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A Review of Sustainable Paper Sourcing: Mitigating Deforestation in the Paper Production Industry

Otis Chan[1] and Thomas Bouldin[#]

[1]Kent School, USA
[#]Advisor

ABSTRACT

The paper industry's rapid expansion and overall large demand have led to severe environmental consequences, including deforestation and pollution. This study examines the detrimental effects of paper production, such as toxic chemical discharge into bodies of water and extensive deforestation. In addition, the study also analyzes potential solutions to mitigate the extreme impact on the environment, such as sustainable paper manufacturing, lean manufacturing strategies, and closed-loop systems. Sustainable paper manufacturing advocates for the use of alternative raw materials. Lean manufacturing strategies reduce the amount of time and materials it takes to make one batch of paper, thus reducing resource consumption and production time and enhancing sustainability and efficiency. In addition, by urging the paper industry to adopt a closed loop system, products can be continuously recycled, remanufactured and thus reduce the amount of waste and additional resources needed. These viable solutions pave the way toward a more sustainable future for the paper industry, mitigating its environmental impact and fostering ecological resilience.

Introduction

While not spoken about as much, the paper industry has silently caused a large amount of waste and pollution currently damaging our environment. The process of the production of paper accounts for the third most emissions in Canada, and the sixth most in the United States (2015 Summary Report. 2017), with the industry being the fifth largest consumer of energy in the world (World GHG Emissions. 2013). China is the world's largest paper producer, producing 125 million metric tons of it in 2021. In comparison, the United States produced 67.5 million metric tons (Forestry Production. 2013). Globally, 414.09 million metric tons of paper was produced in 2022, with 400 million metric tons being around the average produced each year since 2010. In 2015, the paper industry emitted 174,000 tonnes (5.3%) of the total 3.3 million tonnes of emissions released by all industrial sectors in Canada. The pulp and paper industry in the United States emitted 79,000 tonnes (about 5% of total industrial pollutant emissions) in 2015 (2015 Toxics Release Inventory. 2017). Manufacturing paper releases nitrogen dioxide, sulfur dioxide, and carbon dioxide in the air, contributing to pollution and greenhouse gasses that are responsible for climate change, like global warming (Jiang et al. 2021). Paper production is composed of many steps, the first being gathering resources. The reckless deforestation of forests around the world has only increased, due to the increasing demand for paper. In 2009, 371 million metric tons of paper were produced worldwide. In 2022, 414 million metric tons were produced (Forestry Production. 2013). Trees help reduce the amount of carbon dioxide in the atmosphere, with just the Amazon absorbing one-fourth of all carbon dioxide absorbed in the world. Cutting them down also releases the carbon dioxide stored inside them, leading to increasing global warming. Forests also act as many species' natural habitats, with thousands of unique species going extinct because of the mass deforestation occurring every day. The second step, which is the production of paper in the factories itself, is a massive resource drain. Gallons of water are needed to produce just one sheet of A4 paper, as the chemical byproduct is discharged into waters near the factory with no regard

for where it goes, or who it affects. While the paper industry has caused many environmental issues, there are multiple potential solutions to help lessen their environmental footprint. Sustainable paper manufacturing, closed-loop systems, and waste reduction strategies are some of the solutions that could help the paper industry find a balance between profit and environmental impact.

