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Sustainable Work Environment with Lean Production in Textile and Garment Industry

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Abstract

This paper objective is to present Lean Production (LP) as a work organizational model that fosters a sustainable work environment in Portuguese textile and garment industry (TGI). This is achievable through some Lean tools and initiatives, described in the paper, that reduce the energy, water consumption, environmental waste, raw materials consumption and improve leanness and agility. Lean Production has been extensively implemented in all kind of industries and services companies, responding to customers' demand with on time delivery of high quality products at reduced costs, through continuous waste elimination (e.g., overproduction, raw materials, energy and water more than necessary,...). Traditionally, the textile and garment industry had always been to a great extent dependent on natural resources: natural fibers, dyes, water, energy and others. Typically, this industry consumes greatest amount of water and energy, especially in dyeing and finishing processes. These processes have a problem concerning the water and soil pollution. In this manner reducing the consumption of these resources and reducing the pollutants should be a concern for companies and individuals, to achieve a sustainable development. As appointed by the Millennium Project, sustainable development and climate change are the first of the 15 Global Challenges facing humanity and its accomplishment will improve enormously the life for all in the planet. The TGI is also an industry strongly seasonal and with great influence on fashion and climate changes, placing some challenges related with this aspect. The customers demand will change significantly and in short time span appealing to companies' leanness and agility.

Keywords: Lean Production; Sustainability; Textile and Garment Industry.

1 Introduction

The textile and garment industry (TGI) has a large representation in the Portuguese industry and it always had an important role in national economy. Although suffering transformation due to delocalization and closure of companies, this industry continues to be one of the most important Portuguese manufacturing industries. That kind of industry comprises two big sectors: the textile industry, which includes fiber production, spinning, weaving, knitting and finishing (dyeing, printing and finishing) and the garment industry, which includes manufacture of clothing and accessories. Currently, this sector has been very dynamic and competitive, investing in technology, modernization and changing the strategy and performance of companies operating in the sector, developing a culture of quality and innovation, fast response, small amounts of the domain and distribution channels. From the territorial point of view, this industry is spread all over the national territory, although there are two main regions: north of Portugal (cotton companies) and Beira Interior (wool companies), representing 85% of the companies. The sector is composed approximately by 4000 companies (excluding clothing) and some 11000 garment companies, which together represent about 19% of all production units of the manufacturing industry and 1.4% of companies operating in Portugal. It represents 10% of national exports (in nineties this value was 30%), 22% of employment, 8% of turnover and 10.7% of Gross Value Added of manufacturing industry (aicep Portugal Global, 2011).

In spite of TGI drawbacks, this is an industry that it is worth to continue to invest. This investment does not mean that should be a great investment, many times, merely by a better production organization, improvements are achieved. The Lean Production (LP) could help in this organization leading to

sustainable and efficient production work environment. The paper objective addresses LP as a work organization model that could support the accomplishment of this work environment. This is achieved by Lean principles and tools that are used to diagnose, measure, improve and sustain the sustainability of production systems. Furthermore, using the principles, a Lean culture is developed permitting engage people in continuous improvement.

2 A brief literature review

2.1 Lean production

Lean Production (LP) is a model of organization focused on the customer and delivery of on time quality products, materials and information without any wastes, i.e., activities that add no value to the products from the point of view of customer. This designation, Lean Production means "doing more with less" where less implies less space occupied, less transports, less inventories, and most important, less human effort and less natural resources. LP had its roots in Toyota company that designed, after the Second Great War, a production system, Toyota Production System (TPS) (Monden, 1983; Ohno, 1988), which employed some pillars, like JIT production and autonomation concepts and some tools (standardized work, kaizen, heijunka,...) to reduce lead times and the cost of products (Figure 1).

