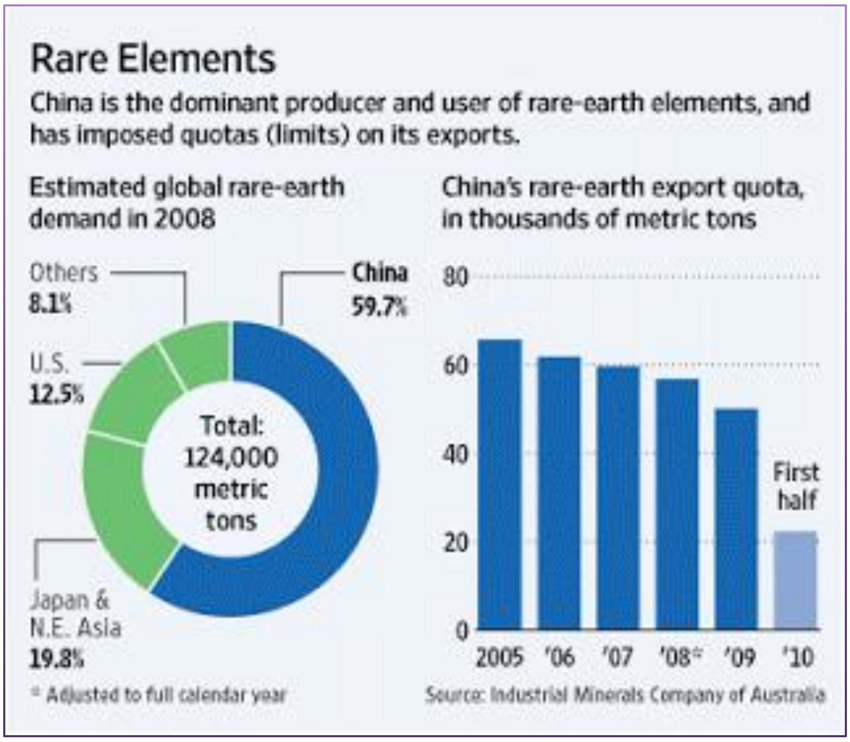
Often referred to as the 'financialisation' of commodities, the volume of investment capital into commodities markets since the beginning of the century is accepted by economists to have fundamentally distorted pricing and the derivatives markets[25].

As global financial markets have become increasingly interconnected there has been amplified market reaction to political and socio-economic shocks. Geopolitical pressures serve to foster price volatility and fuel supply insecurity. Intraregional conflicts across the Middle East and Eastern Europe coupled with ongoing instability in parts of Western, Central and Eastern Africa, Latin America, plus Eastern and South Eastern Asia highlight the precariousness of raw materials access.

Fears of resource security and availability have provoked an alarming political response for certain raw materials, which in turn may have the effect of increased volatility and inhibiting free market access. Protectionist measures by countries to restrict exports of critical raw materials, for example China's dramatic reduction (Figure 6) in export quotas for strategically significant 'rare earth' minerals in 2010[26], have disrupted markets in the past[27].

[23] UK trade: Sept (2016) Office for National Statistics.
http://www.ons.gov.uk/economy/nationalaccounts/balanceofpayments/bulletins/uktrade/sept2016
[24] US Commodity Futures Trading Commission (2013) 'The European Commission and the CFTC reach a Common Path Forward on Derivatives.' http://www.cftc.gov/PressRoom/PressReleases/pr6640-13
[25] Cheng and Xiong (2014) 'The Financialization of Commodity Markets.' Annual Review of Financial Economics 2014. 6:419–1. https://www.princeton.edu/~wxiong/papers/Review_Financialization.pdf
[26] Australian Rare Earths (2015) 'China reduces rare-earth mineral export quotas.' http://www.australianrareearths.com/
[27] Wall Street Journal (2010) 'China cuts export quota on rare-earth materials.'
http://www.wsj.com/articles/SB10001424052970203513204576047041493111426

Figure 6 - Global rare earth elements demand and China's export quota



Source: Industrial Minerals Company of Australia

The major emerging economies, the BRICS states, (Brazil, Russia, India, China and South Africa) employ export taxes, restrictive investment regulations, price subsidies and fixing in an effort to assert control over their natural resources, much to the chagrin of resource dependant economies including the European Union.

Current efforts on the part of the World Trade Organisation (WTO), the international organisation for the promotion of free trade, to encourage free market access are greatly hampered by regulatory deficiencies around export restrictions. This in turn stokes geopolitical tension and promotes 'resource nationalism'.

2.3 Resource nationalism, fragmentation and land-grabbing

An escalation in the acquisition of vast areas of land by nation states and large corporations in recent years is contributing to the problem. This phenomenon, occurring almost exclusively in the developing world, has seen an estimated 35 million hectares of land purchased or leased by foreign investors across South East Asia, Central and South America and Africa. 'This 'land-grabbing' or 'land-banking' was initially motivated by a spike in global food prices as countries and companies sought to secure valuable supplies of land and associated commodities for food and energy production[28].

Appropriations of land are underpinned by bilateral agreements with the aim of addressing national imbalances between material production and consumption demand, specifically targeting strategically important natural capital including oil and gas assets and minerals commodities in resource rich regions.

[28] Guardian (2009) 'The food rush: Rising demand in China and west sparks African land grab.' https://www.theguardian.com/environment/2009/jul/03/africa-land-grab

Examples include Germany's commodities trade accords with Mongolia, Kazakhstan and Chile, in which Germany secured critical metal resources for its domestic manufacturing base. China has also invested heavily in material extraction and energy concerns across Africa, Brazil, Argentina and Australia to support economic development.

Whilst absolute physical scarcity is rarely a fixed limit, many reserves of raw materials are in effect finite due to the cost of extraction. Securing quality, economically viable resources is impeded by resource fragmentation. This is the concept that the exploitation of valuable commodities, particularly energy sources has become marginal due to the difficult and dispersed nature of the materials or as a result of historic levels of abstraction.

Geographic availability is no longer the sole barrier in abstraction: rising energy, technological and labour costs, logistical issues and growing competition combine with the effects of overexploitation. These include deforestation, resource exhaustion, water abstraction and biodiversity loss, which in turn are manifested in raw materials price volatility.

An example of this is the rise in the average cost of new copper mining projects, which has doubled from an average of $5,000 per tonne in the period 1990-2010 to over $10,000 per tonne from 2011 onwards. These pressures are not unique to copper and extend to other minerals, including iron ore, aluminium, and nickel, as well as oil and gas production.

Mitigation strategies are not readily available for all commodities, but in response to increasingly insecure supply as a result of geopolitical events and increases in the price of oil and gas, enhanced extraction methods have been adopted, e.g. fracking.

2.4 World population and commodities

Expanding global population (Figure 7)[29], which is forecast to rise by an estimated 50% by the end of the 21st Century, and will increase further the pressure on finite natural resources[30].

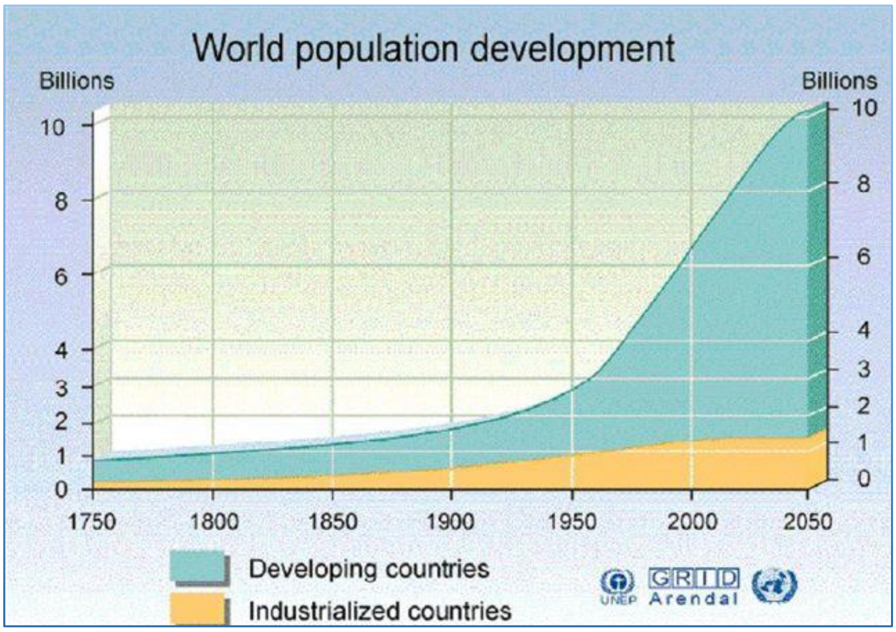
More immediate pressure is the growth of 'middle class' consumers in emerging economies. Over 3 billion people are anticipated to enter middle income brackets by 2030 which will drive consumption and an associated demand for raw materials.

In the medium term, financial commentators, and the Chinese Government themselves, acknowledge that the Chinese economic model with its reliance on state investment is not sustainable and a move towards a more consumer driven market is inevitable. There is also an acknowledgment that the costs and potential benefits of rebalancing China's economy will be felt globally[31].

The main consequence of China's economy rebalancing is slower economic growth which impacts directly on the global economy. Not all of the implications are negative as China's slowdown is likely to reduce the price of hard commodities.

[29] Sustainable Scale Project (2003) 'World population growth chart.'http://www.sustainablescale.org/areasofconcern/population/populationandscale/quickfacts.aspx
[30] Friends of the Earth (2009) 'Overconsumption? Our use of the World's Natural Resources.' http://www.foe.co.uk/sites/default/files/downloads/overconsumption.pdf
[31] McKinsey and Company (2013) 'Winners and losers in China's next decade.' http://www.mckinsey.com/global-themes/asia-pacific/winners-and-losers-in-chinas-next-decade

Figure 7 - World Population development



Source: The Sustainable Scale Project

China consumes a disproportionate share of the world's hard commodities, such as aluminium, copper, and iron ore. In adjusted GDP terms it purchases between four and ten times as much of these commodities as the rest of the world. There is evidence of this in Figure 5, with a significant fall in the price of commodities in 2013 following the announcement of a slow-down in China's economic growth.

Global manufacturers are likely to benefit both from falling commodity prices as Chinese demand drops, and by the likely reduction in China's export competitiveness. How manufacturers benefit overall depends on how and when China's rebalancing occurs.

Not all commodity prices are likely to drop, if rebalancing the Chinese economy succeeds. Income levels in China's middle classes should grow keeping demand for food and textiles strong. This increases pressures on land conversion to food and cotton production, which as history demonstrates is often accompanied by deforestation and soil degradation and increases the risks of commodity price volatility as previously discussed.

The long term effects of climate change and global deforestations will affect the carrying capacity of natural resources. Climate change is predicted to increase the probability[32] of extreme weather events such as drought and flooding which will inevitably impact on the price of agricultural products such as food and textiles.

2.5 Operational risks

Another emerging trend likely to be a factor behind resource security is the management of reputational and operational risks, particularly for big corporates. Certain regions of the world, or specific investments, may be viewed as too sensitive for brands and retailers.

[32] The Intergovernmental Panel on Climate Change 'Climate Change 2013 Summary Report for Policy Makers.' https://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WGIAR5_SPM_brochure_en.pdf

For example, in 2015, UK based Standard Chartered Bank took the decision to evaluate its role in an Australian mining project in response to shareholder concerns about environmental impacts[33]. This was, in part, caused by pressure from NGOs such as Greenpeace, who had campaigned widely on the issue.

The Norwegian sovereign wealth fund, the largest in the world, announced plans to divest from several palm oil producers given concerns over ethical and environmental performance. Environmental and social risks are material and in many respects companies are being forced to address and manage these impacts beyond their traditional sphere of influence. The emerging concept of social hotspots is outlined in the next section.

These market instabilities are compelling drivers for companies to evaluate their reliance on raw materials and to implement initiatives that will reduce the impacts of these materials on the profitability of their businesses.

[33] Financial Times 6th May 2015. Standard Chartered to stop advising on Australian mining project. http://www.ft.com/cms/s/0/f201d9fa-f40c-11e4-bd16-00144feab7de.html#axzz4JZBvyOum

3. Social Hotspots

Burgeoning risks[34] spurred by supply chain complexity and a chronic lack of transparency have left many companies exposed to scrutiny over their sustainability performance. Perhaps nowhere are these risks more acute than the challenges presented by the social element of sustainability.

ISO 26000:2010[35] provides guidance rather than requirements, so cannot be certificated unlike other well-known ISO standards. Instead, it helps clarify what social responsibility is, helps businesses and organisations translate principles into effective actions and shares best practices relating to global social responsibility.

