Laura Seppälä

SUSTAINABLE RESPONSIBLE OUTDOOR CLOTHING

What every designer should know

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What every designer should know

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Summary

Climate change and environmental problems also affect the outdoor clothing industry and sustainable, responsible design is becoming more important. The purpose of this thesis was to draw conclusions on what the outdoor clothing industry can do for sustainability and what aspects should be taken into consideration in the design and manufacture of environmentally friendly outdoor clothing. The aim of my study was to ascertain what designers should know about environmentally friendly design to be able to make sustainable responsible apparel. The study is qualitative in nature. There are several stakeholders on different levels, which affect sustainable development in the outdoor clothing industry. It is very important for designers to know these stakeholders and their actions to understand the challenges of green production. The information was collected using triangulation technique. I have used methods of ethnographic target group observation and group interviewing. The data was collected from textile manufacturers' and outdoor companies' commercial material such as brochures and internet pages. The study investigated what outdoor companies have done for sustainable responsible design and environmentally friendly manufacturing and how it shows in their public advertisements between 2007 and 2009. The atmosphere changed and actions increased enormously in these two years. According to my study the amount of materials advertised to be environmentally sound has increased, but it is very difficult for end-users and even designers to evaluate their environmental impact. Good design, quality materials and the possibility to repair outdoor clothing will increase the life cycle of outdoor apparel. End-users in the mountaineering and kite snowboarding target groups are becoming more environmentally aware, but the clothing features they appreciate most are functionality and safety. The outcome of this research was that lifestyle outdoor brands cannot survive in the business without acknowledging environmentally friendly practices, and end-users' environmental awareness is increasing. It can be concluded that outdoor industry has awakened to take responsibility and started to work for sustainable development.

Keywords: sustainable responsible design, ecological design, outdoor brands, outdoor clothing

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ABBREVIATIONS

COP	The Conference of the Parties
CSR	Corporate Social Responsibility
CTS	Consumer Testing Services
EoL	The End of Life Options
EOG	The European Outdoor Group
EWG	The Eco Working Group
FLO	Fairtrade Labelling Organizations International
GEMS	The Global Environment Monitoring System
IPPC	The Intergovernmental Panel on Climate Change
ISO	The International Organization for Standardization
LCA	Life Cycle Assessment / Life cycle analysis
LOHAS	Lifestyles of Health and Sustainability
MOP	Meeting of the Parties of the Protocol
OIA	The Outdoor Industry Association
PTFE	Polytetrafluoroethylene
REACH	Registration, Evaluation and Authorization of Chemicals (The EU law)
SRD	Sustainable responsible design
SUMAC	Sustainable Innovative Materials in High Tech Applications research project
UNEP	The United Nations Environment program
WCED	United Nations World Commission on Environment and Development
WCP	The World Climate Programme
WWF	World Wildlife Fund

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INTRODUCTION

Figure 1. Valais. (Seppälä 2009.; Photograph by Joe Nunn.)

1 INTRODUCTION

There is no longer any doubt that climate change and environmental problems will be one of the biggest challenges that humankind has ever faced. Climate change will no longer be fixed by user civil activism and ethical actions. The world cannot be saved as side job. Climate change is happening faster and its extent is wider than the world's leading scientists predicted. This state is a serious worldwide, catastrophe situation and everyone should concentrate on preventing it. At the moment we are stripping nature at an unprecedented rate and we need to take much better care of the planet, because we have no other realistic choices. There is no other planet to which we could escape (Fig. 2.). According to the World Wildlife Fund (WWF) and the Global Footprint Network's Living Planet Report 2006, we will need two planets' worth of natural resources every year by 2050 if the current trend continues.[1]

Figure 2. *The Prime Minister asks the scientist if we could move to some planet nearby. In real world we should be able to manage with one planet. (Craabaek 2008.)*

The Outdoor industry makes its living selling equipment and apparel to those who want to enjoy the beauty of nature. Outdoor companies acknowledge that the wild world on which they are basing their business is disappearing. There has been a marked growth in the development of highly functional materials in sportswear and outdoor leisure clothing. The outdoor industry has experienced exceptional growth.[2] End-user groups of outdoor clothing are expanding. There are, of course, outdoor enthusiasts who devote all their free time being outdoors. Also, there is a growing target group of people who wear functional, outdoor clothing in the city because wind and waterproof apparel is handy in changing weather conditions even in urban environments. There is no industry that is totally harmless and

[1] Välimäki 2007; World Wildlife Fund 2006; See also Toiviainen 2007.

[2] Shishoo 2005, 4.; European Outdoor Group 2009.

hopefully we are intelligent enough to realize that everything we do impacts something.[3] There is no sustainability without credibility and all industry actions should be transparent. This also concerns the outdoor industry and especially outdoor industry. I think that Markus Huber puts it well: *"If consumers cannot trust the outdoor industry what other business can they trust?"*[4]

1.1 The aim and focus of the thesis

My pro gradu thesis deals with sustainability in the outdoor clothing industry in general and ecological design of functional outdoor clothing. The thesis examines sustainable responsible design and ecological issues in the outdoor clothing field. It studies environmentally friendly design and manufacturing currently made in the outdoor clothing industry. The aim of my study is to ascertain what the outdoor clothing industry can do for sustainability and what aspects should be taken into consideration when designing and manufacturing environmentally friendly outdoor clothing (Fig. 3.). What should a designer know about environmentally friendly design to be able to make sustainable responsible apparel?

There are several stakeholders on different levels which affect sustainable development in the outdoor industry. It is very important for a designer to know these stakeholders and their actions to understand the challenges of green production. I will study some associations and organizations, as well as the outdoor companies and fabric suppliers, which have made ecological choices in the functional outdoor clothing field. I also want to survey new innovations to achieve environmentally healthy design in the industrial outdoor clothing business.

My end-user study for the Sumac Research Project, looks at end-users' opinions and experiences of functional outdoor clothing which can be exploited when designing environmentally friendly outdoor clothing. The sustainable design aspect was fairly new in outdoor clothing industry in 2007 when I started my thesis, and it makes my topic very important at the moment. I believe that much will happen in area of life-cycle thinking and environmentally sound manufacturing in the functional clothing business in the next few years. The legislation will be stricter and companies will get more involved in working towards more environmentally friendly business practices.

[3] howies Ltd. 2009.

[4] Huber 2008, 3.

Figure 3. The mind map of my study. (Seppälä 2009.; Photograph by Laura Seppälä.)

1.2 Collecting research material, research questions and methods

My research perspective is the designer's point of view. Designers are often among the key people with product managers in the companies to make sustainable responsible decisions when making designs. They make fabric and accessory choices with product managers and material purchasers. My aim is to find out what aspects should be considered to be able to make sustainable responsible design as an outdoor clothing designer. I want to comprehend about sustainability in the outdoor industry, sustainable responsible manufacturing and green design in functional clothing. I research the problem by searching for studies, and studying manufacturers' and fabric suppliers' public information such as brochures and web pages.

I also study what outdoor companies have done for sustainable responsible design and environmentally friendly manufacturing and how it shows in their public advertisements. I saw how attitudes and atmosphere changed in the course of doing my master thesis and what happened in outdoor clothing companies' actions between years 2007 and 2009 according to their promotional material. I chose kite snowboarding and winter climbing as my genre because of their challenging atmosphere and prominent user position. My hypothesis is that lead users take better care of their equipment, because they are enthusiasts and also because sometimes their life depends on correctly working equipment.

My study is qualitative. Triangulation means that several methods are used to collect data. I use group interviewing, target group observation and collect data from outdoor companies' brochures and Internet pages. I use multiple strategy methods for analyzing the data. This means that the same research phenomenon is viewed from different angles. Multiple strategies also means multiple theoretical models or separately collected data are studied at the same time.

Ethnography means surveying culture from inside. Traditionally it is a method used when researching aboriginal people. Researchers have gone to the aboriginals' places of residence and observed them. The same method can be used in the research of any group. An ethnographer can also survey what a certain phenomenon means to this specific target group.[5] A researcher collects several types of data while observing target group, such as video films, photographs and researcher's own notes.[6] My own research is ethnographic, because it

[5] Anttila 1996, 305.

[6] Anttila 2005, 345.

surveys pro amateur culture of kite snowboarders and climbers and how important they perceive environmental values in their apparel and what they think about sustainable responsible design in outdoor clothing. Certain hobby groups also have their own hierarchies. Depending on their skills, some people may have more authority in a group, which can also effect equipment and garment choices. A researcher also has to be aware of the Hawthorn-effect, which means that a target group may behave differently, because they are aware of the attention shown towards them.

According to Anttila, sufficiently profound knowledge about the phenomenon to be researched needs documentary data. Documentary data can be any kind of data which can be documented and is written about the research phenomenon. The documentary data I use in this thesis are the existing scientific literature, clothing companies' brochures, catalogs, newsletters and magazines. It is essential to be critical towards document data.[7]

1.3 My personal motives

My personal interest in the clothing field is in functional outdoor clothing. I did my bachelor's degree in HAMK University of Applied Sciences and so far in my studies I have concentrated on knitwear and technical clothing, mainly in the sports and outdoor field. In my pro gradu thesis I want to concentrate on sustainable solutions in technical outerwear. My aim is to work in the technical outdoor clothing industry in the future and I would like to be involved in making new innovations for a healthier environment. I may say that I picked my subject for two reasons. First of all the topic is extremely environmentally important at the moment and secondly my own professional conscience encouraged me to make this choice of subject. It feels contradictory that clothing made for enjoying nature can actually harm it. I have started to feel a personal responsibility for the state of nature and I would like to be involved in saving what is still left.

I had already chosen the subject for my master's thesis, when I read Pasi Toiviainen's book about climate change and he caused my final environmentally awakening. His and Viktor Papanek's ideas convinced me that I have to do my part in my own field and profession. The outdoor apparel industry is in many ways involved in protecting the outdoors, which are disappearing. I feel that it would be an ideal professional career idea for me to combine outdoors, outdoor sports, technical clothing and protecting the environment.