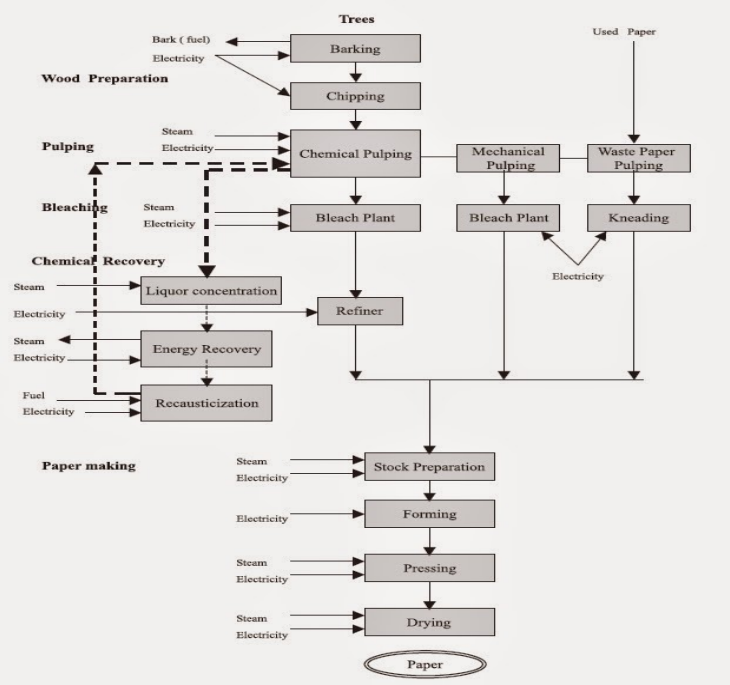

Figure 1. Process Flow Diagram of the Pulp & Paper Industry (Process Flow, 2015)

Problems Caused by the Book Industry

The process of creating paper from trees is a long and arduous process and involves the use of many natural resources in a wasteful manner. After the wood is transported into the factory and turned into wood chips, they go through a process called chemical pulping. In chemical pulping, the wood chips are cooked in a chemical solution, which breaks down the lignin and separates the cellulose fibers. While this process creates higher-quality pulp, it also causes major toxic chemicals to be discharged into rivers. Area mill operations discharged about 250,000 pounds of carcinogenic chemical compounds contaminating the sediment in a singular river in Wisconsin (Environmental Impacts. 2023). This paper production plant also released approximately 14.7 million pounds of known toxic substances between 2019 and 2021 in Wisconsin only. These toxic chemical substances can cause issues such as cancer, fertility problems, endocrine-disrupting chemicals, and other severe problems. It can be spread to people by the chemicals leaching into the groundwater, and being drunk by people. (Singh et al. 2022) In Canada, the paper industry is the third biggest contributing factor to toxic lead in the waters, (2015 Toxics Release Inventory. 2017) while in the United States, the pulp and paper industry was ranked first among industries for the amount of toxic-weighted pound equivalents released into water.

Many natural resources, especially water, are used extensively in the paper-making process as well. Water is used through the chemical pulping stages, as well as the bleaching stages, which are done to make the paper more white. About 324 liters of water are needed to produce 1 kilogram of paper. It requires 10 liters of water to produce a single A4 sheet of paper. In some nations, up to 10% of all freshwater can go to making paper. Wastewater discharged from the factories also heavily affects marine life, to the point of driving them

towards extinction. (Jiang et al. 2021) Factories also produce greenhouse gas emissions, although lessened from before, as they switched from coal to natural gasses and biomass.

Paper waste filling up landfills is also a prominent problem, with paper and paperboard being around 26% of the 258 million tons of waste generated in 2014, and over 14% of the 136 million tons of waste that ended up in landfills in 2014. (Advancing Sustainable, 2016) The ink or dyes in discarded paper thrown in landfills can still affect the environment, as it can be carcinogenic when burned, or leak into the ground when left in landfills. Paper is used in every facet of life, from education to office work and government business. A survey of around three thousand employees in Europe revealed that the average worker printed out 34 pages a day, of which 17% wasn't even used. (Retail Tops, 2006)