It is hoped that adoption of the standard will encourage responsible business practices by all types and sizes of organisation. Founded on principles and practices relating to social responsibility the standard encourages organisations to engage with their supply chain, promoting socially responsible behaviour (Figure 8)[36].

Figure 8 - The seven core areas of social responsibility

Source: ISO 26000

Many supply networks are poorly positioned to cope with emerging corporate social responsibility pressures. In fact many supply chains were built to capitalise on labour arbitrage opportunities in low cost countries such as China, India, Vietnam and Bangladesh, where social and environmental compliance are often poor[37].

Social compliance issues appear endemic to globalised supply networks, particularly for high volume, low cost consumer goods. Although this does not need to be the case, especially if a company can develop and implement an effective social foot printing due diligence system.

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[34] The Conference Board (2014). 'Managing supply chain sustainability and risk.' https://www.conference-board.org/retrievefile.cfm?filename=TCB_DN-V6N13-141.pdf&type=subsite
[35] ISO (2016) 'ISO 26000 - Social responsibility' http://www.iso.org/iso/home/standards/iso26000.htm
[36] Valuestream (2009). 'ISO26000 Social Responsibility Guidance.' https://valuestream2009.wordpress.com/2010/11/04/iso-26000-social-responsibility-guidance-may-offer-supply-chain-opportunities-to-small-mid-sized-manufacturing/
[37] Guardian (2015). 'Protecting a tangled workforce that stretches across the world – Report on GAP clothing control over sustainability issues in some countries.' https://www.theguardian.com/sustainable-business/2015/apr/28/gap-kindley-lawlor-human-rights-workers-jobs-garment-industry

3.1 Socially responsible supply chains

Supply chain issues and risks are linked to increasingly complex product supply chains. The past two decades have seen many consumer products become cheaper in higher income countries. In order to gain competitive advantage, retailers continually revise and update product ranges and global suppliers.

Product ranges can be updated frequently in contrast to traditional seasonal releases. This proliferation of products combined with globalised models of production and consumption make it extremely difficult to track and map supply chains. Manufacturers and retailers will utilise a myriad of suppliers, from different countries in order to develop their product portfolio.

This supply chain complexity is set against a backdrop of ever evolving relationships between consumers and retailers. Society is increasingly interconnected and younger generations are seeking a more interactive consumer experience[38] that is fuelled by a rapid expansion of technology and the ubiquity of social media[39].

Modern consumers are more empowered and as a result more demanding. Any actual or perceived disconnect between a brand's values and its performance can have significant negative impacts and has prompted more consumers to question the provenance of their goods. These questions include where, by whom, and under what conditions the products are being sourced and manufactured.

Growing consumer awareness, facilitated by concerns over social and environmental impacts, together with the growing influence of non-governmental organisations, is calling retailers and manufacturers to task over their sourcing decisions[40].

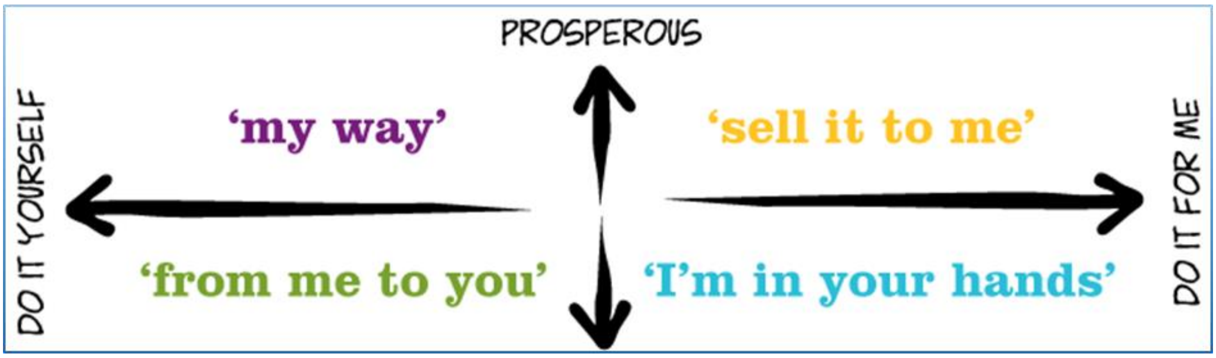
Different stakeholders are raising demands for businesses to adopt more responsibility for their supply chain, where previously there may have been scant consideration to external companies or agents involved in the production process. In turn, some enlightened and progressive global brands are viewing this as an opportunity to actively engage with their consumers to enable customers to get to know their business and what they stand for[41].

Some UK retailers have funded further research looking at global trends and examining how they might affect consumption and consumer behaviour. In particular how sustainable products, services and business models could become mainstream.

The research scenarios explored two of the most uncertain trends for 2020 consumers based on whether they felt they would be more or less prosperous and whether consumers were likely to take the initiative to satisfy their consumer preferences or whether they expected brands to take that responsibility on their behalf.

[38] Forum for the future (2016) Report 'Working with business and government to create a sustainable future.' https://www.forumforthefuture.org/project/consumer-futures-2020/overview
[39] Nielsen Global Sustainability Report www.nielsen.com/content/dam/.../dk/docs/global-sustainability-report-oct-2015.pdf
[40] 5 PwC (2008) Sustainability: Are Consumers Buying It? http://pwc.blogs.com/files/pwc-sustainability-pamphlet13_06_08.pdf
[41] Forum for the future (2016). Consumer trends research for 2020. https://www.forumforthefuture.org/project/consumer-futures-2020/overview

Figure 9 - Consumer behaviour and preference matrix



Source: Forum for the future

These questions formed a matrix (Figure 9) and the quadrants represented different consumer personas based upon their consumption (Figure 10) and behaviour preferences. UK companies are starting to think differently about consumer preference and how their brands need to align to sustainability. This approach helps businesses identify risks and opportunities, inform strategy development, and stimulate innovation.

Figure 10 - Different sustainability consumer personas

My way Consumers buy locally, strengthening their local economies. Vertical farming is widespread, producing more food per unit of land. Sustainable living is high-tech and easy; products such as the personal energy micro-manager help reduce energy consumption and build personal relationships via on-line competitions.	**Sell it to me** Brands and businesses have taken a lot of the hard work out of being sustainable, driven by resource scarcity and a global deal on climate change. Retailers have taken unsustainable products off the shelves and smart products and services are commonplace – all designed to reduce their in-use impacts.
From me to you Communities are strengthened by local food and energy production. Resources are valued much more highly than today because they are scarce and expensive, and there is little or no waste. Goods exchanges are mainstream, encouraging recycling and re-use of goods and resources, from fridges to grey water.	**I'm in your hands** Product to service shift is mainstream. Retailers and brands lease a lifetime's supply of key goods, and also provide heat, water and nutrition. Strict government legislation and economies of scale mean that leasing models are highly sustainable. Consumers adopt "waste not want not" attitude and expect government / business to lead on sustainability.

Source: Forum for the future

Some corporations may be unaware of social issues affecting their supply chains and moreover have varying degrees of control over the actors involved. That said, pressure to uncover and share information on their corporate social performance does not show any signs of abating.

From a regulatory perspective the December 2014 EU Directive on Disclosure of Non-Financial and Diversity Information was added to the Accounting Directive42. This was a significant step and requires organisations with more than 500 employees to report on environmental and social matters including human rights, anti-corruption and bribery. The first reports, covering the financial year 2017-18, are due to be published in 2018.

3.2 Rana Plaza

The importance of corporate social governance was exemplified by the 2013 Rana Plaza building collapse[43] in Bangladesh, where over 1,100 textile workers were killed and many others left with debilitating injuries.

Rana Plaza was severely over occupied with workers and machinery. Workers voiced concerned over cracks that had appeared on the building's exterior, but faced the risk of loss of job or earnings if they did not return to work. Alleged government corruption and a lack of enforcement of building regulations in Bangladesh was fundamental to the disaster. It is also argued that many large corporate organisations were aware of socially unacceptable working environments and conditions in a number of countries but that often the drive for profit compromised the level of scrutiny necessary to ensure that such practices did not occur.

This, and other incidents, has led to much greater corporate engagement, with the principles of "social hotspotting" beginning to be embraced by many organisations. The Rana Plaza incident prompted a major programme of Bangladeshi factory inspections, instigated by two prominent fashion brands, to improve safety and working conditions in factories.

The Bangladeshi government also reacted positively to calls to reform the industry. As the world's second largest producer[44] of apparel products, Bangladesh has a sprawling supplier network. The ability to attract and retain apparel manufacturing contracts is pivotal to Bangladesh's economic development.

In many respects Rana Plaza has been a catalyst for many organisations to scrutinise their supply networks. The incident also exposed consumers to potential social consequences of cheap goods.

The material social risks highlighted by the Rana Plaza incident are not unique to Bangladesh, but are prevalent in many countries and in turn these have become critical business factors[45].

'Social hotspots' are defined as sections or processes within a supply chain that are particularly susceptible to risk or vulnerable to negative impacts. The determination and prioritisation of these social hotspots will be dependent on factors such as the severity of the issue, level of risk, stakeholder and regulatory pressure, volume of business and the company's sphere of influence.

Table 1 presents an overview of social issues categories and themes that businesses should consider when evaluating their supply chain. It is only once this due diligence and risk assessment has been completed that a company can begin to engage with its supply chain and implement strategies to manage the risk via assessment visits, codes of conduct, certifications and corrective actions.

[42] EU Directive on Disclosure of Non-Financial and Diversity Information (Directive 2014/95/EU) http://ec.europa.eu/finance/company-reporting/non-financial_reporting/index_en.htm
[43] Guardian (2013) 'Rana Plaza' https://www.theguardian.com/world/rana-plaza
[44] McKinsey & Co (2011) 'Bangladesh's Ready Made Garments Landscape' https://www.mckinsey.de/files/2011_McKinsey_Bangladesh.pdf
[45] National Archives (2015) 'Modern Slavery Act' http://www.legislation.gov.uk/ukpga/2015/30/contents/enacted

Table 1 - Social issues categorised by theme

CATEGORY	SOCIAL THEMES
LABOUR ISSUES	Labour laws
	Wage assessments
	Forced labour
	Child labour
	Excessive hours
	Freedom of association
	Freedom of collective bargaining
	Right to strike
	Unemployment and poverty
GOVERNANCE	Legal system
	Judicial accountability
	Law enforcement
	Independent judiciary
	Integrity of governance
HUMAN RIGHTS	Gender equity
	Religious and sexual equality
	Indigenous rights
	Conflicts
	Health and disease
	Life expectancy and mortality rates
INFRASTRUCTURE	Transport Infrastructure
	Access to healthcare
	Access to education
	Access to drinking water and sanitation
OTHER	Health and Safety
	Hazardous Substances
	Animal Welfare (Animal products)
	Local environmental impact

Source CIPS[46]

Failure to address or alleviate social hotspots presents genuine risks to a company. In turn, positive action may provide opportunities to improve a brand's standing, its relationship with stakeholders in the supply chain and reduce risks associated with brand reputation and improve supply chain consistency.

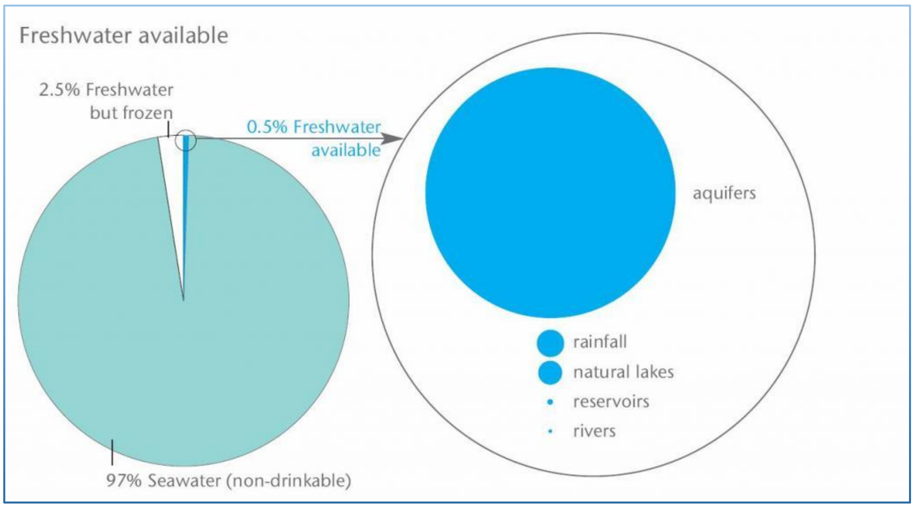
[46] CIPS (2014). 'The Walk free foundation research into Sustainable and ethical procurement'. https://www.cips.org/Documents/Knowledge/Procurement-Topics-and-Skills/4-Sustainability-CSR-Ethics/Sustainable-and-Ethical-Procurement/tackling-modern-slavery-in-modern-supply-chains.pdf

4. Water Hotspots

The issue of water scarcity is increasingly prominent in light of global population growth and movement, economic development, deforestation and the long term impacts of climate change. The concept of water hotspots for local, national and transregional areas of water stress has emerged as a result of growing challenges around securing water sources.