[7] Anttila 1996, 277-280

1.4 Sumac research project

The end-user data of my master's thesis was collected for the Sustainable Innovative Materials in High Tech Applications (Sumac) research project. The research establishes a conceptual framework offered by the theoretical bases of the design research, ergonomics and material technology for sustainable goods and services relative to their environmental impacts. The empirical research subject is focused on sustainable and safe products, product chains and life styles in the frame of outdoor sport and leisure time activities. The objectives of the research project are challenging the traditional sustainable products and production and building scenarios and concepts for eco-innovations; creating sophisticated tools and strategies for environmentally and ethically sound research and design. The consortium also includes sustainable and ergonomic product chains and the emergence of environmentally and ethical sound sports brands. These fields are being researched in three parallel subprojects.

This research project is going to be made by the University of Lapland, the University of Kuopio and Tampere University of Technology. The research project lasts four years from 2007 to 2010. Hanna Söder from Department of Textile does her own pro gradu thesis also in Sumac research project. We co-operate together in the project to create sustainable responsible outdoor clothing concept for outdoor sports related to mountain areas.

1.5 The process of my study

The whole process of my master's thesis took two and half years (Fig. 4.). It was a very significant time period in sustainability in outdoor clothing. A lot has happened in two and a half years and I believe that progress will be even faster from now on.

I started my final thesis and joined the Sumac Research Project in the Fall 2007. At that time I set my research goals, read the literature and collected data for my study. In December 2008, I studied companies' web pages on the Internet for the first time. In January 2007, I took part in holding a Smart Clothes and Wearable Technology course in Wales invited by Jane McCann and Marion Elwanger. They both gave me really good ideas for my study. I met and interviewed Mike Timmins in Bristol, who was really helpful and explained to me principles of textile recycling.

At the end of January 2008, I took part in the Volvo Eco Design conference in Munich and Ispo Trade Show. The EcoDesign Forum in Ispo 2008, was dedicated to the topic of sustainability in the field of industry and sports design. Volvo has hosted the Sports Design

Sustainability" was formed from Bauhaus movement motto, "Form follows Function". I think that the forum was a big step for the industry to go in a more sustainable direction. At the Ispo Trade Show, I talked with garment supplier representatives. Anders Wennergren, from Trendence Production AB, and Eugene Lee, from Raco Textile Corporation, gave me very valuable information. In February 2008, I interviewed kite snowboarders. In March 2008, I climbed on Ben Nevis, Scotland to get an idea of climbing in real conditions and I did my end-user study and interview. In spring 2009, I discussed with Halti's hardwear designer Juha Kosonen about sustainability from the designer's point of view. In summer and fall 2009, I collected my comparative data about outdoor companies, analyzed it and wrote my final thesis. At the end of January 2010, I submitted my thesis.

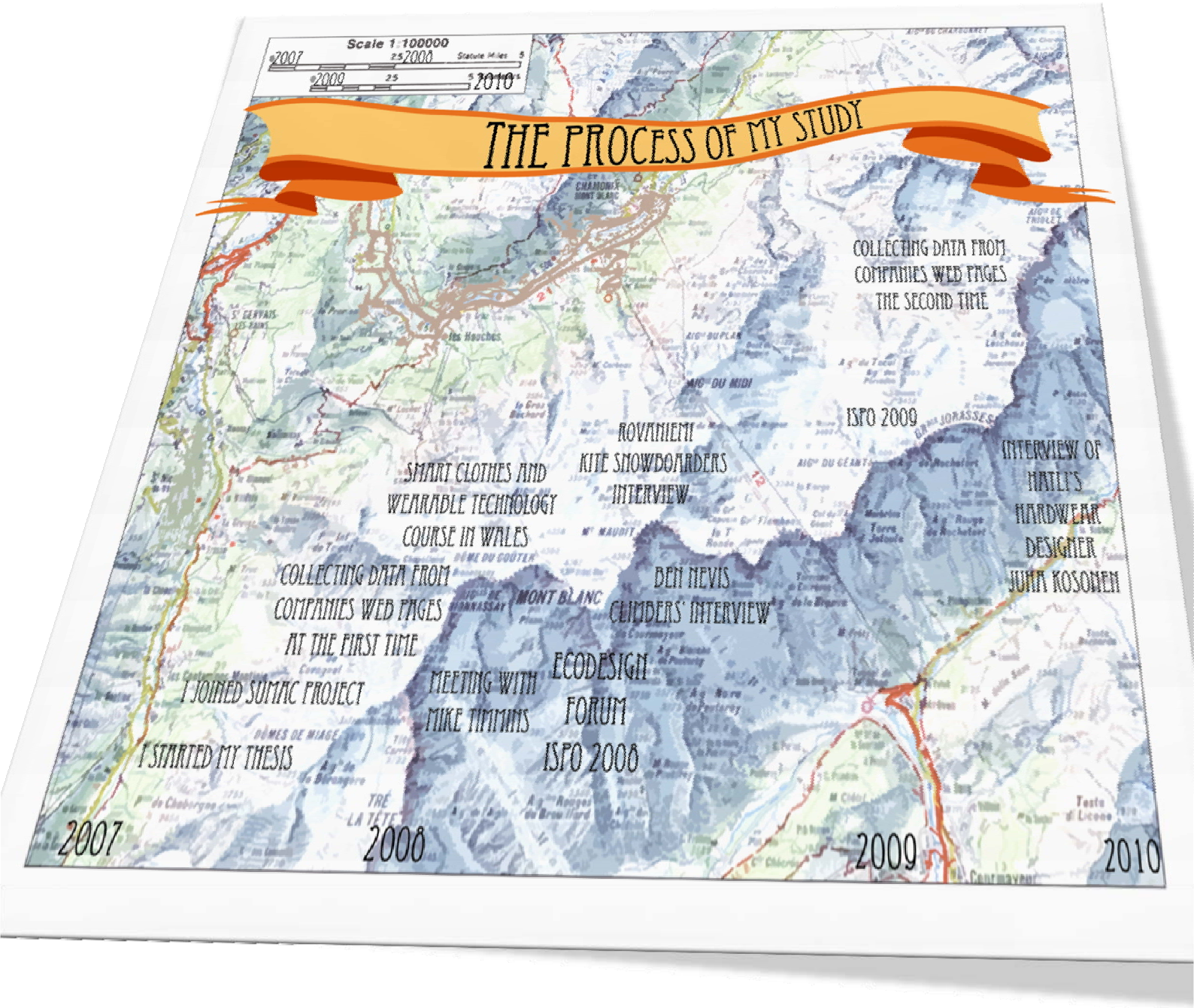


Figure 4. *The process of my study. I started in September 2007 and submitted my pro gradu thesis in January 2010. (Seppälä 2010.)*

BACKGROUND AND THEORY OF SUSTAINABILITY

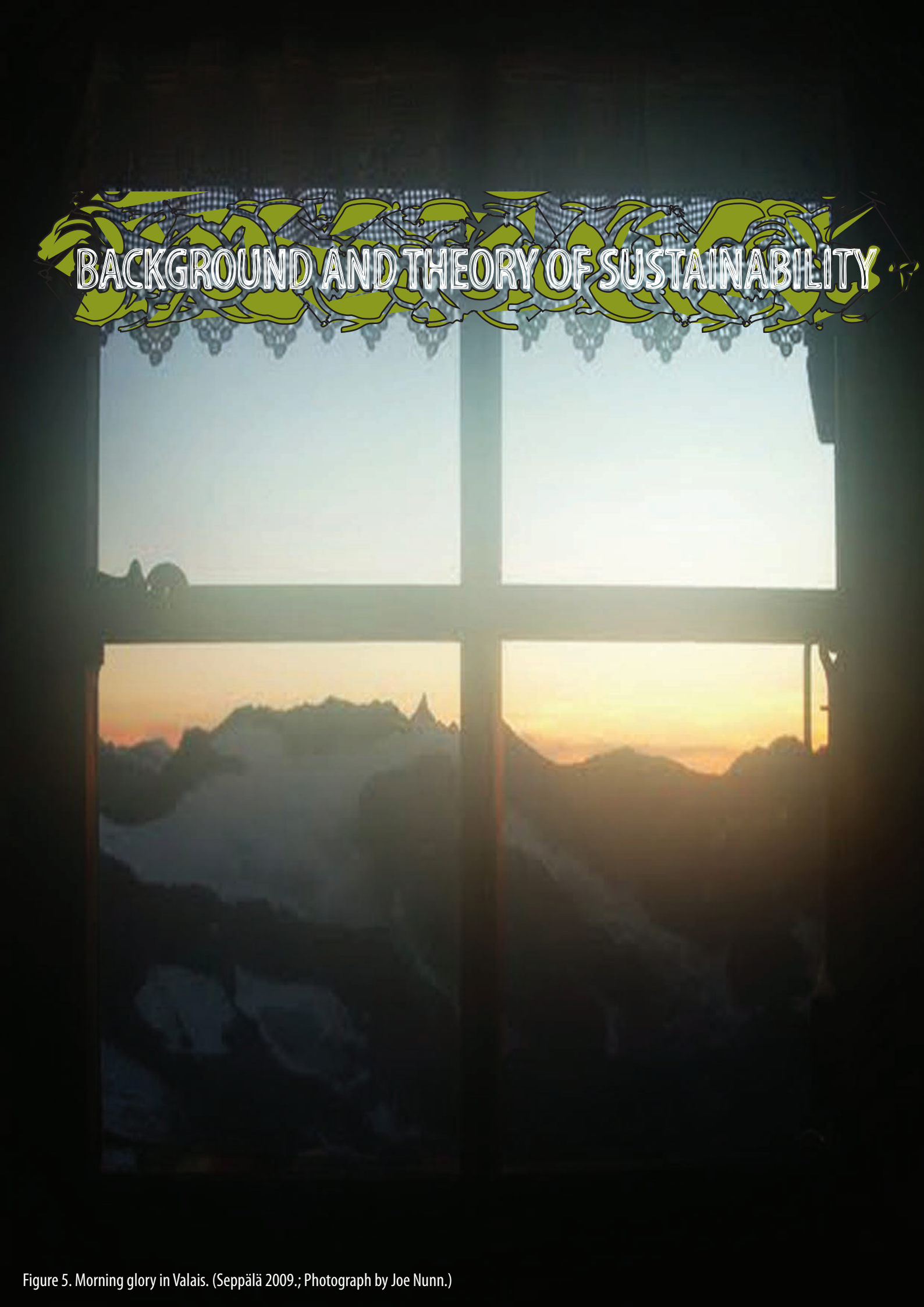


Figure 5. Morning glory in Valais. (Seppälä 2009.; Photograph by Joe Nunn.)