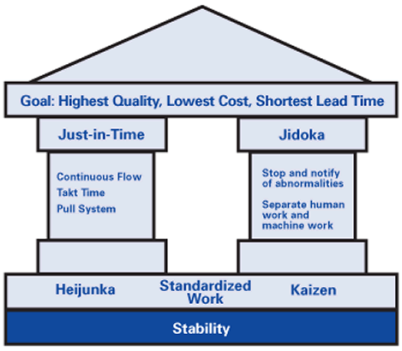

Figure 1: TPS house (LEI, 2008)

It was a book - "The Machine That Changed the World"- written by James P. Womack, Daniel T. Jones and Daniel Roos (Womack et al., 1990) that gave the popularity to the Toyota Production System (TPS). Meanwhile, the LP has evolved into a philosophy of thinking, Lean Thinking (Womack & Jones, 1996), whose basic principles are: 1. Value, 2. Value Stream, 3. Continuous flow, 4. Pull System and 5. Pursuit perfection. These principles imply the dedication of all people, being the last one - pursuit perfection (principle 5) - the one that implies the strongest and continuously commitment of people in order to improve all the processes and activities in companies, through the waste elimination. There are seven deadly wastes: overproduction, transports, movements, waits, over-processing, defects and inventories. Additionally, other authors (Liker, 2004; Bicheno, 2008) add more wastes to this list: making the wrong product efficiently; untapped human potential; inappropriate systems; wasted energy, water and natural resources.

2.2 Sustainable development and eco-efficiency

According to Brundtland report called "Our Common Future", sustainable development is: "*Development that meets the needs of the present without compromising the ability of future generations to meet their own needs*" (WCED, 1987). Sustainable development is based on three pillars (Figure 2): economic; environmental and social responsibility. Economically, companies must grow without compromising their integrity; socially, human rights must be respect, with social equity and social investment; environmentally, companies must worry with environment. Exposing these relationships, it is possible to notice that sustainable development was a concept with a strong connection to the companies or business, but also

involving intensely the government and civil society partnerships to concretize this concept. According to Holliday et al. (2002) *"The prices of goods must reflect all the costs – financial, environmental and social – involved in making them, using them, disposing of them or recycling them."*. This is also applied to the services. Companies exist to satisfy their clients and to have profit, but they don´t must compromise the nature and the future of the planet, working at any price. It is important to have a compromise between the business and sustainability. They must have economic viability, environment respect and social equity of people to have a sustainable business. Achieving full-cost pricing being cleaner and more efficient, producing with less and supplying the customers wanted goods and services makes happy leadership companies (Holliday et al., 2002).