Water resources face a series of threats primarily as a result of human activity. The two main drivers behind the increase in water hotspots are unsustainable abstraction and water pollution[47]. Water is a unique and abundant resource, covering 70% of the Earth's surface, however less than 1% of this water is easily accessible as fresh water (Figure 11)[48].

Figure 11 - Global Freshwater available



Source: WBCSD 2009 Water Facts and Trends

Whilst fresh water in lakes, rivers and groundwater is continuously replenished via precipitation in the water cycle, increasing population, hydropower schemes and water intensive industries such as agriculture increase the strain on fresh water supply.

Availability of water is in a constant state of flux and varies significantly over time and geographical location. Geographic disparity of fresh water supply combined with the fact that it is costly and difficult to transport means that water is often used close to its source. There is increasing recognition amongst businesses that are dependent on natural resources for their raw materials, such as textiles, rubber, leather and timber, that major operational risks exist around the growing scarcity of freshwater.

Whilst water risks for many UK businesses may appear to be indirect and solely the concern of upstream supply chain actors, the issue of water stewardship is potentially very sensitive for retailers and brands with

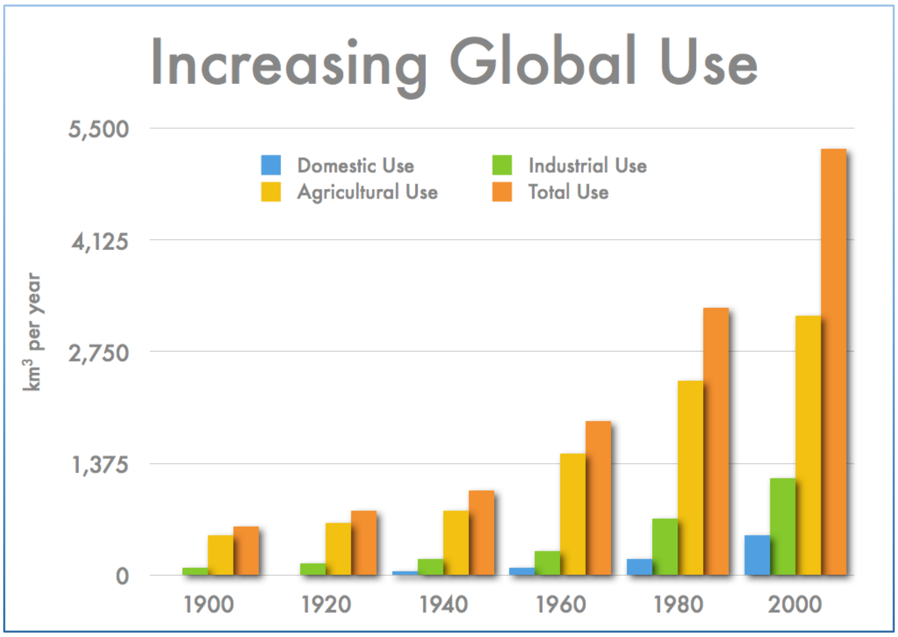
[47] The United Nations World Water Development Report 2015. 'Water for a sustainable world.' www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/SC/images/WWDR2015_03.pdf
[48] World Business Council for Sustainable Development 2009. 'Water v2.' http://www.sswm.info/sites/default/files/reference_attachments/WBCSD%202009%20Water%20Facts%20and%20Trends.pdf

strong corporate responsibility and brand values. Companies such as these must ensure that they are aware of water risks and share the burden of responsibility with their suppliers. At its simplest, water availability issues occur when demand exceeds supply. Typically this happens in regions with intensive industrial or agricultural activity and in densely populated urban areas.

4.1 Water abstraction

Groundwater is the principal source of freshwater (Figure 11). Underground water resources called aquifers, are replenished by rainfall. As aquifer abstraction rates have increased water has been removed faster than it is replenished, diminishing water tables. Low water tables can make rivers less reliable as they are often maintained in dry periods by underground springs. In coastal regions, saltwater intrusion can also degrade groundwater stocks when water tables fall too low.

Figure 12 - Global freshwater use in cubic km per annum



Source: The ImpEE Project, University of Cambridge[49]

Agriculture is the greatest driver of freshwater abstraction and accounts for almost 75% of global water extraction (Figure 12). The cultivation of cotton, used for over 90% of the natural fibres in global textile manufacture, is particularly water intensive. Studies show that 1kg of cotton, equivalent to a pair of jeans and a t-shirt requires, over 20,000 litres of water to produce[50].

Cotton, being a water intensive crop, impacts significantly on the environment, particularly because it is grown largely in regions that are prevalently dry, such as Southern USA, Central Asia, Western and Central Africa and the Indian Subcontinent. Unsustainable cotton cultivation uses and wastes substantial quantities of freshwater.

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[49] The ImpEE Project 'Improving education in Engineering.' Website for lecturers at the University of Cambridge. http://www-g.eng.cam.ac.uk/impee/?section=topics&topic=water&page=materials
[50] WWF 'Cotton Farming Cotton: a water wasting crop' http://wwf.panda.org/about_our_earth/about_freshwater/freshwater_problems/thirsty_crops/cotton/

4.1.1 Impacts of over abstraction

Impacts of over abstraction are well documented. The Aral Sea, lying between Kazakhstan and Uzbekistan was once of the world's most fertile regions and the fourth largest inland sea. The two rivers feeding the sea, Syr Darya and Amu Darya were diverted in a programme by the government to foster cotton cultivation. As a result the Aral Sea level fell by 20 meters between 1962 and the late 1990s. Waterbody salinity rose tenfold from 10g/l to 100g/l decimating fish stocks so that the fishing industry has ceased completely[51].

In addition, about 200,000 tonnes of salt and sand are transported by the wind from the Aral Sea region each year and deposited within a 300 km radius. The salt pollution compromised the viability of agricultural land, destroying pastures and feedstocks for animals. The number of domestic animals in the region has become so low that the government issued a decree to reduce the slaughter of animals for food.

Lack of sustainable water management in the Aral Sea is evidence of the detrimental effects that can be dealt to natural resources, local and regional ecosystems, reliant economies and ultimately society as peoples are displaced and local industries literally 'dry up'.

Freshwater abstraction is a contentious issue across the globe, though rates of freshwater abstraction vary greatly. Asia has the highest rate of abstraction by volume and per capita, as shown in Table 2 [52], increasing the risks associated with rapidly expanding populations and tightly coupled natural resource consumption.

Table 2 - Freshwater withdrawal (2010)

Column	Population 2010	Freshwater Withdrawal	Per Capita Withdrawal	Domestic Use	Industrial Use	Agricultural Use	Domestic Use	Industrial Use	Agricultural Use
REGION	(millions)	(km3/yr)	(m3/p/yr)	(%)	(%)	(%)	m3/p/yr	m3/p/yr	m3/p/yr
AFRICA	1,031.22	214.68	183.57	23.67	7.74	68.59	22.73	7.90	152.82
NORTH & CENTRAL AMERICA	541.03	627.48	372.61	21.30	18.36	40.32	72.88	122.89	149.91
SOUTH AMERICA	392.98	163.39	730.59	14.58	8.18	74.03	65.18	45.85	611.45
ASIA	4142.96	2480.81	756.59	14.58	8.00	73.17	66.67	51.33	633.82
EUROPE	721.78	392.22	554.38	23.37	45.72	22.37	112.27	244.38	147.99
OCEANIA	34.09	62.12	673.69	34.47	19.31	45.91	132.86	68.63	471.52

Source: Worldwater

Contention surrounding water abstraction is not confined to developing countries. UK industries previously exempt, such as farming, will be included under environmental licensing legislation, as the Department for the Environment, Food and Rural Affairs (DEFRA) and the Welsh Government seek to protect the environment and enable regulators to better manage water resources[53].

[51] UNEP 2008 'The disappearance of the Aral Sea.': http://www.unep.org/dewa/vitalwater/article115.html
[52] Worldwater 2010 'Freshwater resource abstraction.' http://www2.worldwater.org/data.html
[53] ENDS. 2016 'Plans to end abstraction exemptions.' http://www.endsreport.com/water/

4.2 Water pollution

Water pollution exacerbates existing problems of water scarcity through contamination of freshwater, thereby rendering it unsuitable for use. Pollution of water resources is accelerated by numerous anthropogenic activities (Figure 13) including the discharge of raw sewage, heavy metals from industrial processes and organic pollutants from domestic, agricultural and industrial sources[54].

This is pollution is exacerbated by a lack of environmental stewardship and appropriate legislation. Expanding industrialisation, particularly in the developing world, is a significant source of water pollution. The proliferation of light industry for the manufacture of consumer goods such as furniture, clothing, footwear, electronics and appliances is characterised by large demand for water as well as chemical and energy inputs which have their own detrimental links to reducing water quality.

Figure 13 - Anthropogenic sources of water pollution

Source: Filterwater[55]

Many facilities use watercourses to carry away waste. Consequently industries are often located near already ‘stressed’ and polluted river basins.

The river Ganges, one of the world’s largest and most polluted rivers is suffering as a result of poor stewardship. Pollution from industrial sources is severe and has led to significant water quality issues in areas downstream of cities. Estimates suggest that approximately 300,000m³ of untreated domestic and industrial wastewater is discharged into the Ganges daily[56].

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[54] UNEP 2010 United Nations Environment Programme ‘Clearing the waters.’ http://www.unep.org/PDF/Clearing_the_Waters.pdf
[55] Filterwater 2016 ‘Causes of water pollution.’: https://www.filterwater.com/t-articles.waterpollution.aspx
[56] Times of India. 2015. ‘37,000 million litres of untreated sewage are discharged daily into rivers.’ http://timesofindia.indiatimes.com/home/environment/pollution/37000-million-litres-of-sewage-flows-into-rivers-daily-Report/articleshow/46657415.cms

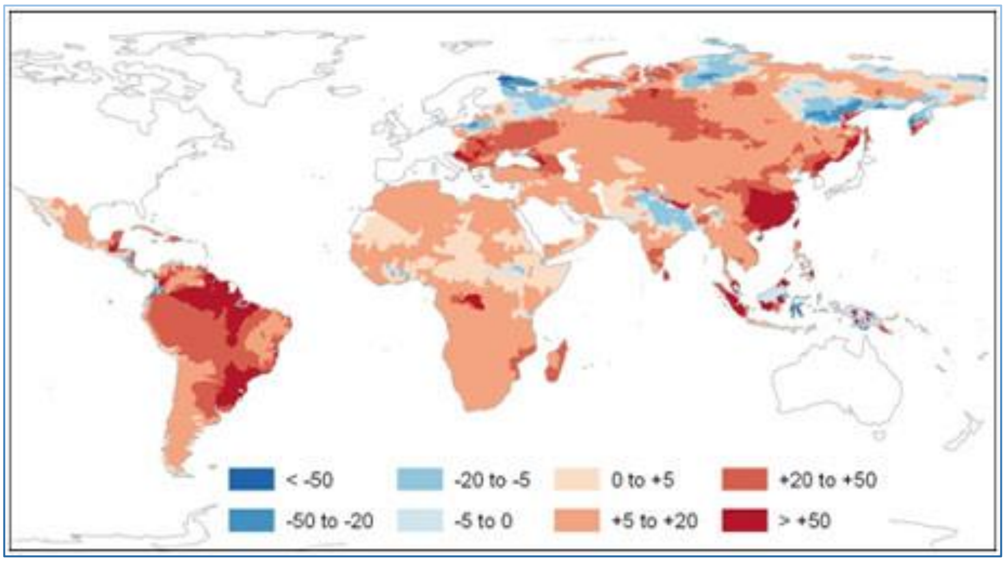
4.2.1 Water pollution and the furniture industry

A part of the furniture industry supply chain that has been heavily implicated in the pollution of the Ganges is leather tanning. It has been the focus of scrutiny by both the WWF research into the impact on Indus dolphins due to river pollution and BBC articles on the important role of the Ganges[57]. Kanpur in Northern India lies on the Ganges and is the second largest exporter of leather goods in India.