2 BACKGROUND AND THEORY OF SUSTAINABILITY

2.1 Climate change, environmental awakening and greenwashing

Knowledge about climate change in the future is an uncertainty. There are plenty of aspects that are not fully understood, but it is scientifically proven that concentration of CO_2 in the atmosphere has clearly increased because of the Industrial Revolution starting from the 19th century; therefore, humankind can be blamed for the greenhouse phenomenon. People, of course, affected the earth and climate before the Industrial Revolution, for example by the complete clearing of timberland areas, but influences have been mainly local. Before finding fossil fuels, people did not have many energy sources available and they mainly used firewood, muscle and wind power. For thousands of years carbon was taken out from the atmosphere and bonded into underground storage. The increasing population as well as technical and economical development drove energy consumption higher than ever in the beginning of 20th century. The increasing need for energy produced by fossil fuels returned carbon back to the atmosphere in the form of CO_2.[8]

At the moment carbon dioxide concentration in the atmosphere is at its highest for 650,000 years or perhaps even 20 million years. Increase of greenhouse gases can be seen to have direct connection for global warming. Climate change can be seen as the greatest environmentally, social and economic threat facing the planet and humankind. Global warming in this century has caused several problems, from environmental catastrophes, droughts, fires, floods and hurricanes to diseases. A great danger is cuts in global food production, which makes one billion people insecure about food. Global warming damages critical ecosystems like reefs, rainforests and the Arctic. Melting of the polar ice causes the sea level to rise meters, which in turn causes great losses in fresh water supplies and may make entire islands disappear. In the worst case scenario the ocean circulation system could be stopped.[9]

In 2007 the Intergovernmental Panel on Climate Change (IPCC) published its Fourth Assessment Report on global warming. The report warned that the global average surface

[8] Allianz Foundation for Sustainability 2008.; Allianz Group World Wildlife Found 2007.; World Wildlife Found 2006.

[9] Allianz Foundation for Sustainability 2008.; Allianz Group World Wildlife Found 2007.; World Wildlife Found 2006.

temperature is likely to rise from 1.8 °C to as much as 6.4 °C in the worst case scenario this century. Even a 2 °C rise in temperature this century would have serious consequences for mankind and all other life forms. The World Wildlife Found published a new report after the IPCC Report on 10th of October 2008 called, *Climate Change: Faster, Stronger, Sooner*. It gathers together the newest research on the subject. It claims that global warming is heading forward much faster than the IPCC has predicted.[10]

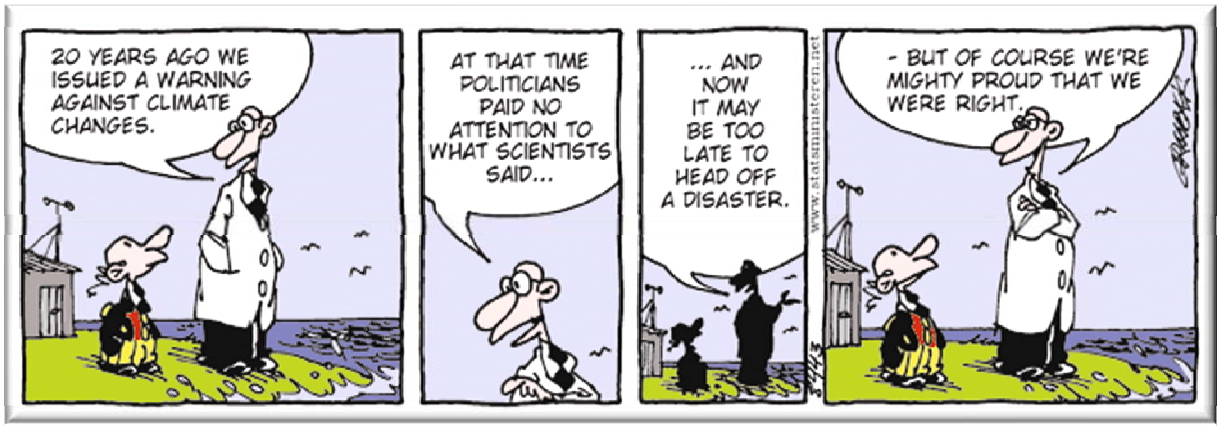


Figure 6. *Notification of climate change did not cause too much action at the beginning. (Craabaek 2008.)*

The history of the notification of climate change starts from the sixties (Fig. 7.). Intensive research started in the middle of the sixties. The first environmental conference called the Conference for Human Environment was held in Stockholm in 1972 (Fig. 6.). The first international agreements were made in Stockholm to protect climate and the United Nations Environment program (UNEP) was established. The conference also founded the "Earthwatch" Program called the Global Environment Monitoring System (GEMS) to collect and evaluate data from weather, human health as well as animal and plant data by institutions working in the United Nations. The purpose of the program was to recognize changes in the environment. The collected data showed that the CO_2 content in the atmosphere had increased compared to preindustrial levels.[11]

The first climate conference was in Geneva in 1979, where the World Climate Programme (WCP) was established and intense international efforts to scientifically understand climate changes started. The 1988 World Climate Conference, held in Toronto, dealt with changes to the atmosphere and gave clear warning of the consequences of global warming. In Toronto, UNEP and the World Meteorological Organization (WMO) founded the Intergovernmental

[10] Allianz Foundation for Sustainability 2008.; Allianz Group World Wildlife Found 2007.; World Wildlife Found 2006.

[11] Allianz Foundation for Sustainability 2008.; Allianz Group World Wildlife Found 2007.; World Wildlife Found 2006.

Panel on Climate Change (IPCC) to Geneva. The task of the IPCC is to predict future development. It collects reports from scientists from different sectors of climate research to make objective reports of the earth's climate. IPCC reports are published every 5 to 6 years and they are an important information source when decisions in politics and business are made. The first IPCC report was published in 1990 and it reported that increasing greenhouse gas is connected to human activity.[12]

The two most important environment conferences in the 1990's were the Earth Summit in Rio de Janeiro, Brazil in 1992 and in 1997 in Kyoto, Japan. A very important framework for all the international actions for climate protection was created in Rio. Since 1995, contractual countries from Rio meet once a year at the Conference of the Parties COP. At COP 2 in Geneva, most of the parties officially recognized that there is recognizable human influence on the global climate, the result of the second IPCC report.[13]

So far the biggest step in climate protection has been the Kyoto Protocol made in 1997 in Japan. The importance of the protocol is that the first time the industrial countries committed themselves as a group to reduce carbon dioxide, methane, laughing gas and other greenhouse gases between 2008 and 2012 below the values of 1990. Although the Kyoto protocol was a huge step forward, there were still huge problems in worldwide agreement on climate protection. The developing countries, including India, Brazil and China did not accept any obligations and of the industrial countries USA, Australia, Croatia and Monaco did not join the protocol.

Meetings after the Kyoto Protocol came into force in 2005 have been called Meeting of the Parties of the Protocol (MOP). In MOP 2 in Nairobi, climate change was identified as the greatest challenge in the history of civilization. In December 2007, the IPCC and Al Gore were awarded the Nobel Peace Prize in recognition of the idea that climate change poses a major challenge to the security of mankind in the 21st century.[14] 2009 could have been the most significant year in climate change history as world leaders met in Copenhagen in December to tackle a new plan for curbing global greenhouse gas emissions.[15] According to the WWF crises can turn out to be opportunities.[16] Financial and climatic crises can become

[12] Allianz Foundation for Sustainability 2008.; Allianz Group World Wildlife Found 2007.; World Wildlife Found 2006.

[13] Allianz Foundation for Sustainability 2008.; Allianz Group World Wildlife Found 2007.

[14] Allianz Foundation for Sustainability 2008.; Allianz Group World Wildlife Found 2007.

[15] 1% For The Planet 2009a.