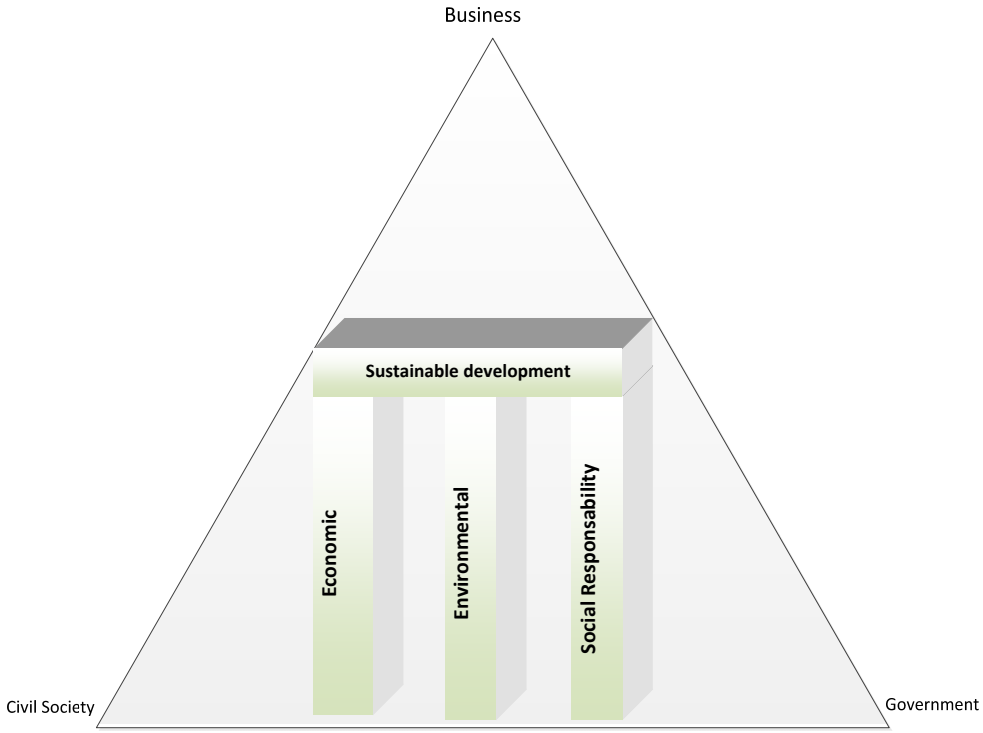

Figure 2: Pillars of sustainable development and partnerships involved

In the book "Walking the talk: the business case for sustainable development" (Holliday et al., 2002), the authors describes ten building blocks of sustainable progress: 1) the market, 2) the right framework, 3) eco-efficiency, 4) corporate social responsibility, 5) learning to change, 6) from dialogue to partnerships, 7) informing and providing consumer choice, 8) innovation, 9) reflecting the worth of earth, and 10) making markets work for all. Enrolling in these steps and with the cooperation of business, government and civil society could create a market that maximizes the opportunity for all. The authors presented also 67 case studies revealing the opportunities and problems faced by them in the path of sustainable progress. Some of these case studies are well-known companies like Shell, General Motors, BASF, Sony, DuPont, Toyota or Nestlé.

The third step is the eco-efficiency concept that linked sustainable development to business agenda. According to Business Council for Sustainable Development (BCSD), eco-efficiency is "*The delivery of competitively priced goods and services that satisfy human needs and bring quality of life, while progressively reducing ecological impact and resource intensity throughout the life cycle, to a level at least in line with the Earth's estimated carrying capacity*." (WBCSD, 1996). Eco-efficiency concept translates the simple idea of "creating more with less" by: (i) reducing materials intensity; (ii) minimizing energy intensity in both products and services; (iii) reducing the quantity and the dispersion of toxic substances and decreasing the level of toxicity of such substances; (iv) promoting recycling and the use of renewable energy; (v) extending the durability of products, and; (vi) increasing service intensity.

2.3 Lean Production and sustainable development

To satisfy the clients, companies consume energy, water and raw materials (natural resources) and must be careful not to be a larger-than-life consumption not only because it is expensive but also natural resources end. So, it is necessary to optimize the processes and prevent wastes of resources in a reasonable "doing more with less". The relationship between Lean production and sustainable development is evident, sharing the same key idea of "creating or doing more with less", and some organizations is benefiting from this relationship since, almost, two decades ago. As Kidwell (2006) explained *"Lean strategies coincidentally benefit the environment, without the need for special "environmental" toolkits or a separate focus on environmental considerations*". Moreira et al. (2010) reviewed the papers about this relationship and created a cause-effect diagram showing the evidence between the seven discussed wastes and the impact (effect) on the environmental performance (Figure 3).

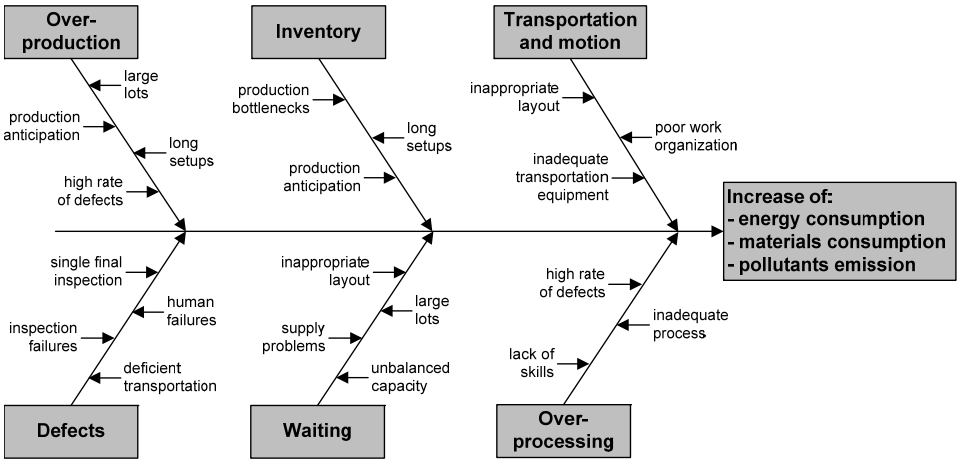

Figure 3: Production wastes as causes of weak environmental performance (Moreira et al., 2010)