Around two-thirds of wastewater discharged by the city's tannery cluster is untreated. Chromium is a key tanning agent in leather making and a recognised human carcinogen. River monitoring revealed chromium levels as much as one hundred times safe levels prescribed by the World Health Organisation[58].

The impacts of over abstraction and pollution are likely to be aggravated by further climate change. Research by the World Bank Group[59] indicates that variations precipitated by climate change are likely to increase water scarcity. Currently 1.6 billion people live in regions of absolute water scarcity (Figure 14), but this is expected to rise to 2.8 billion people by 2025.

Figure 14 - World water deficit regions



Source: World Bank Group (2016)

[57] BBC 2016. 'India's Dying Mother, series of articles on River Ganges.' http://www.bbc.co.uk/news/resources/idt-aad46fca-734a-45f9-8721-61404cc12a39
[58] India Express. 2011. 'High Court orders shutdown of Kanpur tanneries polluting Ganga.' http://indianexpress.com/article/cities/lucknow/hc-orders-shutdown-of-kanpur-tanneries-for-polluting-ganga/
[59] World Bank Group 2016 'Water and climate change.' http://water.worldbank.org/topics/water-resources-management/water-and-climate-change

4.3 Climate change and water hotspots

A key predicted impact of global warming is that it will effectively intensify the current hydrological cycle, resulting in heavier and more frequent rainfall. Heavy rainfall results in substantial runoff, prompting flash floods, reduced rates of absorption into soil and lower groundwater replenishment rates. Evaporation rates are also anticipated to increase with higher average temperatures.

Climate change may also reintroduce water security challenges in countries that have enjoyed reliable water supplies and few water shocks. Much of the developing world will have to face droughts and increased risk of flooding.

Climate change will lead to further glacial retreat which will also result in reduced freshwater supplies. Melting of inland glaciers will cause an increase in water supply to rivers in the short term; however this trend will reverse as glaciers gradually disappear. Conversely, in arid sub-tropical regions of the world rainfall is forecast to decrease and more surface water will be lost to transpiration.

4.4 Water and population growth

Water resources will come under increasing pressure as a result of an expanding global population. The world's population is projected to expand to 9 billion by 2050. Of this additional 2 billion people, over 90% are expected to live in the developing world.

Whilst water demand in the developed world is only gradually increasing due to relatively static populations, water demand (Table 2) in the developing world is increasing as these countries experience rapid population growth coupled with economic and social change.

This will be compounded by growing urbanisation, as people move from rural environments to cities, creating greater regional imbalance between water demand and supply.

Water stressed regions are defined as areas with access to fewer than 1,000m^3 of water per person annually. In 2000 around 0.5 billion people inhabited areas of high water stress. By 2030, projections suggest that as much as half of the world's population could be living in water stressed regions[60].

Finally, poor water governance and transnational tensions mean that water security and strategic water assets such as the Mosel Dam, can foster volatile political hotspots.

4.5 Risks to businesses

The WWF examined the UK's Water Footprint in detail, in particular the impact of food and fibre consumption on global water resources[61]. Large insurance companies describe water scarcity as a significant emerging risk as water is one of the most significant inputs in the supply chain for producers, wholesalers and retailers.

The report examined the indirect and direct water footprint of the UK, along with its associated impacts, and made recommendations for business, government, consumers and citizens.

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60 United Nations. 2016. 'Water for Life decade...' http://www.un.org/waterforlifedecade/scarcity.shtml
61 WWF (2012) 'UK Water Footprint: the impact of the UK food and fibre consumption on global water resources.' http://www.wwf.se/source.php/1407043/wwf_uk_footprint[1].pdf

4.5.1 Recommendations for business

For businesses, reputational risk is prompting financial advisers to encourage their clients to consider environmental risk as an investment issue as poor performance in this area could lead to loss of market share.

WWF suggests that business plays a key role in improving water resource management. UK companies need to ensure that their own operations make efficient use of water, but they must address the issue of water use throughout the supply chain, making good water management a standard element within supplier contracts.

In order to achieve this, companies should seek to better understand water and social economic issues, calculate their own water footprint and reduce impacts in areas where water is either already scarce or is likely to become scarce. By examining the volumes, impacts and risks of water use along the entire supply chain and in partnership with other companies, they can press for effective water resource stewardship.

4.5.2 Recommendations for Government

For the UK Government the recommendations focussed on over abstraction, primarily as a result of increased household consumption. Water consumption per person has risen by 1% per year over the last thirty years, and is expected to rise further in the absence of corrective action. Evidence has shown that water meters can significantly help to reduce water demand.

4.5.3 Recommendations for consumers and citizens

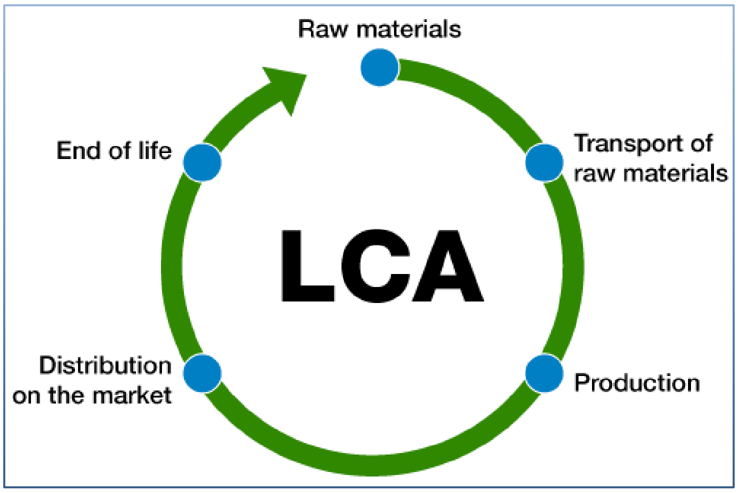
For consumers the advice is much simpler. Reducing waste and increasing reuse and recycling rates will directly reduce water consumption. Selecting retailers and food manufacturers who choose and communicate how they deliver water sustainability through their stores, and crucially in their supply chains, will improve the UKs indirect water consumption.

5. Life Cycle Assessment

Life Cycle Assessment (LCA) is a technique used to assess environmental impacts of consecutive and interlinked stages of a product (Figure 15). This assessment includes the environmental impacts of raw material extraction, materials processing, manufacturing, distribution, product use, repair and maintenance through to end of life management, inclusive of recycling and recovery activities.

The objective of an LCA for furniture is to assess and quantify the environmental impacts assigned to a product by quantifying inputs and outputs of material flows and how these affect the environment. Procedures and guidelines associated with the process of lifecycle assessment form part of the ISO14000 suite of international standards[62].

Figure 15 - Life Cycle Analysis



5.1 Materiality assessment and Life Cycle Analysis (LCA)

5.1.1 Materiality assessment

One type of sustainability assessment, is that of materiality assessment. Unlike life cycle analysis, this is a more subjective assessment implemented by asking an agreed set of stakeholders what they value.

When conducting a materiality assessment it is important to define the goal, scope and which stakeholders to involve. Understanding the context in which different stakeholders will assess sustainability, will in turn influence how a company, product, business model or brand is perceived.

A materiality assessment creates an opportunity to engage customers and stakeholders. Many will already be involved in sustainability and can help provide a platform for change by exposing what matters to them and giving guidance to a business on what to act upon.

Materiality assessments are limited in that they merely offer a perception of what is important, but they offer great benefits to a business as a complimentary approach to life cycle analysis.

[62] ISO (2016) 'ISO 14000 Environmental Management.' http://www.iso.org/iso/iso14000

5.1.2 LCA

Identifying sustainability hotspots through a life cycle assessment (LCA) enables a business to calculate the impacts of its products throughout their entire life cycles. It is an objective quantitative assessment of the environmental impacts, it provides visibility of where the biggest impacts are and where opportunities for improvement exist and then to prioritise impact reduction actions.

Life cycle assessment is science based and uses products and services as a starting point, rather than at an organisation level. This makes it easier to demonstrate where business value lies, as it links directly to a particular stage in the product life cycle.

5.2 Hotspot analysis and LCA

LCA and Hotspot analysis are often incorrectly defined as the same thing. In fact a life cycle analysis is used as one of the components of hotspot analyses to identify the most significant impacts and improvement opportunities.

There are various methodologies that can be used in hotspot analysis that assess the four impact areas of economic, environmental, ethical and social sustainability. These methodologies use both quantitative and qualitative information and should be seen as complementary tools that can expand the scope and range of impacts that are identified by a life cycle analysis.

5.3 Life cycle approaches

Life cycle approaches encompass a range of methodologies and tools for the evaluation of various stages of the life of a product or organization, from raw material acquisition to final disposal[63].

These approaches cover simplified methodologies from qualitative screening tools via carbon footprint analysis, following ISO 14046[64] and 14067[65], to hotspot analysis and targeted life cycle assessment such as environment, social or resource life cycle costing based on the ISO standards of the ISO 14040[66] series and ISO 14072[67].

Life cycle approaches can cover multiple impact categories, for example water use, climate change and land use. Identifying businesses that seek to reduce their impacts along the product life cycle, would typically include the findings from life cycle methodologies, which some also consider life cycle approaches, such as: Life Cycle Management, Sustainable Public Procurement, Eco or Sustainable Design and Eco-labels based on the ISO 14020[68] series of Standards.

[63] UNEP 2014 'UNEP/SETAC Life Cycle Initiative - Flagship Project 3a (Phase 1).' http://www.lifecycleinitiative.org/wp-content/uploads/2014/12/UNEP-Hotspots-Mapping-Project-Final-Report-Phase-1.pdf
[64] ISO 14046:2014 'Environmental management -- Water footprint -- Principles, requirements and guidelines' http://www.iso.org/iso/catalogue_detail?csnumber=43263
[65] ISO/TR 14047:2012 'Environmental management: Life cycle assessment – Illustrative examples on how to apply ISO14044 to impact assessment situations' http://www.iso.org/iso/catalogue_detail.htm?csnumber=57109
[66] ISO 2016 'ISO 14040:2006 Environmental management: Life cycle assessment, Principles and framework.' http://www.iso.org/iso/catalogue_detail?csnumber=37456
[67] ISO/TS 14072:2014 'Environmental management: Life cycle assessment - Requirements and guidelines for organizational life cycle assessment' http://www.iso.org/iso/catalogue_detail.htm?csnumber=61104
[68] ISO 14020:2000 'Environmental labels and declarations - General principles' http://www.iso.org/iso/catalogue_detail?csnumber=34425

5.3.1 Footprint studies

Footprint studies tend to research or focus on one particular indicator, for example greenhouse gas emissions, water use or global land use. This could take the form of an LCA, looking at how much of that particular indicator is produced or consumed during the life cycle of a product; it could also take the form of an annual inventory, totting up how much is used up or emitted during a year of activity at a particular site, for a specific business activity, or for an organisation as a whole[69].

No footprint study is ever perfect and represents a "best estimate" of the emissions from a particular snapshot in time, based on the available data. The ultimate accuracy of any footprint will be limited by company resources available to conduct the study, the data that can be collated and the boundaries selected by the company defining which business processes are deemed in or out of scope.

However the 'purpose' of the study should be to identify areas of concern and focus efforts on improving business performance. Therefore there is an underlying assumption that in applying a methodology or approach consistently it will enable a business to demonstrate continuous improvement rather than making environmental claims such as carbon neutrality.

Table 3 attempts to summarise and clarify the likely outputs and limitations of each type of assessment, which could be useful when considering what type of research is most pertinent to a business.

