

AG1815 Sustainable Development, ICT and Innovation  
Royal Institute of Technology KTH

# Waste Management - Impacts and ICT Solutions

Literature Assignment

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March 18, 2022

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# Abstract

Unsustainable waste management practices have a large impact, both ecologically and socially. Landfills pollute and produce inhabitable areas while harboring materials that could be recycled. Waste incineration has a smaller direct impact, and sometimes produces recyclable residual products, but also contributes to pollution and carbon dioxide emissions. With increased reuse and recycling, the production of virgin materials and newly produced products could decrease. This paper investigates the possibilities of implementing an AI sorting robot for recycling facilities, enabling for recycling without sorting, and the use of a browser extension that could suggest second-hand goods matching the contents of a consumer's cart on an online retailer's website. An AI sorting robot could reduce hazards in the recycling facilities and make recycling more attractive to the consumers, but requires a large investment up front. A browser extension that guides consumers to buy used products instead of new ones would require little additional resources but could have an impact on many workers involved in the production chain of new goods.

# 1. Introduction

Ever since industrialization began, increased consumption has been seen as the key to economic growth. Goods aimed at consumers and industries alike are selling at ever-increasing rates. In a linear economy, the materials in a product are discarded when the product has filled its use, and we are left with a growing mountain of waste. UN Sustainability Goal 12, "Responsible Consumption and Production", mentions this problem, including targets such as "By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse" and "By 2030, achieve the sustainable management and efficient use of natural resources" [1].

Even so, out of the 6300 million metric tonnes of plastic waste estimated to have been produced, almost 80% are now in landfills or nature[2], and every year 50 million metric tonnes of electronic waste are created[3]. One solution to this problem is decreased consumption, resulting in less waste since there are less produced goods to begin with. Another solution is recycling, turning materials into new products. However, often recycling does not happen. This can be due to many reasons, but one reason is that it is more cumbersome to sort recycling than it is to throw it out as waste. In countries like Sweden where waste is incinerated, the negative effects of throwing recyclables as waste are not seen as immediately as in countries that use landfills, but reducing the amount of waste is not the only positive impact of recycling. Recycling reduces the need for the production of virgin materials, which has an impact on the environment in industries using fossil fuels or precious metals for material production e.g. in the production of plastics or electronics.

## 2. Aim

The overall aim of this report is to investigate the problems of waste management processes, and to investigate and hypothesize over possible ICT solutions to these problems.

To do so, the report covers the direct and indirect sustainability problems caused by waste disposal. After this follows a description of how reduced consumption and recycling can solve these problems, and the potential indirect impacts of the two approaches. Finally, the two possible ICT solutions to the waste management problems are discussed. The suggested ICT solutions are reflected on, and both their direct and indirect possible impacts are explored.

The sustainability problems of waste management and production of new goods and materials are essential to understand in order for consumers to understand why changed habits and legislation is needed, and for engineers to understand the impact of the ICT products they are developing.

### 3. Description and Analysis from a Sustainability Perspective

#### 3.1 Description of Direct Impact

The negative impact of waste depends on how the waste is managed. The most common way globally to handle waste is by landfill[4]. Landfills are large areas of land filled with waste, either by placing the waste in piles or by filling a dug hole in the ground[5]. The waste can consist of many different materials, such as electronic waste, construction waste, plastic and cardboard packaging, textiles, and metals. The direct environmental impacts of landfills are many. If rainwater runs through the landfill, it gets polluted by toxic materials such as heavy metals and so-called volatile organic compounds, or VOCs. The resulting liquid, often called leachate can depending on the content of the landfill be toxic to aquatic life[6]. Contaminated rainwater can also enter groundwater reserves, making them unusable for humans and agriculture[7]. It can also travel with water, in the end polluting oceans and lakes[8]. This goes against the UN Sustainability Goal 6, "Clean Water", which highlights the importance of clean water for human consumption, agriculture, and ecosystems. Not only aquatic life is affected, birds and other animals flock to landfills in search of food but often end up eating plastics and other inedible materials instead. This can lead to the death of the animals by starvation, as the gastric system is filled with indigestible materials, and it can also lead to waste being spread outside of the landfill[9]. Since plastics are so light-weight, they can be carried with the wind away from landfills or waste transportation trucks, ending up in the oceans[10]. The problem of plastics in the ocean can be seen clearly. A report by the Ellen MacArthur Foundation and The World Economic Forum predicted that by the year 2050, the oceans will consist of more tonnes of plastic than of fish[11].

Waste incineration has less obvious environmental effects. However, the incineration process releases carbon dioxide, a greenhouse gas, which contributes to global warming. The incineration process also releases other harmful elements, such as nitrogen oxides, sulfur, and acid gasses[12]. The practice of incinerating waste therefore has a negative impact on the Swedish Environmental Objectives, namely goals "Clean Air" and "Reduced Climate impact"[13, 14]. When the incineration process is over, metals can be separated from the ashes and recycled, and if stored and treated the remaining ashes can be used as a building material[15]. This is, however, done at a limited scale in Sweden today, as there are concerns of pollution and legislation which makes use of the ashes difficult[16].