[16] World Wildlife Found 2009.

the opportunity to bring the global economy back in line with global ecology. Copenhagen can be a turning point for the better or it can give the last evidence that climate change can no longer be halted.[17]

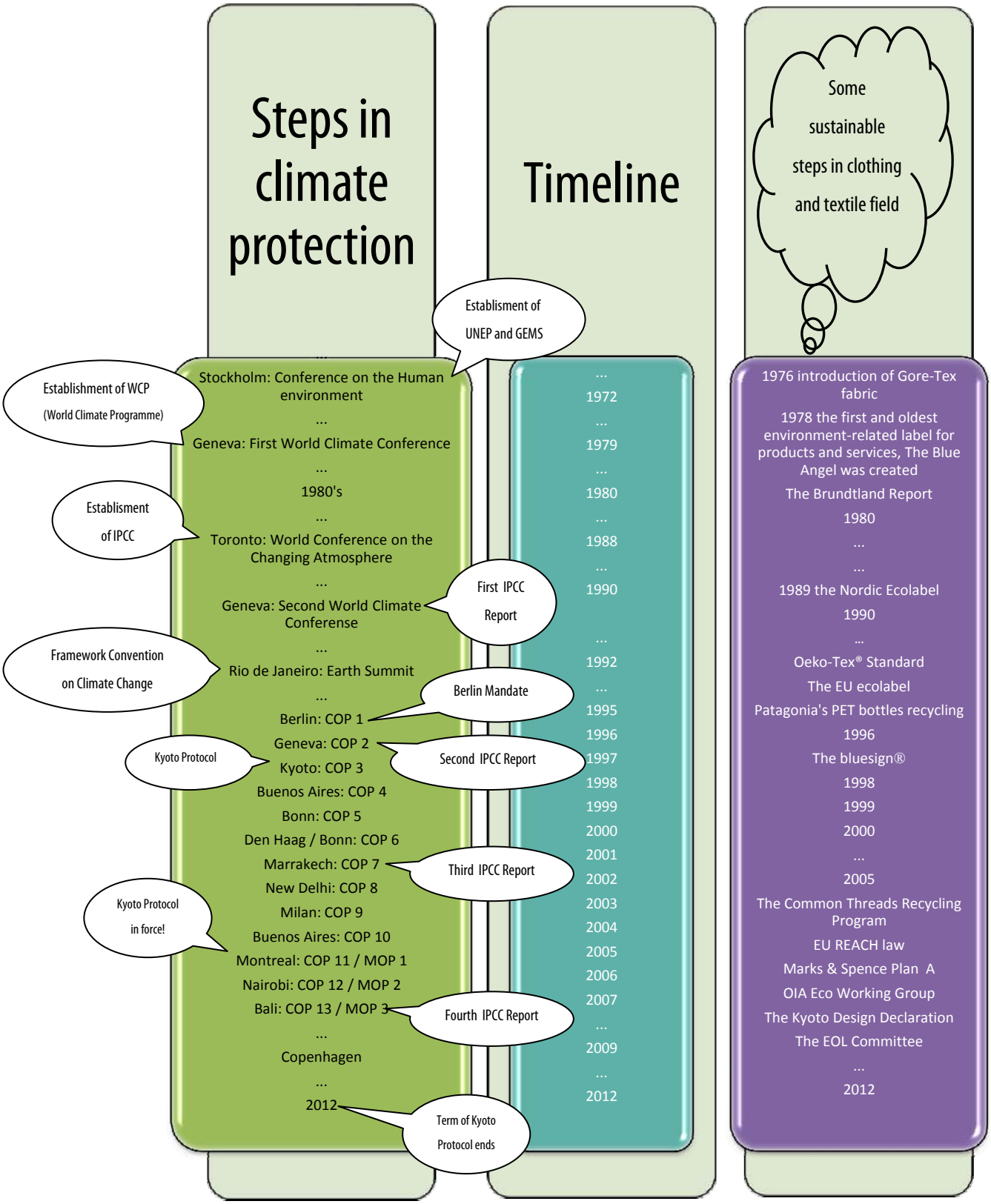


Figure 7. *Timeline of climate protection and environmental steps of textile and clothing industry. (Seppälä 2009 according to Allianz Foundation for Sustainability 2008.)*

[17] Lähteenmäki 2009, 32.

The environmental movement gained in strength in 1980s because of several ecological disasters. According to Kate Fletcher in the early 1990s, natural and recycled fibers dominated trade fairs, trend predictions and industry journals. In the 1990's sustainability was more like a fashion trend. In a way, sustainability has been ahead in fashion and casual clothing compared to sports and outdoor clothing.[18] The first and oldest environment-related label for products and services, The Blue Angel, was created in 1978.[19] I suggest a couple of reasons for functional clothing coming a little bit behind.

There has been an extraordinary development of outdoor sports and it needs to taken into account when thinking of technical textiles and garments. New sports are developed all the time and new sports need equipment and garments with innovations specific for the new sport. Sixty years ago there were only few special types of clothing for sports. Protective coverings, specialized footwear and garments and different protection developments were made in a relatively short time in the latter part of the 20th century.[20]

The biggest developments in functionality and smart wear were made in past twenty years. There has been a marked increase in the development and use of highly functional materials in outdoor clothing.[21] Since the introduction of Gore-tex fabric in 1976, a variety of lightweight, breathable, highly functional fabrics have been developed worldwide. Highly functional fabrics are generally characterized as being waterproof and windproof, sweat absorbing and with high thermal insulation at low thickness values.[22] W. L. Gore has also pioneered sustainability. They launched solvent-free adhesives for manufacturing garment laminates already in the 1990's and adopted Life Cycle Assessment in 1992. Life Cycle Assessment (LCA) is an ecological accounting system that can be used as an internal instrument. LCA determines the environmental impact of products, processes or services, through production, usage, and disposal. Gore was also the first manufacturer of performance fabrics to introduce a high level recycling system for high-performance garments.[23]

The general public finally woke up to climate change in the 21st century. Green advertising was found to have tripled in three years since 2006. One of the turning points of ecological awakening in functional outdoor clothing field was the EcoDesign conference in Ispo 2008

[18] Fletcher 2008, 118.

[19] The Blue Angel 2009.

[20] Buirski 2005, 15-17.

[21] Shishoo 2005, 4.

[22] Shishoo 2005, 4.

[23] W. L. Gore & Associates, Inc. 2007.

(Fig. 8.) and the OutDoor show in Friedrichshafen the following summer. The conference was important and it gathered industry members together to concentrate on sustainability matters and the European Outdoor Group established its own sustainability working group in summer 2008 in Friedrichshafen.

Figure 8. *Motto of EcoDesign forum in Ispo 2008 was "Form follows Sustainability". Volvo SportsDesign Forum 2008.)*

Greenwashing

The change in attitude can be seen in every field of life and science at the moment, but also the verb "to greenwash" has appeared.[24] It means the act of misleading consumers regarding the environmental practices of a company or the environmental benefits of a product or service. Between 2007 and 2009, the availability of these so-called green products has increased enormously. The amount of "green" products has increased by 79% between 2007 and 2009 in the United States and Canada. In fact, fewer than 2 % of the more than 2000 products claiming to be green were found to be completely green.[25]

There are companies which stretch the "truth" to make a product seem more eco-friendly than it is. Interestingly enough, in past couple of years many companies have also included ecological values in their marketing campaigns. It is very hard for a consumer to know what is

[24] TerraChoice Environmental Marketing Inc. 2009.

[25] TerraChoice Environmental Marketing Inc. 2009.

true and what is not.[26] There are several ways to mislead customers. I think that The Seven Sins of Greenwashing picture describes very well why consumers have problems in obtaining reliable information (Fig. 9.).

Figure 9. *Growing consumer demand for greener products and services has created different types of greenwashing. (TerraChoice Environmental Marketing Inc.)*

[26] Karliner 2001.; Lars 2009.

Joel Makower puzzles over the problem; has economic crises have affected consumers' green shopping habits? There are at least a couple schools of thought. According to Makower the first hypothesis is that green consumerism has been steamrolled by the recession and ecological lifestyle is viewed as a luxury which is no longer affordable. The opposing thought is that green shopping has endured as consumers get back to basics and consumers are rethinking their need to consume. Also, consumers are becoming less wasteful and more conscious of the impact of their purchases.[27]

Pasi Toiviainen states that man will not save the world as a side job; it will need many actions and sacrifices. He says that we all have to think about what we are working for. We have to build an ecological society and work for it every single day. The key words are simplicity, little consuming, declining consumerism and giving up unnecessary things. He says that society and politicians should promote the right changes. Eco-friendly technology is already here and we should start to use it despite the cost. Regarding energy sources, he trusts wind energy and solar power most. There are many problems with the use of bio fuels. Burning wood adds more carbon dioxide to the air. Fields should be used for growing food crops. He also thinks that polluters should pay big penalties for polluting. If the price of emissions and pollutant energy is high enough, ecological solutions will be adopted. We just need the will and courage to do so.[28]

2.2 Ethics and responsibilities of professions

Victor Papanek wrote in 1995 that we all are involved with issues of ecology. People have two different ways to approach the problems caused by environmental destruction. In his category the first way is to do something on an individual or family level, which means practicing conservation and preservation whenever possible. For example, sorting and recycling our garbage. The second way, and maybe the worst solution, is leaving the whole problem to the experts, an ill-defined group of scientists and activists.[29]

Papanek suggests that we should adopt a third way. "*We must examine what each of us can contribute from our own specific role in society.*"

[27] Makower 2009.

[28] Välimäki 2007.

[29] Papanek 1995, 17.

He demands us to ask question: *"What can I do as a professor, construction worker, taxi-driver, school teacher, prostitute, lawyer, pianist, housewife, student, manager, politician or farmer? What is the impact of my work on the environment?"*[30]

Papanek already thought in 1970 that designers had become a dangerous breed by creating a whole new species of permanent garbage to clutter up the landscape, and by choosing materials and processes that pollute the air. In his opinion mass production must be planned and designed, which demands high social and moral responsibility of the designer. Papanek started his book Design for the Real World in 1970:

"There are professions more harmful than industrial design, but only a very few of them and possibly only one profession is phonier. Advertising design, in persuading people to buy things they don't need, with money they don't have, in order to impress others who don't care, is probably the phoniest field in existence today." He also wrote in the same chapter, that: *"Before in the "good old days", if a person liked killing people, he had to become a general, purchase a coal of mine, or else study nuclear physics. Today, industrial design has put murder on a mass-production basis."*[31]

Papanek made his statement 40 years ago and nothing has changed, actually most things have become worse. According to John Thackara *"80 % of the environmentally impact of today's products, services and infrastructures is determined at the design stage."* He states that we are filling up the world with technology and devices, but we have lost sight of an important question: What is this stuff for and what value does it add to our lives?[32]

Riikamaria Paakkunainen contemplated this complex issue already in 1994 in her master thesis. According to her it is not a satisfying goal to demand that everybody should only own two sets of clothes, neither that they should not be beautiful or even fashionable. Ecological clothes can also look aesthetic.[33] Ecological design has been considered to look a rather hippy or unsophisticated until recently, but it does not need to look that way. *"Ecofriendly does not have to mean ugly: Good design is one of the keys to bringing together ecology and the economy. This leads to products, systems, infrastructure and services that serve their purpose while requiring a minimum of resources, energy and space. It also reduces waste and the use*

[30] Papanek 1995, 17.