Table 3 - Summary of different types of assessment summary

Type of research	What it can tell a business	Might be useful for	Data required	Limitations
Hotspot screening	Which parts of an organisation are likely to have the largest environmental impact	Deciding which parts of a business to focus on for further action	Basic information on material or financial flows in different parts of your organisation	Provides a rough picture. Useful for deciding where to focus future efforts
Single metric footprint	One key measure of an organisation environmental impact e.g. water or carbon	Understanding and communicating. Identifying opportunities for reduction of a key environmental impact	Information on relevant inputs and outputs of materials, energy or money in relevant parts of the business	Focuses on just one environmental indicator
Multi metric footprint	Two or more indicators of your environmental impact, e.g. water and energy use	Understanding and communicating. Identifying opportunities for reduction of multiple environmental impacts	Information on relevant inputs and outputs of materials, energy or money in relevant parts of the business	More data than a single metric footprint, can be more complex to communicate
LCA Full product	A detailed picture of everything extracted from, and released into, the environment by your business activities	Understanding, identifying and communicating opportunities for environmental impact reduction	Detailed information on inputs and outputs of materials, energy or finance in the business	Lots of data collation and complex results requiring further interpretation

[69] WRAP (2013) 'Carrying out a Life Cycle Assessment or Footprinting Study' http://www.wrap.org.uk/sites/files/wrap/Carrying%20out%20LCA%20or%20footprint%20Topic%20Guide%20-%20final%20v1.pdf

5.3.1 LCA Full Product

A full LCA is a complex exercise, detailing a picture of everything extracted from and released into the environment as a consequence of the manufacture, consumption and end of life management of a given product.

It requires extensive data collection and subsequent interpretation, which is why many organisations may initially chose to focus their efforts on a single or dual metric footprint such as greenhouse gas emission and the water footprint of a product due to resource or financial limitations.

A good example of a dual metric footprint can be seen in the FIRA circular economy project 'Remanufacturing for the Circular Economy'[70]. Project finance and resource limitations meant that the most value would be gleaned in assessing the comparative carbon and water footprints of new and remanufactured task chairs. However a full LCA should take into account a much wider assessment of direct and indirect aspects and impacts of a product's lifecycle that includes;

- Abiotic depletion potential - This is the consumption of non-renewable resources, such as fossil fuels, metals and minerals.
- Global warming potential (GWP) - Measure of how much a given mass of greenhouse gas is estimated to contribute to global warming equivalent to the same mass of Carbon Dioxide (CO_2e).
- Ozone layer depletion (ODP) - Measure of chemicals released contributing to a reduction in the amount of ozone in the stratosphere.
- Human toxicity - Measure of the effect of the emissions of a life cycle or product on human health.
- Ecotoxicity – Measure of how chemicals affect fresh water aquatic, marine aquatic and terrestrial organisms that is specific to different environments (i.e. land and water based)
- Photochemical oxidation - Measure of the formation of reactive substances (mainly ozone) which are harmful to human health and ecosystems, and which may also damage crops.
- Acidification potential – Measure of the ability of certain substances released to build and release H^+ ions which have a damaging effects on natural and anthropogenic environments.
- Eutrophication potential - Measure of the impacts to the environment due to excessive levels of macronutrients caused by emissions of nutrients to air, water and soil.

The ISO14040 standard states in Annex A, 'Application of LCA' that there is no single solution as to how LCA can best be applied within the decision making context. Each organization depending on its size, culture, the nature of its products, internal systems, tools and procedures available must decide which approach is the best to follow.

The LCA technique with proper justification could be applied in studies that are not LCA studies. Other examples include cradle-to-gate studies, gate-to-gate studies, and specific parts of the product life cycle such as waste management or product components. However, wherever a company chooses to deem a boundary,

[70] FIRA (2016) 'Remanufacturing for the Circular Economy' https://www.fira.co.uk/news/article/research-report-remanufacturing-for-the-circular-economy

importance should be placed on data quality, collection and calculation as well as allocation and critical review. These will be discussed in greater detail in the Methodology section.

5.3.2 End of Life Management

Another key consideration for a complete LCA is that of end of life management. To fully assess the impacts of a product it is important to understand the environmental impacts at the end of the first life of the product. This also has profound effects for Circular Economy thinking as companies seek to reduce the environmental impacts of their products by extending the life of materials and components used in furniture production, through reuse, remanufacture and recycling activities.

Relatively few companies have voluntary end of life product stewardship in place and therefore externalise the environmental costs associated with processing products at the end of their first life. A full life cycle analysis can assist raising awareness direct and indirect environmental impacts related the entire value chain.

This was a key project objective on a research project into Steelcase products[71]. Whilst the research is quite old it did highlight that Steelcase did not have an end-of-life product stewardship program in place. In the absence of such a scheme the lifecycle assessment the end-of-life product was assumed to have entered the standard municipal solid waste (MSW) management system and their environmental impact calculated accordingly.

Analysing municipal waste processing streams for the products under study revealed relatively low recycling rates for components such as plastics (5.5% recycled) and ferrous metals where only 28% of the material was recovered. The remaining waste after recycling was either incinerated (14.7% of total MSW) or landfilled (56% of total MSW).

The LCA provided transparency to design, sourcing, manufacturing, and marketing stakeholders that could be incorporated into design improvements for future Steelcase office furniture products. Including the results of the LCA with other criteria, resulted in more informed decisions regarding product development, manufacturing, and life cycle product stewardship.

When assessing the impact of potential re-use cycles for products a full LCA would take account of displaced environmental impacts such as avoidance of landfill impacts, waste incineration and raw material inputs through the re-use of materials and components, whilst separately assessing any additional processes such as product dismantling, cleaning and refurbishment.

[71] University of Michigan (2005) 'Life Cycle Assessment of Office Furniture Products' Thesis paper submitted by Bernhard Dietz http://www.css.snre.umich.edu/css_doc/CSS05-08.pdf

5.4 Challenges to launching LCA and footprinting studies

Businesses often face common challenges when seeking to develop life cycle assessment or footprinting studies as the business benefits are not always readily understood.

Securing senior management buy in and therefore sufficient financial resources can be challenging. Demonstrating potential cost savings as well as environmental benefits from an initial scoping study can help to build a robust business case for more significant investment.

The availability of data is usually a key factor in the effectiveness of any life cycle assessment. Where data is not readily available it is perfectly acceptable to fill some data gaps with realistic estimates taken from other data sources, especially if the results of the study are to be used to inform internal decision making within a business.

Some organisations may be reticent to commit further effort following an environmental assessment. Key stakeholders, internal and external, may expect businesses to follow through and tackle environmental impacts. However this barrier is presumably negated through an element of self-selection; if a business wishes to understand its environmental impact as part of a sustainability assessment, it presumably has the ultimate aim of identifying areas for improvement, then targeting further resources to tackle impact areas.

Having researched the context of hotspot analysis and life cycle assessment the following section explores in greater detail some of the methodologies available for those businesses seeking practical application of product sustainability assessments.

6. Methodologies

This section of the report will introduce methodologies and approaches for assessing social, water and environmental impacts of products.

6.1 Social supply chain footprinting

A socially responsible company considers the impacts of its supply chain, taking care to look beyond its own sphere of local operation. By internalising factors such as environmental and social performance and encouraging good governance a company can derive real added value[72].

The concept of social supply chain footprinting builds on the concept of life cycle assessment and sustainability management programmes. Whilst environmental metrics such as energy use, waste generation, carbon emissions and product recyclability are now embedded in organisations, social issues can be trickier to quantify. Typically relying on qualitative as opposed to quantitative data, a robust process of engagement with upstream suppliers is needed to identify issues and challenges.

Longer term, social footprinting must form the cornerstone of an organisation's comprehensive sustainability assessment, particularly in light of growing pressures like resource depletion and climate change. At corporate level a number of respected standards exist, including the Global Reporting Initiative (GRI) and UN's Global Compact[73].

Significantly both have signed an agreement to align their work in advancing corporate responsibility and transparency. Either can be easily adopted as a social footprinting framework, irrespective of the size and scope of a business[74].

In an effort to enable product level social footprinting, New Earth, a not-for-profit sustainability organisation, has developed the Social Hotspots Database[75] (SHDB). The SHDB is an interactive online tool for mapping social risks in over 227 countries across 57 sectors. It uses data from a number of sources including the World Bank and International Labour Organisation.

Essentially it employs a Social Life Cycle Assessment (S-LCA) methodology based on global input and output modelling. This allows companies and users to assess the social and socio-economic impacts of a supply chain by country specific sectors, calculate labour intensity and derive a report on the share of worker hours at risk of social impact.

For businesses the value behind this tool is that it can be adopted to create a scaled down social life cycle assessment for its entire operation or specific product lines and demonstrate that it is taking its social responsibility seriously.

[72] CIPS (2014). The Walk free foundation research into Sustainable and ethical procurement. https://www.cips.org/Documents/Knowledge/Procurement-Topics-and-Skills/4-Sustainability-CSR-Ethics/Sustainable-and-Ethical-Procurement/tackling-modern-slavery-in-modern-supply-chains.pdf
[73] UN Global Compact (2016) 'Corporate Sustainability Initiative' https://www.unglobalcompact.org
[74] Global Reporting Initiative (2013). 'Sustainability Report 2012 / 2013'. https://www.globalreporting.org/resourcelibrary/2012-2013-Sustainability-Report.pdf
[75] Social Hotspots Database (2016). http://socialhotspot.org/

Other product social impact assessment have materialised. Prompted by a lack of consensus in how to assess social sustainability at a product level a coalition of industry experts, including furniture manufacturers, came together to form The Roundtable for Product Social Metrics[76].

The aim was to consolidate principles for product social sustainability assessment, harmonise approaches, and propose a practical method to assess the social impacts of products. The result of the working group collaboration is a freely available methodology[77] for social impact assessment at product level.

6.2 Product Social Impact Assessment

This methodology enables the evaluation of potential social impacts of a product or a service throughout its life cycle. The boundary of the assessment is set by the practitioner to include those parts of the value chain that are relevant for the assessment, as follows:

- Cradle to grave: includes the whole supply chain, from raw material extraction to manufacturing, retail, consumption, and end-of-life.
- Cradle to gate: includes part of the supply chain, from raw material extraction to a life cycle stage in the supply chain.
- Gate to gate: includes part of the supply chain, from direct suppliers to a life cycle stage in the supply chain.

Transportation impacts for social hotspot analysis are generally excluded in most of the case studies because they are relatively low compared to other life cycle stages. Transportation should be included in assessments where it plays a major role, therefore expert judgement is needed when considering an assessment. Ultimately each organisation will need to apply its own judgement as to the boundary of the assessment.

End-of-life, as a separate life cycle step, is not relevant for many products that are consumed such as food, or household chemicals where no dedicated end-of-life phase exists. In other sectors, for example furniture[78], the end-of-life phase contributes in a relevant way to the product's life cycle and where possible should be assessed. If end-of-life is included then the same procedure as used for the manufacturing phase can be applied since workers and local communities are active within it.

The assessment covers the impacts on three stakeholder groups; workers, consumers and local communities. These three groups include those who are directly impacted by the product, or live close to its production, use or disposal. The entire supply chain upstream and downstream activities are taken into consideration.

The first two groups are directly related to the product, as they include those who either use the product, or work within the supply chain, product manufacturing, or a role associated with treatment of the product at disposal. The final group, local communities, includes those who are directly impacted by the product because they live in the surroundings of any one of the life cycle stages.

[76] Roundtable for Product Social Metrics (2016) http://product-social-impact-assessment.com/roundtable-for-product-social-metrics/
[77] Product Social Impact Assessment (2014) http://product-social-impact-assessment.com/wp-content/uploads/2014/07/Handbook-for-Product-Social-Impact-Assessment-3.0.pdf
[78] Product Social Impact Assessment | Task Chair Component (2014) http://product-social-impact-assessment.com/pilot-task-chair-component/

6.2.1 Furniture Case Study

Several pilot studies were conducted prior to the publication of the assessment handbook, which included the furniture sector and assessment of a Steelcase task chair component made of DSM polyamide grade.

The methodology selected was a “scales-based” assessment, which involved the collection of quantitative and qualitative data, which are then aligned with a scale used in the assessment methodology.

The scope of the assessment was the life-cycle stages from materials production to use phase, with the following actors:
Materials production via direct and indirect suppliers
Component production: injection moulding at a Steelcase supplier
Assembly and completion of the final product: assembly of the task chair at Steelcase
Use: consumer

Some actors within the life cycle were deemed out of scope due to either a lack of available or commercially viable data collation. These include end-of-life, transportation, and some of the materials production steps.

6.2.2 Key findings

One of the key outcomes from the pilot study was that this type of product social impact assessment could be applied to most office furniture products. It was also highlighted that many of the industrial operations occur during the stages assessed, meaning that a number of stakeholder groups from workers and local communities are directly or indirectly involved.