Lean Production carries a dramatic reduction to all kinds of wastes being a whole-system thinking (Lovins et al., 2007) and it is totally akin with a socially responsible strategy. The U. S. Environment Protection Agency (US-EPA) discovered this way of thinking more than two decades ago and they are adopting the Lean Thinking principles and adapting Lean tools like VSM, 5S, JIT production or others to assess the use of hazardous materials, the energy and water consumption, the pollution, and so on. They created guidebooks, toolkits and reports to be use by the companies (Table 1).

Table 1: US-EPA guidebooks, toolkits or reports and case studies

Reference	Guidebooks, toolkits or reports	Case studies
(US-EPA, 2000a)	The Lean and Green Supply Chain: A Practical Guide for Materials Managers and Supply Chain Managers to Reduce Costs and Improve Environmental Performance	GM, Commonwealth Edison, Andersen Corporation, Public Service Electric and Gas Company
(US-EPA, 2000b)	Pursuing Perfection: Case Studies Examining Lean Manufacturing Strategies, Pollution Prevention, and Environmental Regulatory Management Implications	Boeing Everett and Boeing Auburn Machine Fabrication
(US-EPA, 2003)	Lean manufacturing and the environment: research on advanced manufacturing systems and the environment and recommendations for leveraging better environmental performance	Apollo Hardwoods, General Motors, Goodrich Corporation, Warner Robins U.S. Air Force Base
(US-EPA, 2004)	Findings and Recommendations on Lean Production and Environmental Management Systems in the Shipbuilding and Ship Repair Sector	Bath Iron Works, Bender Shipbuilding and Repair, Northrop Grumman, Southwest Marine Inc., Todd Pacific
(US-EPA, 2007)	The Lean and Environment Toolkit	
(US-EPA, 2008a)	Working Smart for Environmental Protection: improving State Agency Processes with Lean and Six Sigma	Delaware, Iowa, Michigan, Minnesota, and Nebraska agencies
(US-EPA, 2008b)	Lean in Government Starter Kit: a Practical Guide to	

	Implementing Successful Lean Initiatives at Environmental Agencies	
(US-EPA, 2009a)	The Lean and Chemicals Toolkit	Canyon Creek Cabinet, Goodrich Aerostructures, Lockheed Martin
(US-EPA, 2009b)	The Environmental Professional's Guide to Lean & Six Sigma	
(US-EPA, 2011a)	Lean, energy & climate toolkit: Achieving Process Excellence Through Energy Efficiency and Greenhouse Gas Reduction	Baxter International, General Electric, Toyota Motor Manufacturing North America, Cummins, Inc.
(US-EPA, 2011b)	Lean & water toolkit: achieving Process Excellence Through Water Efficiency	IBM, GE, DTE energy

Others authors have proposed different alternatives such as toolbox using 5S and poka-yoke tools to help addressing the environmental management system (EMS) (Pojasek, 1999a, 1999b) that have been applied and adapted to improve the systems (Gogula et al., 2011). Benefits of this application are the reduction of disposal costs by establishing a reusable container program with its suppliers, more effective resource utilization implying financial benefits, savings in avoiding product obsolescence and disposal (US-EPA, 2000). Additionally, by applying this, space, cost, energy needs, air emissions, solid waste are reduced (US-EPA, 2003).

3 Achieving sustainable work environment with Lean production

From the previous section, it was obvious that companies could save large amount in reducing wastes, particularly, SME companies (Alves et al., 2011). With some exceptions, Portuguese textile and garment companies are included in this category and presented many problems such as: accumulated stocks everywhere due to the wrong product produced, to the anticipated production or to the large lots (overproduction), demotivation of operators and high absenteeism, high level of accidents, operator's specialization, high energy and water consumption, high raw materials consumption and disposal, high pollution of rivers, soil and air, among others.