[31] Papanek 1970, ix.

[32] Thackara 2005.

[33] Paakkunainen 1995.

and emission of hazardous substances. An ecofriendly approach embraces the complete lifecycle of a product."[34]

Sustainability is made up of production and material choices and ethicality from correct way of treating people. Michael Braungart and William McDonough propose in their book, *Cradle to cradle,* us all to challenge the idea that humans and human industry must damage the natural world. They have an inspiring idea of a world that has plenty of everything and is at the same time safe, beautiful and effective.[35]

2.3 The concept of sustainability

In the 1970s, increasing concern about the effects of economic development on health, natural resources and the environment led the United Nations World Commission on Environment and Development publish Our common future also known as the Brundtland Report in 1978. It involves the equitable sharing of the benefits of economic activity across all sections of society to enhance the well-being of humans, protect health and alleviate poverty. If sustainable development is to be successful, the attitudes of individuals as well as governments with regard to our current lifestyles and the impact on the environment will need to change. It is defined in the Brundtland Report:

"Sustainable development is development that meets the needs of the present without compromising the ability of the future generations to meet their own needs."[36]

Sustainable development is not just about the environment, but about the economy and our society as well. The concept of sustainability is enclosed within four aspects of sustainability, which are environmental, economic, social and cultural sustainability. Economic growth and indefinite continuation of an organization should be possible. All the implications of growth, not just financial, must be considered. Local and global aspects should be taken into consideration as well as individual and collective points of view. Economic growth should not be at the expense of natural habitats, indigenous peoples and future generations. For commercial sustainability, a balance needs to be struck between environmental sustainability, social sustainability and economic sustainability (Fig. 10.). Each underpins the others, and the absence of one represents long-term instability for an organization.

[34] Volvo SportsDesign Forum 2008.

[35] McDonough & Braungart 2002.

[36] United Nations World Commission on Environment and Development, 1987.

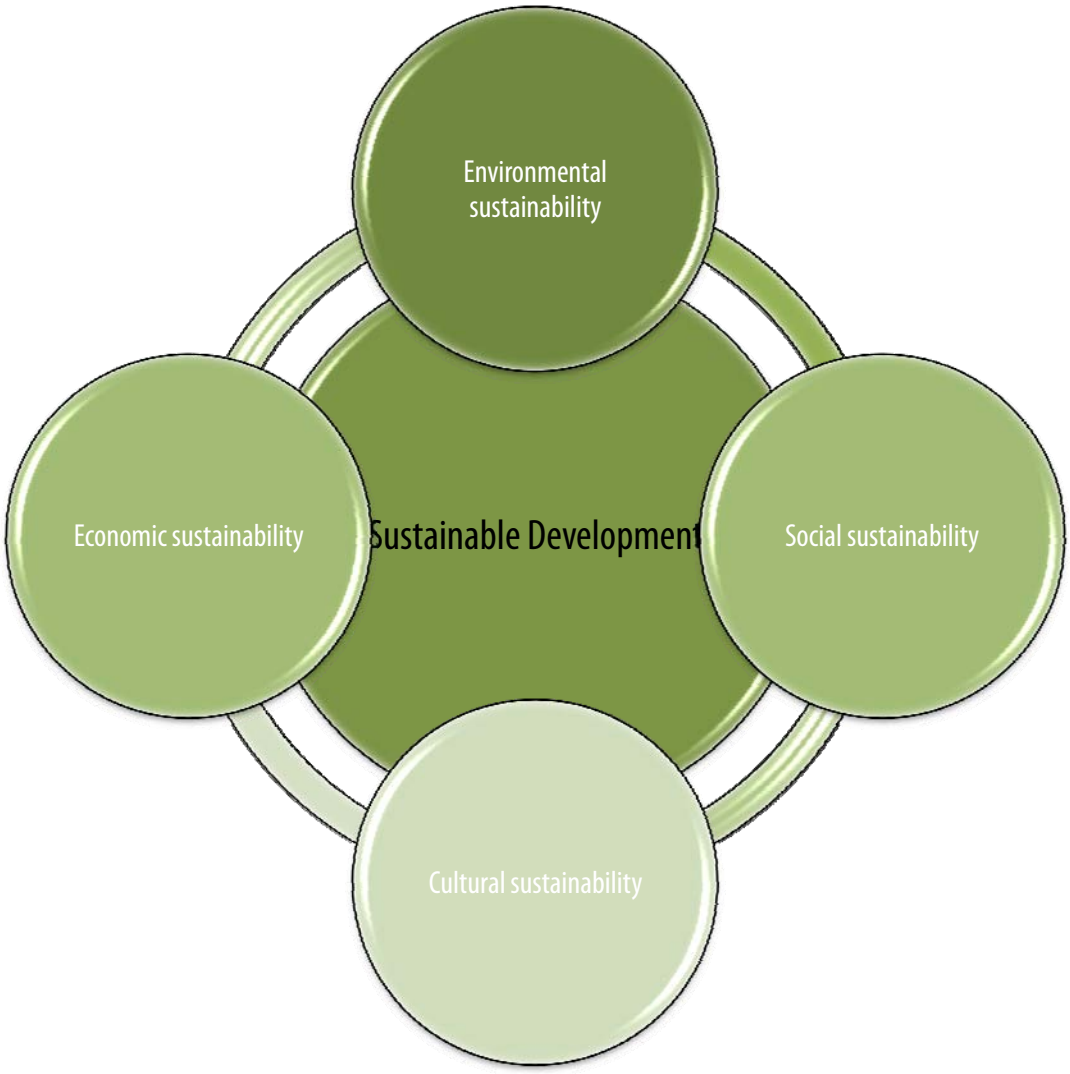


Figure 10. *Four aspects of sustainable development (Seppälä 2009, according to Suojanen 1997, 12.)*

Environmental sustainability

Environmental sustainability requires that development is in balance with natural phenomena and takes into account preserving natural resources. Nature, humans and society are in a hierarchical relationship with each other. Environmental sustainability is a template because nature is above everything else. Sustainable development encourages the conservation and preservation of natural resources, the environment, and the management of energy, waste and transportation. Sustainable development is development based on patterns of production and consumption that can be pursued into the future without degrading the human or natural environment. Some important aspects for environmental sustainability that demand attention are: compliance with environmental regulations, controlling and managing waste and other pollutants, efficient use of energy and minimizing transport impacts, both transportation of the employees to work and transportation associated with the organization's activities.[37]

According to Papanek, pollution is often thought to be only the smoke from factory chimneys or the exhaust fumes from cars, but pollution falls into several phases during production. The choice of materials can cause different types of problems from damage in the ozone layer to the depletion of natural resources that cannot be replaced. Thus material choices made by designers and manufacturers are crucial. Every choice in a designer's work can have far-reaching and long term ecological consequences. The manufacturing process itself may be polluting. It should be thought through if there is something in the manufacturing process itself that may endanger the workplace or the workers. If a product needs packaging where it is transported, marketed and distributed, it can be a crucial point when aiming at ecologically aware design.[38]

The finished product itself should be needed, because there are too many different versions of the same item available in many cases. Since the manufacture of most industrial or consumer products uses up irreplaceable raw materials, the profusion of objects in the market-place constitutes a profound ecological threat. The transporting of materials and products further contributes to pollution by the burning fossil fuels. After the useful product life is over, many products can have negative consequences and discarded products destroy the landscape.

[37] Suojanen 1997, 14.; Papanek 1995, 29-32.

[38] Papanek 1995, 29-32.

Recycling them could save raw materials and protect the soil, the water supply and wildlife from poisoning.[39]

Waste can be seen from each three sustainability perspectives. From the environmentally sustainability perspective waste produces air, soil and water pollution. Inefficient use of non-renewable resources produces unnecessary waste, which destroys landfill sites. One of the problems of disposal waste is that long-term pollution and health effects are unclear.[40] Most of the products dumped into landfills were made from valuable materials that required effort and expense to extract and make. Biodegradable materials such as food and paper also have value, but in landfill they cannot decompose and return biological nutrients to the soil. In the cradle-to-grave model everything is designed to be thrown away, but as McDonough and Braungart ask; what is away? There is no such a place as away. We are turning the Earth into one big landfill.[41] From the perspective of social sustainability, uncontrolled waste is unsightly and smells bad. Some waste is particularly hazardous to health, but well-managed recycling programs can provide jobs. Waste also has an economic sustainability aspect. Waste raw materials are a direct financial loss to the organization and improper waste disposal can lead to substantial fines. Disposal costs including landfill tax continue to rise.[42]

Social sustainability

Social sustainability means ensuring basic needs for individuals and society, as well as making quality of life reasonable for everybody.[43] The textile and garment manufacturing industry is guilty of poverty wages, excessive working hours, overtime working, lack of job security and denial of trade union rights in the worst cases.[44] Environmental aspects and unsafe work conditions are also linked together when people work with dangerous textile dyes and finishes. Some important aspects for social sustainability include attention to the organization's human resource plan. All employers should provide safe, healthy and adequately remunerated working arrangements and should employ local residents under flexible working arrangements, where possible. Employers should also keep positive relationships with employees, customers and neighbors as well as produce goods and provide services to meet real needs.

[39] Papanek 1995, 29-32.

[40] Timmins 2008, handouts and personal communication.

[41] McDonough & Braungart 2002, 27.

[42] Timmins 2008, handouts and personal communication.

[43] Suojanen 1997, 12

[44] Fletcher 2008, 41.

Cultural sustainability

Cultural sustainability means that development should be in harmony with people's culture and values. Cultural sustainability should be based on each nation's own cultural heritage. We need knowledge of our cultural history and common cultural vision.[45] Globalization brings habits and working methods of industrial countries around the world and destroys local habits and ways of doing things. For example, when western clothes spread everywhere the ways of making national costumes will be forgotten.