Steelcase and DSM made a number of observations:

- Verifying data quality is challenging if reports are provided by suppliers, which in turn can limit confidence in the answers and resulting risk mitigation strategy.
- This pilot study looked at one component of an office chair, a completed office chair might contain up to 400 parts creating challenges in allocating the social impacts of the final product.
- The scope of the pilot made it difficult to assess the end-of-life stage.
- Product Social Impact Assessments can provide additional data that can be used for CSR communications, except that with this type of assessment there is a more important focus on specific products and/or specific life cycle stages (e.g. external production)

For future case studies the participants recommended:

- Creating a database with end-of-life principles and data.
- Suggested improvements might include requesting extra evidence that substantiates the answers, or performing audits.
- Data collection could be optimised if collected together with environmental data e.g. LCAs, certifications, CSR reports
- Assessments create new information that could be leveraged in marketing material, whether relating to improving customer experience or driving social improvements within the supply chain.

The need was apparent for further consultation amongst stakeholders to find a practical solution to the best way to allocate social impacts to the finished product.

6.3 Water footprinting

In order to assist organisations with identifying and calculating their water impact, the Water Footprint Network (WFN)[79] have developed a global standard for calculating a water footprint called the Global Water Footprint Standard.

The water footprint of an organisation is the total volume of freshwater used both directly and indirectly to produce and supply a company's products or services. The standard categorises a water footprint according to three components as shown in Table 4.

Table 4 - Types of water footprint

Type	Description
Blue Water	Water sourced from freshwater surface or ground resources and is either evaporated, incorporated into a product or abstracted and, subsequently, discharged into a separate watercourse. Industry, domestic and irrigated agriculture use can have a blue water footprint.
Green Water	Water from precipitation (rain and snow) that is stored in the root zone of soil and is used by plants. It is relevant to agricultural and forestry products such as timber and cotton.
Grey Water	Fresh water required to assimilate pollutants in order to meet specified water quality limits. This considers point-source pollution discharged to a freshwater resource either directly or indirectly.

Source: Water footprint network 2016

Standard water footprints can be created for the following:

- Production processes
- Consumer habits and patterns by nation, region or local area
- Products and services
- Businesses, sectors and organisations

In similar vein to carbon footprinting, water footprints are divided into different scopes; direct and indirect. The operational footprint is the water consumed or polluted directly by a company's operations, whilst the supply chain footprint covers indirect consumption and discharge in order to produce the products and services that will subsequently form the production inputs for a business (Table 5).

Once the scope of a water footprint assessment has been determined, data collection and analysis must be undertaken. Data can be obtained locally, or alternatively datasets are available from various sources including WaterStat[80].

[79] Water Footprint Network. 2016. http://waterfootprint.org/en/
[80] Mekonnen, M.M. and Hoekstra, A.Y. (2011). National water footprint accounts: the green, blue and grey water footprint of production and consumption. Value of Water Research Report Series No.50, UNESCO-IHE. http://waterfootprint.org/en/resources/water-footprint-statistics/

Table 5 - Direct and Indirect water footprints

<table>
<tr><th colspan="2">Operational Water Footprint</th><th colspan="2">Supply Chain Water Footprint</th></tr>
<tr><th>Direct Water Footprint</th><th>Overhead Water Footprint</th><th>Indirect Water Footprint</th><th>Overhead Water Footprint</th></tr>
<tr><td>Water incorporated into the product.</td><td rowspan="3">Water consumption or pollution related to water use in kitchens, toilets and cleaning.</td><td>Water footprint of raw materials purchased by the company.</td><td>Water footprint of infrastructure, including construction materials.</td></tr>
<tr><td>Water consumed or polluted through a washing process.</td><td rowspan="2">Water footprint of other parts and consumables purchased by the company.</td><td rowspan="2">Water footprint of materials and energy used by the business.</td></tr>
<tr><td>Water thermally polluted through cooling usage.</td></tr>
</table>

Source: Water Footprint Network

It is important that any data is aligned with the methodology stipulated in the Global Water Footprint Standard[81]. Information and trends identified by a water footprint assessment can be used to develop strategies to manage and mitigate water usage.

Previous sections introduced three other methodologies; price volatility, water and social. To complete the suite of tools in hotspot analysis it is important to consider a life cycle greenhouse gas approach.

Each of these approaches reference the four impact categories of economic, environmental, ethical and social sustainability and are used as components in hotspot analysis to identify the significant aspects at a product level.

6.4 Life Cycle Assessments (LCAs)

There are two main types of LCA. Attributional LCAs analyse and quantify the environmental impact of a product at a point in time (snapshot) and Consequential LCAs identify the environmental impact of a proposed change under study, which means that it is necessary to take into account implications of the change.

The procedures for performing a life cycle assessment are detailed in Environmental Management Standards ISO 14040:2006 Life cycle assessment / Principles[82] and Framework and in ISO 14044: 2006 Life cycle assessment / Requirements and guidelines[83].

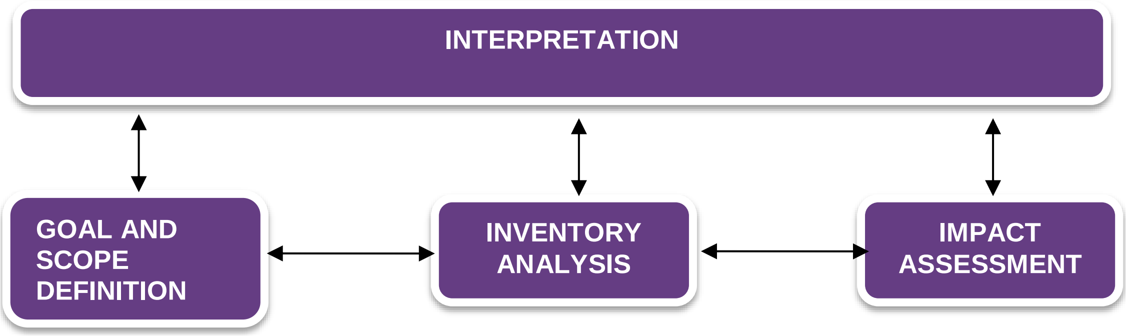
The life cycle greenhouse gas (GHG) emissions approach, which is a sum of all greenhouse gas emissions of the life cycle of a product and within the specified system boundaries of the product, can comply with specifications such as PAS 2050:2011[84] Specification for the assessment of the life cycle greenhouse gas emissions of goods and services.

[81] Water footprint network (2011) 'Water Footprint Assessment Manual - The Global Standard' http://waterfootprint.org/en/resources/publications/water-footprint-assessment-manual-global-standard/
[82] ISO (2016) 'ISO 14040:2006 Environmental Management Life cycle assessment / Principles and Framework.' http://www.iso.org/iso/catalogue_detail?csnumber=37456
[83] ISO (2016) 'ISO 14044:2006 Environmental management Life cycle assessment / Requirements and guidelines.' http://www.iso.org/iso/catalogue_detail?csnumber=38498
[84] BSi PAS 2050 (2011) 'Specification for the assessment of the life cycle greenhouse gas emissions of goods and services.' http://shop.bsigroup.com/upload/shop/download/pas/pas2050.pdf

6.5 Stages of a Life Cycle Assessment

A Life cycle assessment should be carried out in four distinct, yet interdependent stages. Figure 16 highlights the information flow and dependencies.

Figure 16 - Stages of life cycle assessment



6.5.1 Goal and Scope

The suite of ISO 14000 standards mentioned previously states that any LCA must start with a clearly defined goal and scope including technical details and a guide to the work involved. Technical details may include:

Units of Measurement - Quantification of what is being studied and provides a reference to enable products to be compared.
System Boundaries – The system boundary should be defined for each product under assessment. A system boundary should include all material life cycle processes and make clear any assumptions and limitations e.g. what is included and omitted in these processes.
Allocation Methods - Used to partition the environmental load of a process when several products or functions share the same process
Impact Categories – for example Human toxicity, global warming

6.5.2 Inventory Analysis

An inventory analysis for a product system would include the flow of inputs for water, energy and raw materials with release to air, land and water. This flow model would include activities that are going to be assessed in the product supply chain and within the technical system boundaries. Data for inputs and outputs are collected and related to the functional unit defined in the goal and scope definition.

6.5.3 Impact Assessment

Once data is obtained, environmental impacts are evaluated. Categories are selected from the data flows and models created for the products being assessed under LCA. Categorisation for a furniture product may include:

- raw materials (split into categories such as timber, board, plastics, textiles and metal);
- utilities;
- transport;
- waste management;
- packaging.

The impact of each of these categories can then be measured using the common functional unit and then collated to provide an overall impact. The collated data can be measured using multiple functional units specific to the aspects of the business, such as kilowatt hours for gas or electricity energy usage, water consumption in cubic metres and business mileage by employees in kilometres or litres of fuel consumed. This data must then be converted into the common functional unit of kilograms of carbon dioxide equivalent, kgCO2e, which has been released into the atmosphere as a result of these business processes.

6.5.4 Interpretation

Life cycle interpretation is used to identify, quantify and evaluate the results of the impact assessment and summarise the results with a set of conclusions and recommendations. The key point is to communicate the final results in a fair, complete and accurate manner.

6.6 PAS 2050:2011 as a life cycle assessment and analysis tool

There are a number of 'off the shelf' methodologies that define in more detail the four stages of life cycle assessment, provide guidelines and can be adopted to calculate a business' own LCA for use in hotspot analysis. PAS 2050:2011 is one such methodology and is a publicly available standard.

PAS 2050 was developed in response to an industry desire for a consistent method in understanding and assessing the life cycle GHG emissions of products. The primary objective is to provide a common basis for GHG quantification and drive a GHG emission reduction programme.

PAS 2050 is focussed on a single environmental issue, GHG emissions and their contribution to climate change. It does not assess the social, water and price volatility environmental impacts of the other hotspot methodologies. Climate change is a major issue for governments, manufacturers and individuals. A number of GHG impact negatively on the environment, the most significant of these is carbon dioxide.

The calculation of a carbon footprint not only includes emissions of carbon dioxide but also methane, nitrous oxide and families of gases including hydrofluorocarbons and perfluorocarbons. The contribution of these other gases is calculated as a carbon dioxide equivalent (CO2e). This means that all footprint data is represented in terms of mass (normally Kg) of carbon dioxide.

PAS 2050 also provides a simple and easily understood approach to assessing and allocating CO2e to end-of-life. GHG emissions are allocated to the product system that gave rise to the waste, this includes combustion that does not lead to energy recovery, such as methane flaring from landfill sites and waste combustion where energy recovery is present.

PAS 2050 also makes provision for recycled materials and recycling activities and for the treatment of emissions associated with reuse. In the case of where a product is reused the GHG emissions per instance of reuse is assessed on the basis of;

$$\frac{(A + F) + (C + D + E)}{B} = \text{GHG emissions}$$

Where:

a.) is the total life cycle GHG emissions of the product, excluding use-phase emissions;
b.) is the anticipated number of reuse instances for a given product;
c.) is emissions arising from an instance of refurbishment of the product to make it suitable for reuse;
d.) is emissions arising from the use phase;
e.) is emissions arising from transport returning the product for reuse;
f.) is emissions arising from disposal.

The specification acknowledges that this is a simplified treatment of reuse and more sophisticated modelling should be used where data is available to take account of changing demand patterns and system losses.

6.6.1 Implications for circular economy

Whilst maintaining the relatively simplistic approach PAS refers to, there is the potential to demonstrate the environmental benefits of reuse cycles for a given product. This methodology was applied to the Remanufacturing for the Circular Economy project as shown in table 6.

Table 6 - Environmental benefits of remanufacturing vs new product[85]

	New	Remanufactured	Difference
Kg CO2e	52.567	20.126	-61.7%
Recycled Content (% by Weight)	49%	78%	-29%
Recyclability (%by Weight)	98%	98%	0%
Company Footprint	6.844kg CO2e	6.844kg CO2e	0%
Foams and Fillings	6.681	5.826	-12.8%
Textiles	0.821	0.821	0
Metal	21.159	2.083	-90%
Plastic	16.613	4.277	-74.26%
Packaging	0.076	0.076	0
Others	2.706	2.704	-0.07%
Transport	2.008	1.836	-8.57%
Utilities	2.503	2.503	0

Applying a simple calculation for the aggregated carbon footprints of the new and remanufactured products divided by the number of product reuse cycles will lower the average footprint per life cycle of the product. In effect this means that the more reuses of the product that are possible, assuming that the process for refurbishing is low carbon and that not many new materials are needed, the lower the footprint per life cycle for the product will be.