According to the US-EPA (2011b), the apparel (garment) industry uses high volumes of water in raw material production however authors are more concerned in the manufacturing phase. This section will, mainly, divulgate proposals, some available, others in development, to reduce the water and energy consumption, environmental wastes and raw materials in manufacturing phase. Additionally, proposals to improve leanness and agility are summarized.

3.1 Proposals for the reduction of energy and water consumption

This problem analysis could be detailed by technological process of the textile industry: spinning, weaving, textile ennoblement (dyeing and finishing), knitting and sewing. From all the processes, dyeing and finishing, are the one that consume more energy and water: it is impossible to dye and finishing without water and some processes have several washes, so, high water consumption and energy to heat the water.

According to ATP (2000), the volume of water annually consumed varies between 90 000 m^3 and 800 000 m^3. In table 2, it is possible to see the water consumption by treatments (operations), substrate used and machine.

From the table 2 it is perceived that the type of substrate, machine and process used, influence the water consumption. Understanding this influence could improve the decisions took by companies, taking a decision that reduces the water consumption. Today, technological advances should concern on how to reduce the water and energy involved in the transformation process. Currently, there are research projects in progress that investigate the possibility of replacing the water by CO_2 in the dyeing of synthetic fibers. Others related projects are using enzymes to optimize the dying process (less time, less energy and less water) and some performance indicators involving various stakeholders are been developed to help companies visualizing the economic benefits of these projects (BATinLoko, 2010). However, there are

other challenges for the environment that is necessary to be aware like the use of nanotechnologies and its impact in the environment (Almeida & Ramos, 2012).

Table 2: Influence in water consumption according type of substrate, machine and process used

Treatments	Substrate type	Machine	Water consumption (l/Kg)
Desizing, bleaching, dyeing, rinsing, soaping, softening	cotton fabrics and their mixes	washing machines off	25-50
Washing wool fabrics and their blends	wool fabrics and their mixes	washing machines off	50-100
Bleaching, dyeing, rinsing, soaping, softening	knitted cotton mixes	Jet	100-150
Bleaching, dyeing, rinsing, soaping, softening	yarn and cotton mixes	Autoclave	120-200
Washing, dyeing and rinsing, softening	wool knitwear mixes	Jet, Barca	100-150
Washing, dyeing, rinsing, soaping, softening	yarn and mixes	Autoclave	50-100

In ITMA 2011 - International Exhibition of Textile Machinery 2011, held in Barcelona in September, the main message given was to build machinery more efficient, less water and energy consuming.

The US-EPA (2011b) is a toolkit developed to help companies to improve water efficiency. This toolkit is based on Lean principles and applies some tools such as root cause analysis, 5Why, fishbone diagram, 5S, Kaizen events, value stream mapping (VSM) and Visual management as practical strategies and techniques to identify problems sources and improving common Lean results related to time, cost and quality, reducing water use, costs, and risk. In this toolkit is also divulgated a spreadsheet developed by Global Environment Management Initiative (GEMI), to help the creation of a water balance for a facility, available at: www.gemi.org/waterplanner/calc-waterbalance.asp.

The US-EPA (2011a) is another toolkit to address the energy efficiency and climate pledging a reduction of greenhouse gas emissions, costs and risk. The delivery of value to customers continues assured through the products quality. The tools employed in this toolkit are VSM, Six Sigma, standard work, visual controls, employee engagement and mistake-proofing, Kaizen events, Total Productive Maintenance (TPM) and plant layout reconfiguration.

3.2 Proposals for the reduction of environmental waste

Environmental waste is an unnecessary or excess use of resources or a substance released to the air, water, or land that could harm human health or the environment. Environmental wastes can occur when companies use resources to provide products or services to customers, and/or when customers use and dispose of products (US-EPA, 2007).