Deforestation

According to The World Counts, 42% of all global wood harvest is used to make paper, with 12% of global greenhouse gas emissions being from deforestation. Between 2010 and 2015 there was an annual forest loss of 7.6 million hectares and an annual gain of 4.3 million hectares per year, resulting in a net annual decrease in forest area of 3.3 million hectares. Since 1990, 420 million hectares of forest have been lost as a result of human activity including land clearing for agricultural farming and logging. (Global Forest, 2020) When loggers cut down forests, CO2 escapes into the atmosphere. Forests hold up to 228 to 247 gigatons of carbon, more than what humans produce annually, but because they release carbon dioxide when cut down, it makes deforestation a huge factor in global warming. (Deforestation and. n.d) Forest loss contributes nearly 5 billion tons of carbon dioxide into the atmosphere every year, which is equivalent to nearly 10% of annual human emissions. About 2% of working forests are harvested each year. Forests also act as the habitat for many species, with deforestation destroying their natural home and ecosystem, sometimes leading to their extinction. According to recent estimates, the world is losing 137 species of plants, animals, and insects every day to deforestation. A horrifying 50,000 species become extinct each year. Millions of people also depend on the forest for their income and livelihood. Healthy forests help create local rainfall, which is essential for the ecosystem and the people living around the area to survive. When deforestation occurs, forests stop producing rain, resulting in changes in precipitation and river flow (Deforestation and. n.d)

Much of the wood harvested in North America is used for paper, around 36%. (Bowyer et al. 2014) Despite attempting to solve the problem of deforestation with the use of plantation forests, they are usually monoculture which has a negative effect on the wildlife and ecosystem that lives in the area. Despite the government's efforts to protect their forests, usually by issuing sustainable forest areas, illegal logging is an issue due to the high demand worldwide for paper products. In Indonesia, illegal forestry deforested 4.2 million hectares of rainforest, destroying the natural habitat of endangered species like the Sumerian tiger. In Indonesia, Greenpeace estimates that around 76-80% of logging is illegal.

Potential Solutions

Sustainable Paper Manufacturing

Fortunately, there are multiple potential solutions for the variety of problems paper production causes. The main goal is not to stop paper manufacturing, as it is unrealistic due to the growing demand for paper, but to implement sustainable paper manufacturing. Sustainable paper manufacturing is a broad term used to describe practices that minimize the environmental impact of paper production, while still meeting the demand for paper products. A direct way to help lessen the need for lumber, in turn reducing the deforestation and effects caused because of it, is the use of alternative raw materials. There are many different alternative materials that can be

used, with the most common one being Post-Consumer Waste, which is just old paper being recycled from the bin. The average American uses 650 pounds of paper per person, with a large amount of that same paper arriving in a landfill after its use. This makes Post-Consumer Waste relatively cost-efficient, as well as abundant. Another alternative material is leftover waste from farms, such as straw, bagasse, and corn husks. They're usually in abundance and use fewer resources to turn into paper. Another raw material, Kenaf, is similar to the cotton plant and uses 15-25% less energy than pine to make pulp. Bamboo produces 4 to 5 times the fiber of the fastest-growing commercial tree species and can be used for other things such as clothing. By using ingredients that already exist, the deforestation of entire areas can be prevented while money can also be saved. Another way to lessen the environmental impact is silviculture. Sustainable forestry is about silviculture, when you nurture and reforest areas that have been deforested. Silviculture encompasses various techniques such as regeneration, site preparation, tree planting, and reproduction methods. Different silvicultural systems like selection systems, clearcutting, shelterwood, and seed-tree methods have specific applications in forest management. (Nyland. 1996) The goal is to maintain or enhance biodiversity by preserving habitat structure, promoting native species, and protecting sensitive ecosystems.