## 3.2 Analysis and Discussion of Impact from a System Perspective

When consumption decreases or materials are properly recycled, it results in an enabling effect in the form of a decreased need to produce new goods and virgin materials.

An often talked about material in terms of recycling and environmental impact is plastic. Plastic is used for everything from household machines to clothing, furniture, electronics, and packaging. Virgin plastics are made from petroleum, meaning oil. Oil is produced by drilling into the ground, either on land or in oceans, and pumping the oil up to the surface. When oil drilling is done in the oceans there is a risk of pollution, as seen from the BP Deepwater Horizon oil spill in 2010, which affects wildlife to this day [17]. Not only wildlife is affected, but the oil spills also have an indirect negative impact on the fishing industries, as it kills the fish [18]. A change in the system where recycled plastics get incorporated into the production of new plastics would decrease the need for oil production. This could have an indirect effect on the price of oil, which could have an impact on the price of gasoline. If the price of gasoline drops, this could have an indirect negative effect on the environment through an increase in petrol-driven cars. Oil production is not the only negative impact of the production of virgin plastics. It also pollutes the air by releasing toxic materials such as methyl ethyl ketone, which can cause respiratory irritation and at high exposure levels could cause problems with the nervous system, and methylene chloride, a known carcinogen [19, 20, 21].

Precious metals, such as silver, gold, and copper, are often used in electronics. The production of these materials in their virgin form is problematic both from an environmentally and a socially sustainable viewpoint. The environmental impacts include the physical disturbance of natural habitats as mines and roads are built, the erosion of exposed rock containing metals which releases the metals into the groundwater reserves, and acidification of water as exposed pyrite oxidizes [22]. The social impacts stem from the use of so-called conflict minerals, which can be produced under conditions where human rights are not respected, such as through slavery or for the benefit of armed groups engaging in conflicts killing civilians. These minerals include cassiterite, wolframite, tantalite, and gold [23]. When electronics are properly recycled, much of the metals can be reused. However, some recycling gets sent to low-income countries, where people are forced to do the dangerous work of dismantling and extracting the metals by hand, with little or no safety equipment. Sometimes the plastics in the electronic devices are burned to reveal the metals, producing poisonous gasses and polluting the ground, and precious metals are stripped in acid baths. Water and agricultural land are polluted, leaving inhabitants with the only option of buying more expensive bottled water and imported food, and one of few ways they can afford this is by working with the hazardous metal extraction[24]. An indirect effect of this is that it forces groups in the area to remain in poverty, counteracting the UN sustainability goals 1, "No Poverty", 6, "Clean Water", and 8, "Decent Work and Economic Growth"[25, 26, 27] .

Production of consumer goods has a massive impact on the environment. 4 million metric tonnes of carbon dioxide are released every year from the production of new textiles and clothes consumed in Sweden alone. Many of these products are thrown away, even if they could still be used. Around 60% of clothes and textiles thrown in the household waste in Sweden are still in good condition[28]. Much of the consumption goods in Sweden are imported, and the clothing sector is no exception. Unfortunately, many major clothing brands outsource their

production to factories where workers are forced to work long hours under unsafe conditions. As seen in the Rana Plaza collapse in Dhaka, Bangladesh in 2013, which claimed the lives of 1132 garment workers [29], the safety standards of these factories are very poor. Sewing is not the only part of the production of clothes that raises social and environmental concerns. Cotton, which is commonly used in textiles, needs massive amounts of water to grow [30], and pesticides used for growing cotton have been involved in many deaths[31]. Another popular fiber to use for textiles is polyester, which is a type of plastic and is therefore connected with all the problems of plastic production. Even textiles made from recycled plastics can be problematic, as fibre blends consisting of several types of fibres, such as plastic and cotton, are expensive to recycle. Instead, they often end up either in a landfill, or in the waste incinerator [32].



## 4. ICT as a Possible Solution for Sustainable Development

### 4.1 AI Assisted Recycling Sorting

One solution for making recycling as easy as possible is to allow consumers to not sort their recycling before discarding it. Instead, a robot using a camera and AI (artificial intelligence) could be trained to identify and sort recycling.