[85] FIRA (2016) 'Remanufacturing for the Circular Economy' https://www.fira.co.uk/news/article/research-report-remanufacturing-for-the-circular-economy

Using the example from the FIRA project we can see that the footprint of the product would reduce as below;

- 1st Product lifecycle 52.567 kg CO2e
- 2nd Product lifecycle 36.347 kg CO2e
- 3rd Product lifecycle 30.939 kg CO2e
- 4th Product lifecycle 28.236 kg CO2e

6.7 Furniture footprinting - using furniturefootprinterTM

One method used to calculate carbon footprints for products and organisations within the furniture industry is the[86] furniturefootprinterTM, which defines procedures that ensure consistency of approach in the assessment of carbon footprints. The software package is specifically designed for the furniture industry, provides accurate secondary data and simplifies the process of carbon footprint calculation.

6.7.1 Methodology for furniture footprinting

The accurate calculation of a carbon footprint requires a systematic approach plus a consistent system boundary and scope of coverage. The Furniture Industry Research Association's methodology is based on the business to business approach prescribed in PAS 2050: 2011. In effect this captures raw material and components plus their delivery to the organisation being assessed within this scheme and subsequent processing and packaging. This is a "cradle to gate" assessment[87].

The physical boundary for the companies assessed using this methodology are defined as the site where the item was manufactured. Therefore some aspects traditionally included in Cradle to Gate assessment such as emissions from the transport of products to the first customer' site, all activities once the product has arrived at the first customer, that is additional manufacturing steps, final product distribution are omitted.

Units of analysis

The term carbon is taken to mean carbon dioxide equivalent (CO2e). Outputs are reported in kgCO2e, or the amount of carbon dioxide equivalent in kilograms attributable to a final product.

Boundaries

Many assessments use Cradle to Gate boundaries which include all carbon impacts from resource extraction of raw materials ('cradle') to the point before a product is transported to the next customer ('gate'). The use and disposal phases of the product's lifecycle are omitted in this case.

Within the discipline of carbon footprinting there are other boundaries that need to be defined. There are two types of emissions that should be considered when calculating carbon footprints, direct and indirect GHG emissions. Direct GHG emissions are from sources that are owned or controlled by the company. Indirect GHG emissions on the other hand are the consequences of the activities of the company but occur at sources owned or controlled by another company.

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[86] Furniture Footprinter Available at: https://footprintreporter.com/fira/
[87] FIRA (2011) 'Benchmarking the carbon footprint of furniture products.' https://www.fira.co.uk/images/news/fira-carbon-footprinting-document-2011.pdf

To help further define direct and indirect emission sources, improve transparency, and provide utility for different types of organizations, three scopes (scope 1, scope 2, and scope 3) are defined for GHG accounting and reporting purposes[88].

Scope 1 direct GHG emissions occur from sources that are owned or controlled by the company, for example, emissions from combustion in owned or controlled boilers, furnaces, vehicles; emissions from chemical production in owned or controlled process equipment.

Scope 2 accounts for GHG emissions from the generation of purchased electricity consumed by the company. Scope 2 emissions physically occur at the facility where electricity is generated.

Scope 3 emissions are a consequence of the activities of the company, but occur from sources not owned or controlled by the company. Examples of such activities are extraction and production of purchased materials; transportation of purchased fuels; and use of sold products and services.

6.7.2 Allocation

There are two main considerations when allocating carbon footprinting data; those attributable to the organisational footprint of a company and those attributable to the footprint of individual products. A total footprint comprises the organisational footprint of a company plus the footprint attributable to its products.

The carbon footprint of a product is calculated by producing an organisational carbon footprint utilising scope 1 and 2 emissions and adding product materials procurement and processes to this total. Product specific elements are the materials used in the production of the furniture item and, where applicable the production processes and finishes.

The company data was compiled from one year’s utilities figures and one year’s business travel. This collated footprint data was then attributed to individual products by dividing the total CO2e by the number of products manufactured by the company in that year, regardless of the type of product manufactured.

Whilst this a deviation from PAS 2050, it allows the company and utility usage to be allocated to a product by a simple calculation, rather than expensive research and monitoring.

6.7.3 Inventory Analysis

The following bullet points detail the emissions flows included and excluded from the scheme.

The emissions included in the assessment:

- raw materials and components entering the premises
- transport of raw materials and components from the manufacturer to the premises
- all office materials (stationary) and equipment (computers, printers)
- energy usage (e.g. fuel, electricity)
- manufacturing processes onsite
- manufacturing service provision including consumables
- outsourced activities

[88]FIRA (2011) ‘Benchmarking the carbon footprint of furniture products.’ https://www.fira.co.uk/images/news/fira-carbon-footprinting-document-2011.pdf

- business &administration support activities; sales, operation of the premises, cars and travel
- packaging materials, both temporary and permanent
- storage of a product on site / or an associated facility including transport
- processes used in the disposal of waste generated during the production of a product including transport of the waste from its point of post-sale use to the point of disposal or recycling
- internal processes required to recycle a product to a state where it is an input to another process

Emissions excluded are:

- delivery / transport to the first customer
- all activities once the product has arrived at the first customer such as additional manufacturing steps, final product distribution, retail, consumer use and disposal/recycling
- manufacture and ongoing maintenance (consumables to be included) of capital goods, such as plant machinery, transport equipment, electricity generating plant, office furniture for internal use
- the building and maintenance of premises
- staff travelling to and from their place of work
- immaterial emissions (individual elements contributing less than 1% of a footprint provided that these elements, when combined, do not contribute 5% or more towards the total footprint)

6.8 Examples of Impact Assessments

This section provides examples of impact assessment for different types of furniture products. The data sets are collated from multiple organisations, all with different company footprints. Company footprints and product footprints are totalled and averaged to provide an indicative footprint for furniture products from UK furniture manufacturers.

The grouped products selected are similar in terms of their design, functionality and components. The purpose of this is to highlight where in the supply chain types of products most severely impact on the environment.

6.8.1 Product Selection

The product groups selected illustrate impact assessments across different sectors of the furniture industry.

Table 7 - Life cycle assessment products

Furniture Sector	Product	Description
Office	24hr Office Chair	Office chair designed for continuous use by one adult to sitting at a workstation.
Office	Office Desk	1600 x 800 rectangular desk
Kitchen	Wall Unit	1000mm kitchen wall unit
Bedroom	Mattress (double)	Double mattress
Upholstery	Sofa	Fabric covering

The footprint data used in the lifecycle assessment of the listed products is taken from research data in the Furniture Industry Research Association report benchmarking carbon footprints of furniture products[89] and the results are presented in Appendix A. Each product group has an impact assessment with the data set listed and an average carbon footprint calculated. An interpretation of the results for each product group is accompanied by comments as to where the carbon footprint of the product offers opportunity for improvement.

89 Fira 2016 'Benchmarking carbon footprints of furniture products'. Available at: https://www.fira.co.uk/images/news/fira-carbon-footprinting-document-2011.pdf

7. Conclusion

The research paper on hotspot analysis and life cycle assessment was introduced as one element of FIRA's Circular Economy project and an industry response to waste and over consumption of finite resources.

The discourse within this paper recognises that for many organisations adopting sustainability hotspot analysis represents a significant challenge to existing orthodoxy. Many furniture manufacturers have no quantifiable measures of the environmental impacts of their direct and indirect resource consumption, material inefficiency, and waste generated within their supply chain.

The research goes further, highlighting that it is necessary for retailers and manufacturers with complex and often global supply chains and customers to adopt a more risk based approach to the supply of raw materials, components and products. Understanding where potential resource, water and social hotspots exist can help to minimise operational and reputational business risks and influence business decision making and strategy.

Corporate social responsibility reporting legislation, green procurement policies and increasingly sustainable corporate procurement criteria is also driving companies to re-evaluate their supply chains in order to meet legal and customer requirements and to mitigate reputational damage to their brand by avoiding exposure to poor social practices within their supply chain.

Companies that embrace sustainability encompass these considerations in their assessment of suppliers, which in turn has profound effects on all stakeholders operating within that supply chain. Increasingly retailers and corporate procurement are seeking to manage their supply chain due diligence by ensuring that their suppliers are carrying out due diligence using the same criteria and process. Suppliers who embrace this approach within their own business can quickly gain a competitive advantage.

Whilst there are limitations to all of the methodologies discussed in this paper there are also clear benefits. Life cycle analysis of products helps organisations understand the environmental impact of the products that they manufacture or sell, and the environmental hotspots that exists via the materials selected for use in the manufacturing process.

There are clear opportunities to utilise hotspot analysis, LCA and single or dual metric footprint analysis to expose products that currently lend themselves to circular economy activities or are particularly vulnerable to hotspots. Models that keep raw materials and components in use for longer reduce the need to purchase new inputs and therefore reduce environmental impact of products.

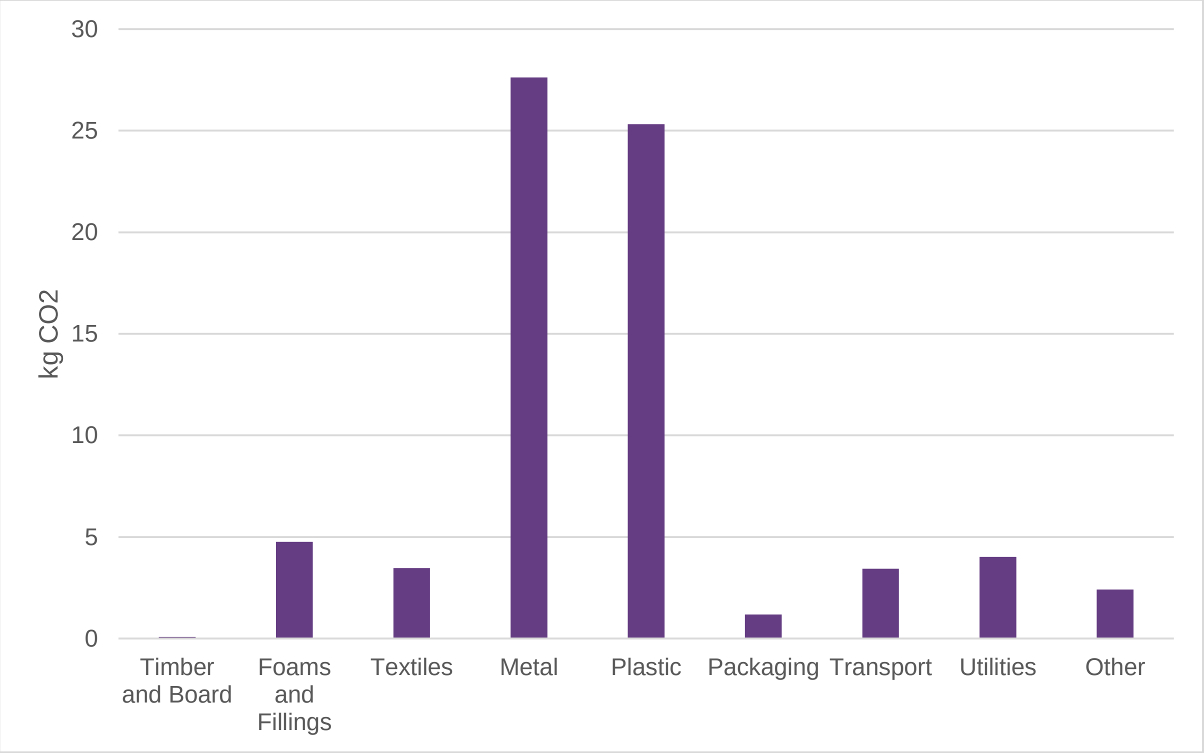
Results from hotspot and lifecycle analysis provide a clear incentive for companies to select materials that are robust and lend themselves to reuse to mitigate material risks and environmental impacts. For designers the incentive is to make things last longer, by modifying the design of products so that it makes refurbishment easy and demonstrates that identified hotspots have been eradicated or minimised.

Finally the ability to demonstrate that a company can lower the CO2e for a given product, by ensuring that it has multiple "life cycles" will lead to increased circularity of that product. The example from the remanufacturing for the circular economy project demonstrates the dramatic reduction in carbon footprint of a product as it is taken through multiple product lifecycles.

Appendix A

Impact Assessment - 24hr Office Chair

Data Set - 13 chairs from 6 different companies
Average footprint – 73 Kg CO2e



Interpretation of Results

The over-riding contributors to the final product footprint are the carbon embodied within just two materials; metal and plastic. These two materials account for approximately 70% of the total footprint of a task chair.