Lean Manufacturing Strategy

Lean manufacturing strategy is done by reducing the amount of time it takes to produce one batch of paper. The lean manufacturing strategy is used to eliminate waste, improve quality, reduce time and costs, and enhance operational efficiency. By increasing the efficiency of the production line, producing more in less time is possible. By reducing production time by 50%, the environmental footprint left would be reduced by 50% as well. Reducing the byproduct from paper production also helps curb the environmental footprint. This system proposes separating byproducts into four categories: Perfect items, which can be sold for full price on the market, Non-reworkable defect items, which can be sold at a low price for raw materials, reworkable defect items, which can be reworked and sold for near full price, and lastly disposable waste, which is just thrown out. By using this model, the research team was able to lessen the number of pollutants by 25%, a significant change. This model's total cost per cycle increased by 0.0053%, with the price being so low because of government-implemented systems of pollution cap and trade. This allows companies who innovate and produce less environmental waste to purchase credits from the government, which saves money. This study proposes utilizing the Theory of Constraints (TOC) to enhance sustainability within manufacturing processes by systematically reducing cycle time. TOC identifies bottlenecks, and critical resources that might limit production rates, and suggests maximizing their utilization to maximize sustainability. Traditionally, TOC focuses on increasing production throughput, but this study applies it to enhance sustainability. The least sustainable area becomes the constraint location. Processes with fixed resource consumption, like furnaces or milling machines, are termed "location X". In a balanced manufacturing line, sustainability depends on resources at location X, regardless of how much they produce. Design improvements can increase machine capacity beyond 100%, reducing cycle times and enhancing sustainability. Summed up, the study proposes systematically reducing cycle time at one location to improve sustainability at another, aligning with TOC principles (Goyal et al. 2022).

Closed-Loop System

A closed-loop system, in simple terms, is a system where materials and products are continuously recycled, remanufactured, and reused, minimizing waste and reducing the need for new resources. It has many components, the first being resource optimization. This involves selecting materials that can be easily reused, recycled, or repurposed. They are also made to be able to last longer and be more durable than other materials. Another component is energy efficiency, which can be done in many ways. Incineration, which is a thermal treatment procedure, is done by burning solid waste in facilities called waste-to-energy plants. Using the heat generated

by burning the waste, thermal energy is harvested, with the dangerous byproducts such as noxious gasses being filtered out by emission control systems. When using the re-manufacturing strategy, which is reusing materials to create new items, energy usage lessened by 40% when compared to conventional production, causing significant reductions in greenhouse gas emissions (Sharma et al. 2023). Companies are working towards achieving Net Zero Water, which would allow them to completely reuse a batch of water instead of using more. Water can be reused 10 times or more throughout the pulp and paper mill process before it is discharged. 88% of the water used for production is treated in wastewater systems and returned to the environment. Another component of a closed-loop system is waste reduction, which involves using the inevitable waste produced by the production of paper and using it for other purposes, instead of throwing it away. Paper manufacturers can compost organic waste generated in the production process, such as wood chips and bark, to reduce waste and produce a useful product. Energy recovery systems can capture waste heat from paper production processes and use it to produce energy or use the heat elsewhere. The average American uses 650 pounds of paper per person, with a large amount of paper being used for schools, textbooks, or offices. Many of those instances that need paper can be done online instead. While it might not solve all the problems caused by the paper industry, digitalization is still an idea that should be explored and developed further. The global market for sustainable packaging solutions, including sustainable paper, is expected to reach $244 billion by 2025.

Conclusion

The book industry is currently contributing to one of the biggest factors affecting global warming: the paper industry. There are various ways in which they affect the environment, chief among them being deforestation. Around half of the trees being cut down are being used to make paper, with each tree lost being more carbon dioxide added to our atmosphere, heating the planet up. Scarily, paper is on the rise, with 400 million tonnes of it being produced per year. However, the materials needed aren't the only thing affecting the environment, as the production process wastes even more natural resources. A shocking statistic is that it requires 10 liters of water to produce a single A4 sheet of paper. Chemicals are also used during the process of making paper, with some carcinogens being carelessly dumped into nearby rivers despite their toxic attributes.

Thankfully, there are plenty of proposed solutions. Sustainable paper manufacturing tries to stop the damage being done from the start, as it advocates for alternative sources, such as straw, bagasse, and corn husks, to be used. Since they are usually in abundance, it can help minimize deforestation. Closed-loop systems are used in manufacturing processes in many other industries as well. It refers to a system where all resources are used until their limit, such as treating water to reuse it many times or using heat made from production to create energy. An obvious solution would be to maximize waste reduction. This is done by perfecting the process and making it so that fewer resources are needed to produce a sheet of paper. Finally, certificates issued such as FSC or PEFC can help too, as they help people identify which companies are sustainable and care about their own environmental footprint.

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