Economic sustainability

Some important aspects for environmental sustainability include attention to business plans, profit and loss accounts, the balance sheet and cash flow forecast. Economic sustainability also means that workplaces continue and people can count on their living in the future.[46] I do not review economic aspects in more detail in my thesis, but it is sure that business has to be profitable. No one wants to do unprofitable business and it is one of the biggest challenges for ecological design. This is going to be big challenge because of the current economic crisis.

According to Fletcher there are two major forces to influence sustainability, technology based improvements and legislation driven change. The textile and garment industries have sought to improve technology to make materials faster and cheaper.[47] The legislation has influenced industry, because not following legislation is expensive and industry is not willing to drive away customers. Even if customer's actions can affect industry, I think that customers cannot be held responsible for industry's actions. They cannot know all the aspects and industry is responsible for offering safe choices. If textile and garment industry would be sustainable responsible, customers could not make bad choices.

[45] Suojanen 1997, 12.

[46] Timmins 2008, handouts and personal communication.

[47] Fletcher 2008, 43-44.

2.4 Sustainable responsible design and life cycle analysis

Sustainable responsible design (SRD)

The term sustainable responsible design will be shortened to SRD from now on. According to Jason McLennan *"sustainable design is a design philosophy that seeks to maximize the quality of the built environment, while minimizing or eliminating negative impact to the natural environment."*[48]

Sustainable responsible design can be also called environmental design, environmentally sustainable design, environmentally conscious design, ecological design or just ecodesign. SRD is the philosophy of designing physical objects, the built environment and services to comply with the principles of economic, social, and ecological sustainability. Design is a process of creation and problem solving. Design goes far beyond form, structure, final styling or graphics. The designer must consider many different aspects, for example:

- Does the product enhance and heal the living world, or does it diminish it?
- Does the product preserve ecological structure and process, or does it degrade it?[49]
- Are materials recycled and can they be recycled, will they decompose, be reused, are they toxic in manufacture, use or afterlife?
- Is the product useful, does it fulfill a real need, is it robust and durable, easy to repair, use the least amount of materials for the most performance?
- Does it generate pollution and is it energy efficient?
- Is the least amount of packaging used to transport and display the product?
- Is the styling going out of date too quickly, can the product be upgraded easily as technology improves?
- Can components be salvaged for use in newer version, when product is no longer usable?[50]

There is a great opportunity to change end products by adding greater value in many criteria and enhancing the concept of sustainability. Sustainable responsible design, including environmentally and socially responsible design practices, makes products and services significantly better. Designers and consumers face the challenge of considering the lifelong

[48] McLennan 2004.

[49] Van der Ryn & Cowan 1996, 18.

[50] Society for Responsible Design

impact of products. The responsibility extends well beyond the time a product is used. Designers have to view the entire history of a product from materials extraction, through manufacture, transportation, sales, use, and post-use.[51] According to Van der Ryn and Cowan ecological design is the effective adaptation to and integration with nature's processes. It proceeds from considerations of health and wholeness, and tests its solutions with careful accounting of their full environmentally impacts.[52]

According to O'Connor and Iain Cox, Design Wales uses the following working definition: "*Sustainable responsible design follows a holistic "lifecycle thinking," multi-stakeholder approach, taking into consideration all the key environmentally, social, and economic impacts throughout the lifecycle of the product/package, without unduly compromising other criteria, such as performance, aesthetics, function, quality, and cost.*"[53]

Sustainable responsible design is not only advantageous for nature; it can also mean money for companies which are following sustainable responsible principles. Consumers are more and more concerned about the state of the world and global warming. They are also becoming more willing to pay more for products manufactured in an environmentally friendly way.

Increasing amount of population growth and increase in waste has made recycling and life-cycle thinking more acute than ever. Frank O'Connor and Iain Cox proposed in 2005 that sustainable responsible design is becoming important to businesses worldwide. Supply chain, consumers and legislation have pushed it to the top of the agenda. According to them, until now action has been taken mostly in large international companies. Small and medium-sized enterprises are one of the key elements in national economies throughout the world. Small and medium-sized enterprises play a significant role in the design, development, and manufacture of new products at the moment. Small and medium-sized enterprises can have a competitive advantage from sustainable design. Taking sustainable design into consideration in manufacturing companies can also increase their benefits.[54]

Papanek proposed that perhaps there should be no special category called sustainable design. "*It may be simpler to assume that all designers will try to reshape their values and their work, so that all design is based on humility, combines objective aspects of climate and the ecological use of materials with subjective intuitive processes, and relies on cultural and bio-*

[51] Society for Responsible Design 2009.

[52] Van der Ryn & Cowan 1996, 18.

[53] O'Connor & Cox 2005, 73.

[54] O'Connor & Cox 2005, 72.

regional factors for its forms. End-users are also implicated in this ecological crisis. In our greedy rush for more and more material goods, we have seriously neglected our links with nature and our responsibility to the environment."[55]

Although Papanek suggests that there should not be separately sustainable responsible design and then conventional design, we have to know what aspects have to be taken into consideration when making sustainable design. When we have adapted all those aspects and brought them into action, we can just call it design again. Paakkunainen predicts in the discussion part of her master thesis that knowledge of ecology will adapt on what the obligatory skill designer has to know as happened to ergonomics in 1970's.[56]

Life cycle analysis (LCA)

LCA stands for lifecycle analysis or assessment later in my thesis. According to Tatsuya Hongu and Glyn Phillips there has been development of different methods for analyses of the environmental impact from materials, products processes and activities. LCA is one of these methods. LCA quantifies the environment burden from cradle to grave for a production system. It includes raw materials, processes, transports, use and final waste disposal. Life cycle assessment is about total environmentally burden. (Fig. 11.).[57]

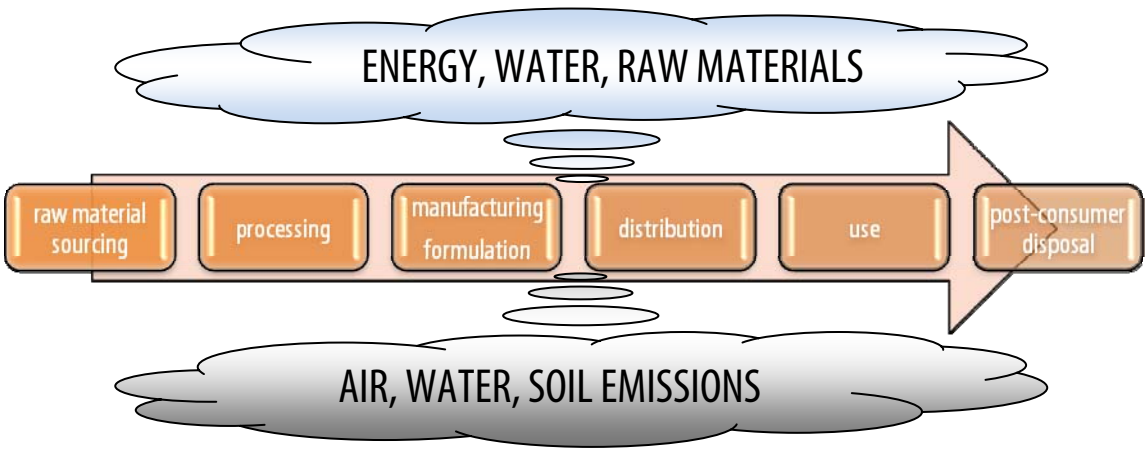


Figure 11. *Life cycle assessment determines the environmental impacts of products, processes or services, through production, usage, and disposal. (Seppälä 2009, according to Fletcher 2008, 47.)*

[55] Papanek 1995, 12.

[56] Paakkunainen 1995, 71.

[57] Hongu & Phillips 1997, 203.; See also Makower 2009.

Figure 12. Ben Nevis (Seppälä 2009.; Photograph by Laura Seppälä.)

3 FUNCTIONAL CLOTHING DESIGN

3.1 Papanek's six-sided function matrix

In Papanek's opinion design embodies a sense of wonder, a feeling of completion that is lacking in many other fields. Designers have the chance to make something new, or to remake something to be better. *"Design gives the deep satisfaction that comes only from carrying an idea all the way through to completion and actual performance."*[58] Papanek introduced his six-sided function matrix in 1970 (Fig. 13.). In 1995 he took more consideration of the consequences of a product. This matrix shows the aspects affecting functionality. According to him a responsible designer has to take into consideration use, method, association, aesthetics, need and consequences.[59]

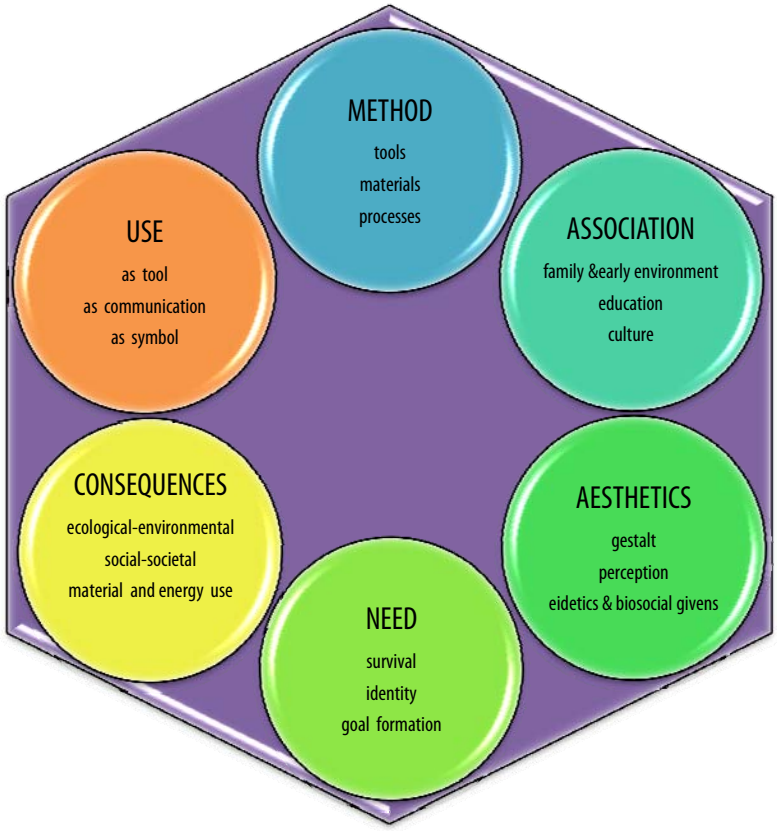
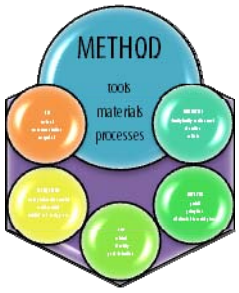


Figure 13. *Papanek's six-sided function matrix (Seppälä 2009 according to Papanek 1995, 34.)*

[58] Papanek 1995, 7.; See also Anttila 1996, 49-64.