During the industrial process companies produce pollutants substances, materials wastes, air emissions, wastewater discharges and hazardous and solid wastes (trash or discarded scrap). The hazardous substances can affect the workers during the industrial process and the consumer when they are present in the product. Dyeing and finishing use chemical products and dyes that, when discharged directly into rivers, could be prejudicial. That kind of effluents must be processed before discharged into the river in order to not contaminate the rivers, killing fish and wildlife or, even better, is not to use these products or try to replace them with less pollutant which is not always possible, since products quality will decrease. The registers or labels on products should be checked, as well an estimation of the level of pollution that it causes.

In Portugal, environmental concerns have increased and, in the textile industry, some important work is been done. In respect to the Environmental Management, textile companies are managed according to NP ISO 14001:2004 and some companies also by regulation (EC) Nº 1221/2009 of the European Parliament and the Council of 25 November 2009 (EMAS, 2009). Nowadays, few Portuguese textile companies are registered under Eco-Management and Audit Scheme III (EMAS III), according to the Portuguese Environment Agency (PEA). Under the NP ISO 14001:2004, International Standards relating to environmental management are intended to provide organizations with the elements of an environmental

management system (EMS), which can be integrated with other management requirements helping these organizations to achieve environmental and economic objectives (NP ISO 14001:2004, 2004).

The European Union (EU) eco-label (Figure 4) for textile products ensures that certain substances are not used because they are prohibited or, if can be used limits the amount, according to environmental standards to be fulfilled.

Figure 4. EU Eco-label (EU, 2000)

Another label is the Öeko-Tex® Standard 100 (Figure 5) applied to a textile or accessories, ensuring textile that products are not harmful substances to human health. This label is based on a norm prohibiting or restricting the presence of certain substances in textile products. The products are classified in four categories according to the use and contact with the skin: I) baby products, II) products in contact with the skin (interior clothes, bed sheets), III) products which are not in direct contact with skin (coats, ...) and IV) decorative material. A company with their products or the entire production chain for these products, that is, all companies involved in its production, certified according to Öeko-Tex® Standard 100 could obtain the Oeko-Tex Standard 1000 certification.

Figure 5. Oeko-Tex Standard 100 and 1000 (International Oeko-Tex Association, 1992)

Öeko-Tex Standard 1000 complements the Öeko-Tex® Standard 100 and is more focused on products with testing, auditing and certification of production units which respect the environment throughout the entire textile chain. To obtain a certification according this standard, companies must fulfill a certain criteria relating to production process that respect the environment and prove that, at least 30% of total production, is already certified to Öeko-Tex® Standard 100. Without exception, this standard show that these products are safe in terms of human ecology and environmental criteria were fulfilled. Unfortunately, Portugal have very few companies certified by Öeko-Tex® Standard 1000. There are others certifications to ensure environmental responsibility, namely Global Organic Textile Standard (GOTS) (IWG, 2011).

The environmental concern allows companies to reduce costs by reducing energy consumption, water, and products and so on; increased sales for the valuation of services; improving the image; opening new markets. It is important to notice that the technological advances should concern about the reduction of greenhouse gas emissions or the reduction of the use of chemicals, without changing the quality of textile products.

US-EPA, once again, provide companies with some toolkits to achieve this reducing environmental wastes (US-EPA, 2007) and enhancing environmental performance related to all aspects of chemical manufacturing, management and use (US-EPA, 2009a). Tools used for achieving this are VSM, Six Sigma, 6S (5S + safety), standard work, visual controls, employee engagement and mistake-proofing, Kaizen events, Total Productive Maintenance (TPM). Time, cost and quality of products are, in this way, assured to the client.

An environmental management system is based on the PDCA cycle (P – Plan; D – Do; C –Check; A - Act) and its main objectives are: eliminate or minimize the environmental impact of an organization, establish and comply with the environmental policy; periodically check the objective and systematic management

system implemented, to achieve continuous improvement in environmental performance (NP EN ISO 14001:2004, 2004).