There are already trials of this type of system, but since the technology requires a large investment it is only economically viable for plants processing a lot of recycling[33]. Not having to sort recyclables would likely increase the rate of recycling, leading to production companies having to rely less on virgin materials. An indirect effect of this would also be lower costs, as recycling would not have to be put in different containers and held separate throughout the collecting or discarded due to being mixed in with other materials. Some recycling facilities which handle mixed recycling rely on workers to manually sort incoming materials. If a robot does the sorting, the risk for injury due to for example broken glass would decrease[33]. However, a possible indirect effect of less need for workers would lead to the loss of jobs. Even though the introduction of ICT solutions does not result in a loss of the total amount of work available in the long run [34], it would mean that the workers currently employed for sorting waste would lose their jobs. Another system effect that an easier recycling process could have is an increase in used materials. When recycling is made easy, there is less incentive from the consumer to lessen the amount of materials that are bought, as the amount of waste produced becomes less obvious.

Even if recycling is better than discarding, it is not a perfect process for all materials. Plastic degrades in the recycling process and can only be recycled around 7-9 times before it is too brittle to turn into new products [35]. However, there is no guarantee plastics are recycled this many times, often recycled plastics are used for goods that are not, or can not be, recycled. This means plastic might end up in a landfill or waste incinerator after just getting recycled once [36].

Recycling is therefore not the end-all-be-all of waste problems but needs to be implemented in combination with consumption-reducing efforts.

### 4.2 Online Shopping Browser Extension for Pre-Owned Items

An item bought second-hand is not connected to the environmental and social sustainability problems of the production of new goods, which means that a possible solution to lessen the amount of waste produced is to reuse items to a greater extent before discarding them. An

ICT solution for this could be a browser extension that checks online second-hand shops for the item put in a cart on a website of a retailer for newly-produced goods. This gives an easy way for consumers to find products they are looking for, without contributing to the environmental impact of newly-produced goods. This would decrease the environmental impact of the production sector by decreasing the consumption of new products.

Since internet shopping is already done through browsers, and since most major browsers support the use of extensions [37, 38], the direct impacts of implementing this solution are small. There are privacy concerns to using extensions, as they require users to share information about their internet usage, but many consumers already use similar extensions to receive coupons, e.g. Honey, with over 10 million users worldwide [39]. If the consumption of new goods decreases, production companies would be forced to change their tactics of business. Many companies producing clothing and accessories are so-called fast-fashion companies [40]. The business model relies on the rapid production and consumption, of low-quality goods at a low price. This business model only works when there is high consumption of the goods, as the profit margin is too low for the businesses to survive otherwise. Fast fashion companies, much like electronic companies, often buy wares from factories placed in low-income countries. The workers have very low wages and work under poor conditions, breaking the UN Sustainability goal 8, "Decent work and Economic Growth", goal 12, "Responsible Consumption and Production" and in turn goal 10, "Reduced Inequality"[27, 1, 41]. UN Sustainability Goal 8.7 states that "[...] by 2025 end child labour in all its forms". Child labor has been reported in factories producing textiles, and since the supply chain for these products is so complex, and since the clothing brands put high demands on flexibility and meeting deadlines, whether a producing factory uses child labor or not is not always known by the clothing company [42]. The use of child labor counteracts the UN Sustainability goal 4, "Quality Education" [43]. When children are forced to work in factories, they miss out on education. This leads to them being stuck on low-wage jobs throughout adulthood, with little chance to achieve a better standing.

If consumption of consumer goods decreases due to the use of this extension, it could lead to different indirect effects both ecologically and socially. Firstly, as mentioned, a change in the business model of fast fashion and similar model companies. This could result in higher prices for goods, which could mean lower-income consumers would not afford to buy items in the same quantity. A higher price could mean a higher wage for workers, but could also lead to just more profit for the companies. This would likely not be enough to ensure fair treatment of workers but would have to be combined with a consumer push for better transparency in the production and changed legislation. A decreased demand would also lead to decreased supply. This might result in a loss of jobs for the workers in the production line.

## 5. Reflection

As an engineer in ICT, I have a responsibility to increase the awareness of problems and solutions with ICT in regards to environmental and social concerns. This includes choosing and influencing the workplace, and always have sustainability consequences in the back of my mind when working on a project or product.

As a consumer, we all have a responsibility to reduce, reuse and recycle, in that order. The consumption rates today are not sustainable by any means, and the population of Sweden lives as if we had the resources of 4,2 worlds [44]. It is in my opinion clear that capitalism does not support humanity in an extended period, as it promotes consumerism and wastefulness, and rewards practices such as planned obsolescence and short-lived fashion trends. Often the blame is put on the consumer: "We only produce what the people buy", but in my opinion, the consumption patterns are a product of an industry pumping billions into marketing. In 2019, the year before the covid-19 pandemic, it is estimated that companies spent approximately 613.9 billion US dollars on marketing worldwide [45]. How are consumers supposed to stand up to the demands of multi-billion dollar industries to consume more, follow trends, and stay updated with the latest tech? With this in mind, I think it is the consumers' responsibility to demand politicians to introduce legislation that promotes sustainable production and consumption, and which punishes unsustainable practices to such a degree that they become economically unviable.

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