[59] Papanek 1995, 34.; See also Anttila 1992, 146-171.



Method

Method means interaction between tools, materials and processes. Materials and tools should be used in the best possible way. To save money, energy and waste, the correct materials should be used for the correct purpose. The designer should pick the correct material for each use and take all these aspects into consideration.[60]

Associations

We make associations based on our family background, early environment, education and culture. Many associational values affect our behavior towards a product.[61] For example, if we associate our outshell jacket with a very valuable piece of clothing, we take better care of it. The reason for our attitude can be that the garment proclaims our lead user position and environmental values. Association also has a lot to do with brand image. The same quality garment may be evaluated to have different value depending on the brand's image. Big, outdoor brands have several collections for different sports and the same brand's collections' image may differ depending on the target group. Most of the big brands and especially small brands have a specific sport image. For example, a snowboarder may not want to choose a jacket meant for skiing for reasons of image, even though it would be functionally suitable. In past years freestyle skiing clothes have come very close to snowboarding style. Climbing clothes differ in style from skiing and snowboarding image partly because of the sport's qualifications, but also in style matters.

Aesthetics

Papanek says that aesthetics is one of the most important tools for a designer.[62] It helps him to form his ideas for pleasant, delightful and meaningful concrete products. Having an eye for aesthetics can be the way to produce a product to give satisfaction. Evening dresses are possibly more often seen as pleasant and aesthetic, but I cannot

[60] Papanek 1970, 8.

[61] Papanek 1970,19.

[62] Papanek 1970, 22.

see any reason why it would not be possible to make aesthetic, pleasant functional outdoor clothing. And of course many outdoor companies are doing it already. For me, clothing could also be a piece of art, where a designer can convey her or his ideas and impressions of the world or even make a statement.

Need

Need is the main reason for producing anything at all. Papanek suggests, however, that it is much more challenging to satisfy the real needs of a human being in the sense of economic, psychological, spiritual, technological and intellectual needs than to satisfy unnecessary needs created by marketing and fashion.[63]

Consequences

Consequences are absolutely the toughest part for the designer to handle. He or she should think what the consequences of producing the product are and how the product affects ecological, environmentally and social aspects.[64] This is one of my main interests in my thesis. Sustainable, responsible design attempts to solve the problem of consequences. Consequences are also one of the hardest things to measure. Among other measurement tools, life cycle analysis is one method to measure the effects on the environment.

Use

Use should be seen as tool, as communication or as a symbol. The simple question is: does it work as it should work? I would also like to add, does it work as well as possible? Functional clothes should enable and even enhance performance. Anttila thinks that the function analysis of the use of garment can be made from standpoint of user. The clothing analyze can be done from meaning and purpose of use and how clothes are used. How practical, wearable, functional or fashionable they are for different users in various situations.[65]

[63] Papanek 1970, 15.

[64] Papanek 1995, 34.

[65] Papanek 1970, 13.; Anttila 1996, 49.

3.2 Demands of functional clothing designer

The repertoire of a designer's skills and talents includes the ability to research, organize and innovate and the capacity to develop appropriate answers to new or newly emerging problems. Designers need the training to communicate their design developments through drawings, models, mock-ups and feasibility studies, video or film, as well as through verbal, computer-generated or written reports. They need talent to combine form-giving with rigorous technical considerations and with a sense of humane and social factors and aesthetic enchantment. The important wisdom for them is to anticipate the environmental, ecological, economic, and political consequences of design intervention.[66]

To develop good, new functional clothing design both technical and creative issues must be understood. It is necessary to have knowledge of human anatomy, physiology and in-depth information about activity what for clothing is going to be made.[67] A designer needs to have a good knowledge of graphics and the skills to test for answers to emerging problems through experimentation, computer modeling and making working prototypes. A designer should also have a profound knowledge of textiles and fashion to design aesthetically and ergonomically satisfying products, which are produced using the latest advances of functional and smart developments. Shishoo thought in 2005 that to become leading functional clothing designer, a person needs to realize that the performance has actually become the aesthetics in sportswear. All new innovations like breathable water- and windproof fabrics, innovative stretch materials, interactive materials and wearable technology make an epitome of functional clothing.[68]

There are many performance requirements of functional smart clothing (Fig. 14.). Active users demand widely differing properties from their functional clothing. Fibers and fabrics must fulfill the consumer requirements of comfort, drape, fit and ease of movement and they should work as a barrier to rain, snow, cold, wind and heat depending on the final use situation.[69] According to Voice, Dafniotis and Towlson, there are sports where comfort and fit are the most important characteristic. In general, they think that the most important characteristics of clothing for sports or fitness activities are in following order: comfort, freedom of movement, breathability, machine washability, durability, fit and lightness of weight.[70]

[66] Papanek 1970, 7-33.

[67] McCann 2005, 54.

[68] Shishoo 2005, 5

[69] Shishoo 2005, 2.

[70] Voyce, Dafniotis and Towlson, 2005, 204-205.

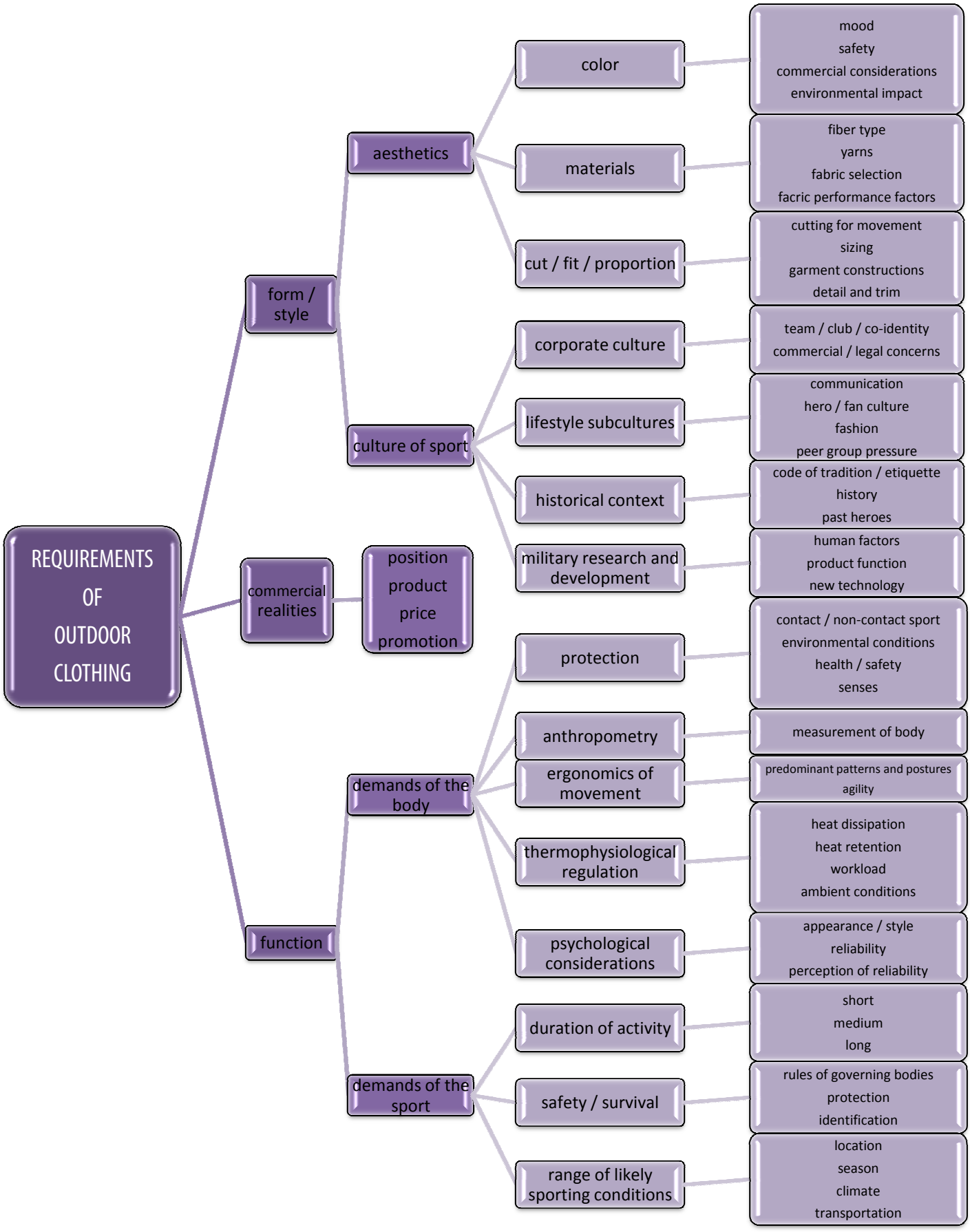


Figure 14. *The requirements of knowledge for functional clothing designers according to Jane McCann (McCann 2005.)*