Other efforts intended to apply a continuous application of an integrated preventive environmental strategy (processes, products and services) to reduce risks to humans and to the environment come from organizations like United Nations Environment Program (UNEP) that had been developing cleaner production programs (UNEP, 1996). WBSCD and UNEP recognize that eco-efficiency and cleaner production program are complementary, reinforcing the same goal of sustainable development (WBCSD/UNEP, 1998). A recent report from the same organization, UNEP (2011) addresses some challenges for decoupling natural resource use and environmental impacts from economic growth, identifying driving factors, both technological and economic from countries where decoupling is already taking place.

3.3 Proposals for reduction of raw materials consumption

Textiles companies have been an industry strongly dependent on raw materials consumption, like cotton, natural fibers, silk, wool, dyes, among others. So, it is fundamental to assure a biodiversity of species and take care for its continuity. The economics of ecosystems depends on that. This is the reason why UNEP hosted studies like The Economics of Ecosystems and Biodiversity - TEEB (TEEB, 2010) – reporting that the economic values of biodiversity and ecosystem services, must be considered in the decision-making processes.

This has been the concern of many great companies (Diesel, O&M agency,…) that launched campaigns to prevent the killing of animals for their skin (WWF, 2010), Figure 6. Research on alternatives materials could be one solution to natural materials. As an example, the green textiles are more promoted than before. Materials like biological cotton or use of more friendly fibers such as polyester or hemp are real alternatives to the existent and were promoted in the last textile forum organized in Portugal (CITEVE, 2011).

Figure 6. Campaign from O&M agency: “Fashion claims more victims than you think” (WWF, 2010)

Recycling materials are also an alternative to satisfy demands instead of exploring the existent ones, for example, use of clothes from recycled materials such as PET products. Another interesting project is the transformation of old clothes in paper sheets for weddings invitations or paper bags for shopping.

Lean production, promoting the urgent need to reduce/eliminate the seven wastes, particularly overproduction, defects and over-processing, will avoid, the extraction of raw materials to produce unneeded products among other effects (Moreira et al., 2010). Tools to reduce these wastes like JIT production, leveling, standard work, mistake-proofing mechanisms, will reduce the raw materials depletion. Adopting a Lean consumption (Womack & Jones, 2005), instead of a mass consumption behavior, by an adequate culture will also contribute to this reduction. The provider and the consumer will be aligned, with the first (provider) supplying exactly what the second (consumer) want, where and when he/she want without waste his/her time by solving his/her problem permanently.

3.4 Proposals to improve leanness and agility

It is worth to mention that The Millennium Project (2009) sustainable development and climate change are the first of the 15 Global Challenges facing humanity and its accomplishment will improve enormously the life for all in the planet. Due to global warming, causing by climate changes and the disappearance of well-defined seasons, the textile companies had to change their business strategies as a way to satisfy the market because some winter days are warm as well as others during the summer are cold. Therefore, the demand for certain items, such as finer knitwear during the winter and even tops improved companies to rethink their management strategies.

The traditional seasonal demand and the way of working are changing and companies must be flexible in order to respond quickly to their customers following Lean strategies producing only what is needed, on the right quantity and on the right time (JIT production). By doing this, large lots of the same product provoking overproduction will be avoided. Other Lean tools already referred are necessary to implement the JIT production, being the most important tool, the engagement and motivation of people. With engaged and thinking people the company will have the agility for adapting to changes that are occurring (Alves et al., 2012).

4 Concluding remarks

This paper showed that Lean Production and Sustainable development are totally aligned with the same purpose. It is worth to notice that the trend already exists and that all stakeholders are trying to reduce water, energy, raw materials and environmental wastes. Using Lean principles and tools like VSM, 5S, Kaizen, TPM, poka-yoke mechanisms or others, would benefit to achieve these objectives. Textile industries are also trying "walking the talk" and are doing some changes to the conventional processes. This was exposed through the great number of projects already in progress permitting to the companies walk the right way.

Some proposals were presented in this paper showing that some efforts are been doing in order to sustainable development but much has to be done. LP could help achieve this sustainable development and help to aware for the biggest barrier to sustainable development that is resistance to change. This paper tried to present what can be done in textile and garment industry nevertheless these proposals can be applied to all industries and services. As a future work, the authors will develop a proper methodology that links all these "loose ties", showing that all important topics are connected.

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