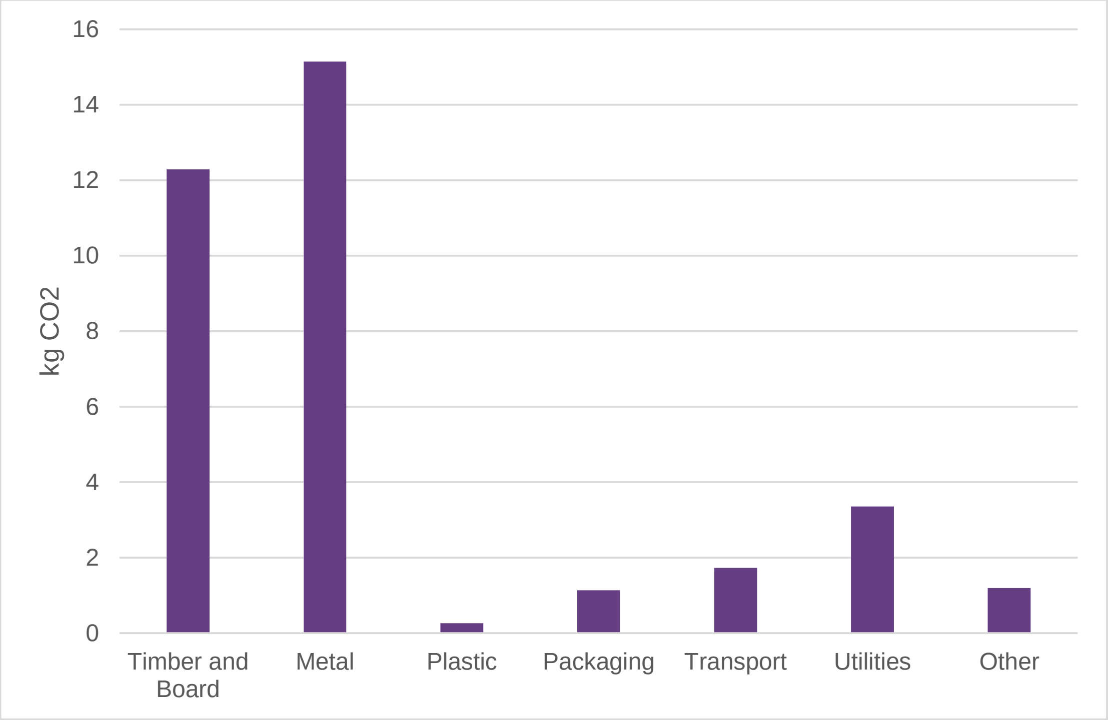
Many chairs, especially those assembled from a kit of parts have a predominantly plastic construction, with minimal metal content restricted to the gas lift cylinder and seat reclining mechanism. However, more design-led products often use metal components as a style feature, particularly in the base of the product.

Conclusion

Significant carbon footprint reductions can be achieved by minimising metal content, followed by plastic and then other materials.

Impact Assessment – Office Desk 1600 x 800

Data Set - 8 desks from 6 different companies
Average footprint – 35 Kg Co2
Categorisation Graph



Interpretation of Results

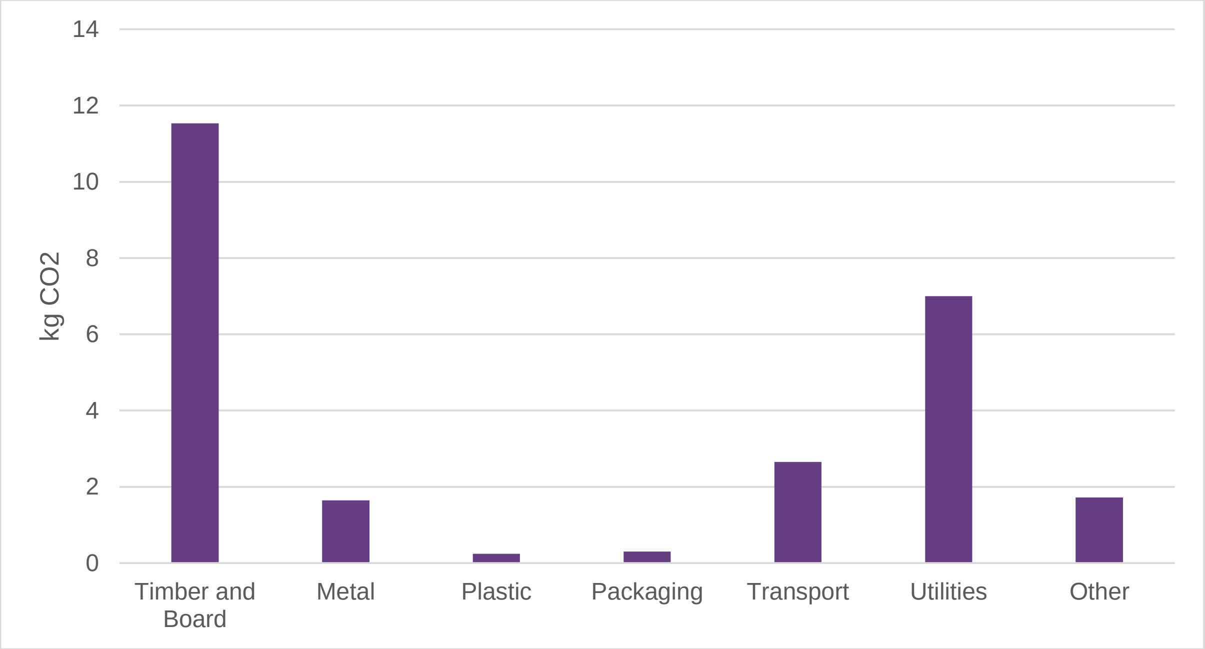
Results show that the two largest contributors to the product's final footprint are timber / board and metal. Desk design is generic across the range of products examined. An MFC board top with plastic edging and a metal powder coated framework assembly for the legs.

Conclusion

Significant carbon footprint reductions can be achieved by minimising metal content, followed by plastic and then other materials. However this might involve challenging the generic design of common desking in the marketplace.

Impact Assessment – Kitchen 1000mm wall unit

Data Set - 5 wall units from 4 different companies
Average footprint – 25 Kg Co2
Categorisation Graph



Interpretation of Results

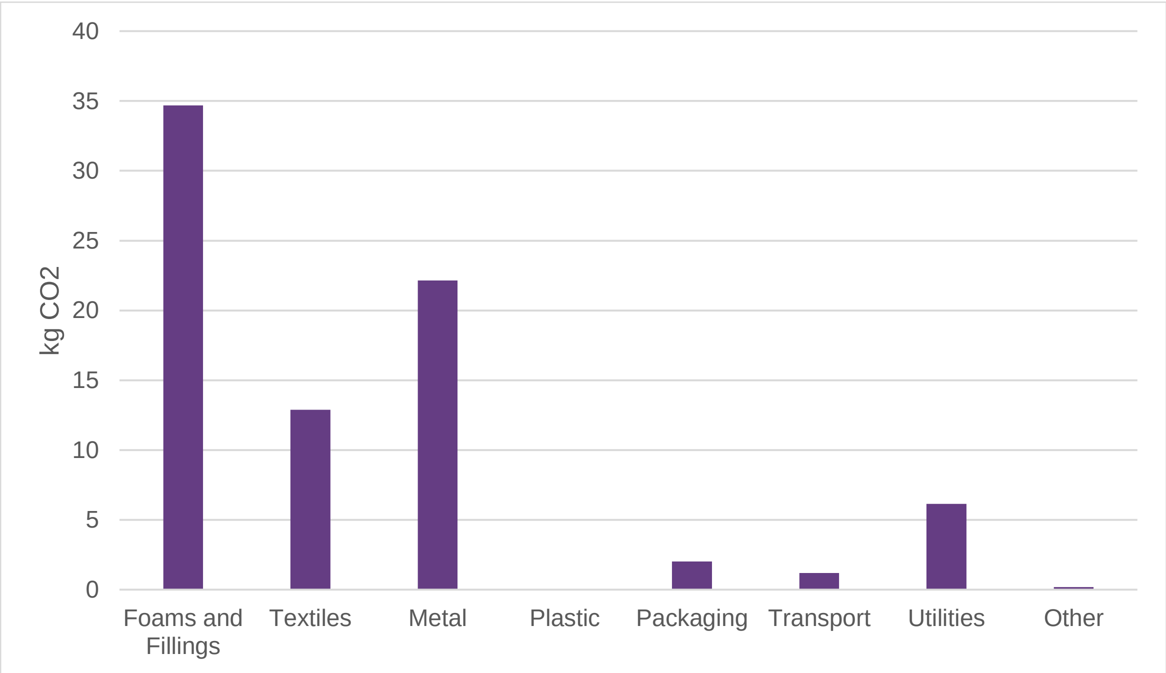
The largest carbon impact being the raw material content, primarily the timber and board which is used in the product. The second highest carbon contributor is the onsite company utilities usage, which also contributes to the organisational footprint.

Conclusion

The data indicates that manufacturers and designers looking to reduce the embedded carbon within their product should look to minimise the amount of board materials within their products. There was a significant impact of utilities in the energy used in the manufacture of the product. There is therefore a potential opportunity for some manufacturers to implement energy efficiency measures to reduce the total carbon footprint of their products.

Impact Assessment – Mattress Double

Data Set - 19 mattresses from 4 different companies
Average footprint – 80 Kg Co2
Categorisation Graph



Interpretation of Results

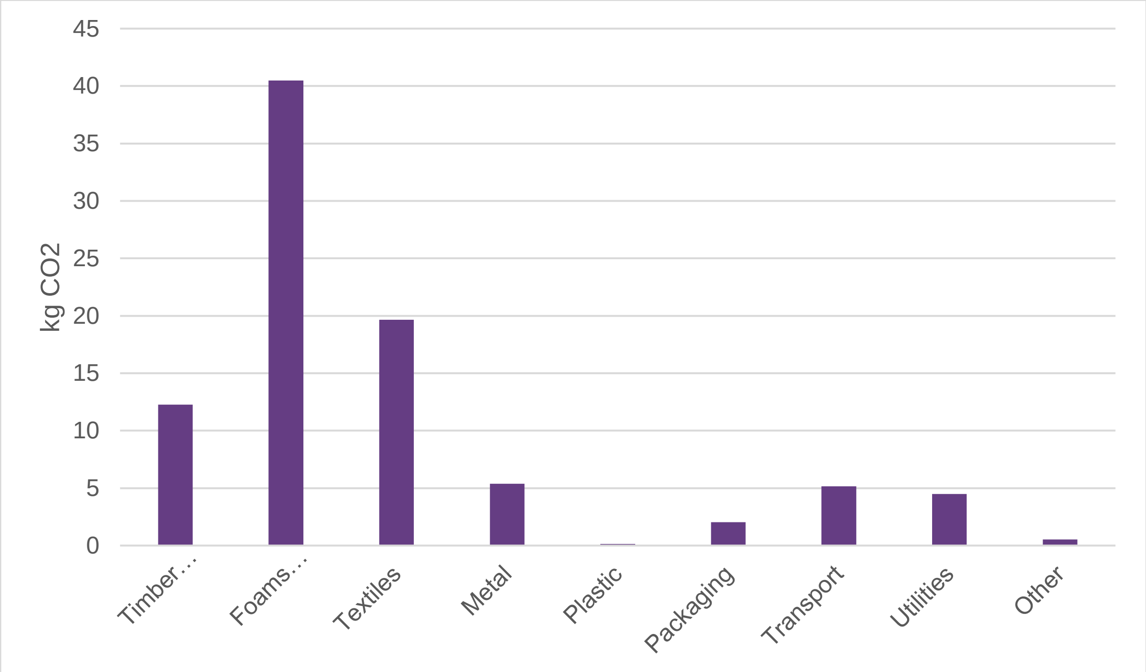
For mattresses, the carbon impact of raw materials which are the materials used in foams and fillings, textiles and metals has the biggest impact. Mattresses come in a number of designs including sprung, pocket sprung and foam. In addition, price points are determined by thickness and comfort which also relates to the volume of materials in a product. The design of products has a significant effect on carbon footprints.

Conclusion

The design of products has a significant effect on carbon footprints. For example, the carbon footprint of a double mattress depended mostly on the amount and type of foam or filling used and the number of springs contained within the mattress.

Impact Assessment – Sofa

Data Set - 11 sofas from 4 different companies
Average footprint – 91 Kg Co2
Categorisation Graph



Interpretation of Results

The largest contributor to total carbon footprint is material content, in particular foams and fillings. Other emissions categories of importance are the fabric content and frame material, which in the majority of cases is wood.

Conclusion

Significant reductions in the carbon footprint of a sofa can be achieved by minimising the amount of fillings used, or by switching to fillings with the least carbon impact. The carbon footprint of polyurethane foam is estimated to be approximately 20% lower than that of visco-elastic foam.