3.3 The smart garment layering system

The modern functional outdoor clothing concept is based on a layering system. The classical version is a three layer concept, which includes base layer, middle layer and shell layer. Each layer has a specific function and they are designed to work together to offer overall comfort and protection. All the layers should remove sweat and extra heat from the skin to the outside of the garment and repel water and wind. Different layers allow a person to adjust his temperature. When person feels too warm, he can take off some layers or open ventilations. When a person starts to feel too cold, he can add more layers and close the ventilations.[71] According to McCann, the smart garment layering concept is adopted from military combat outfits. The British introduced a seven-layer version in 1950 for the Korean War. Today's concept principles are from military use, but the civilian outdoor companies have modified them.[72]

The first layer or in other words the base layer is the layer closest to the skin. It can be also called a second skin. The biggest innovations in the base layer have been the development of fibers and seamless technology. Because undergarments touch the skin it is important that they feel comfortable, do not irritate and remain cool or warm enough depending on the situation. The most important purpose for the base layer is remove sweat from the skin to the next garment layer. A fairly new trend is to make the base layer also fashionable. It is also meant to be seen. Bramel suggests that the major source of design innovation in first-layer garments came from the introduction of new fibers. High-wicking, fast-drying, odor reducing or UV-blocking fibers brought new properties to enhance performance underwear, but they did not radically influence first layer design.[73]

The introduction of seamless and stitchless garments was not a huge success at first. Garments often were not completely seamless and sometimes welded seams looked less aesthetic than old traditional sewn seams. In recent years the seamless manufacturing process has been seen as a new opportunity to make different and new designs. It makes possible to create garments combining several functions in a single knit and smooth layer and it can respond to the specific needs of each body part.[74] Juha Kosonen has an interesting point of view to regard base layer. Sweating is the body's response to heating caused by exertion. If

[71] Bramel 2005, 33.

[72] McCann 2005, 45.

[73] Bramel 2005, 33.

[74] Bramel 2005, 26-27.

the base layer is too effective and removes sweat too fast from the skin, skin simply produces more sweat for cooling purposes and the sweating amount actually increases.[75]

The second, a middle layer is between the undergarment and the shell layer. Depending on the weather, there may be also two middle layers. In cold conditions thinner and thicker middle layer garments can be used at the same time. The middle layer is to warm and also draw moisture away from first layer to the third layer. Fleece is a Jersey knit fabric with a brushed pile and has been a common choice for second layer material. Fast wicking and light weight are expected from the second layer.[76]

The shell layer is intended to protect the wearer from different elements like water, wind and UV rays. Mostly outshell fabrics are laminated or coated to repel water and wind. Waterproofness has to be reached with the best possible breathability.[77] Laminated fabrics can be 2-layer, 2.5-layer or 3-layer fabrics. The softshell layer has changed the classic three-layer system to a four layer concept. Softshell is bonded fabric where two different types of fabrics are bonded together with laminate between them. Fabrics may be woven, knitted or made of fleece. Usually the fleece is inside. Softshell may be elastic, breathable, windproof and water resistant. The problem with softshells is that they cannot be taped waterproof, because water runs in soft surface. Softshell can be used as outer shell, but in really tough conditions hardshell is needed and softshell is a so-called third layer.[78] The protection equipment could be called fifth layer, although knee, elbow, wrist and ankle protection are often worn on top of the base or middle layer.

3.4 Cutting for movement and new garment manufacturing methods

When making clothes for moving, freedom of movement needs to be ensured (Fig. 15.). One way to allow for movement is to use stretch fabric. Stretch fabrics provide freedom of movement and prevent discomfort when moving. If fabric does not stretch too much, space for movement needs to be built through pattern cutting. Depending on the end-use a garment needs to have a certain caliber and shape to allow movement. Fashion also effects measurements. In the eighties sport clothes were much bigger than required by movement.

[75] Kosonen, 2009, Personal communication.

[76] Bramel 2005, 33.; Elsasser 2005, 142.

[77] Bramel 2005, 33-34.

[78] Bramel 2005, 35.

Some subgroups or part of them, like some snowboarders, still use garments whose measurements are not the most functional.[79]

Measurements are a key element in pattern making. When making functional clothing there is a need for static measurements and dynamic measurements. Girth and length measurements are static measurements. These are measured from a standing person. Dynamic measurements take movements into consideration. Basic posture is measured first and then movement position. The difference between these two has to be added to the patterns. According to Voyce, the human body has four key stretch points. Simple body movements such as bending elbows or knees can stretch skin 12 to 45 %. Elasticity is needed in garments to respond to movement of the body. Elasticity, made by for example by Elastane, is also needed for garment to return to its original size and shape.[80]

When making a design seam, positioning is taken into consideration. In waterproof garments fewer seams often mean better waterproofness. Each seam needs to be taped and taped seams are rarely as sealed as pure fabric. The direction of the seams should be considered. If seams are faced upwards, there is bigger chance that water will penetrate. Other than the leakage problem shoulders are bad place for seams, because a backpack is often carried. Seams may feel uncomfortable under backpack straps. Many seams should not end up at the same place, because the intersections may become thick and hard to tape. Curvy seams are also difficult to tape. Wrinkles and folds also cause problems for taping, because they have to be double taped and are still difficult to waterproof. All the eyelets, buttons, ring snap buttons, velcros and zippers also need to be taped to ensure the garment is waterproof.

Fast developing garment technology and new manufacturing methods can save energy, fabric waste, cut-loss and emissions. Welding, bonding and laser cutting reduce the need for stitching. The environmental impact can also be reduced by innovative production technology such as whole garment or seamless knitting. Whole garment knitwear is made in one entire piece. The knitting machine makes knitting three-dimensional directly. According to Allwood et al. seamless knitting has significant energy saving potential, because it takes around 30 to 40 per cent less time than for conventional sewing and manufacturing.[81]

[79] Mäkinen, Antikainen, Ilmarinen, Tammela & Maisa 1996, 118-119.; Tikkanen, 1998, 29.; Voyce et al., 2005, 204-207.

[80] Mäkinen et al., 1996, 118-119.; Tikkanen, 1998, 29.; Voyce et al., 2005, 204-207.

[81] Allwood, Laursen, Malvido de Rodriguez & Bocken, 2006, 33.

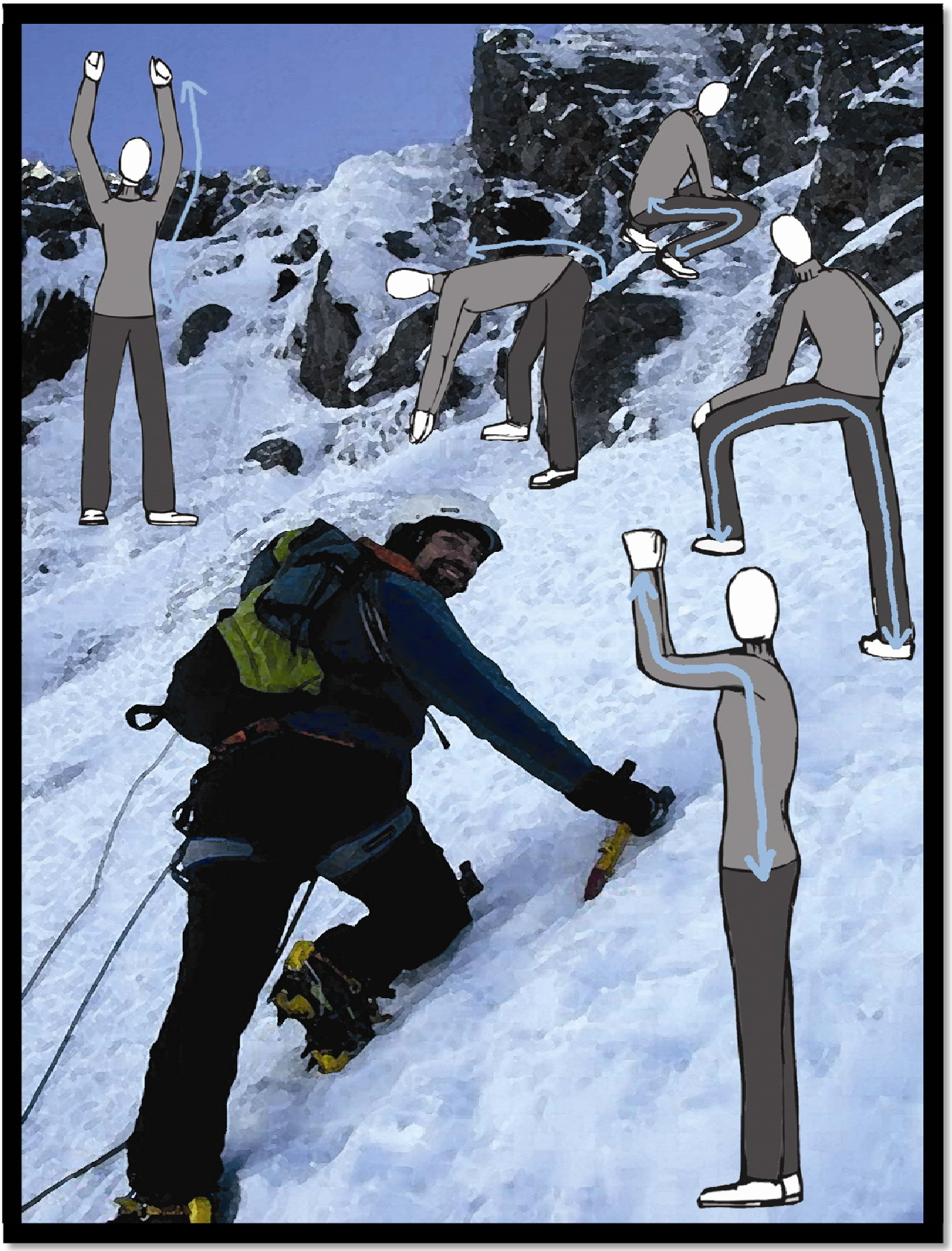


Figure 15. *Outdoor clothing should allow freedom of movement. According to Voyce body movements such as bending elbows or knees may require more than 50% stretch. (Voyce et al.2005, 204-205). (Seppälä according to Tikkanen 1998, 119.)*