UBC Social Ecological Economic Development Studies (SEEDS) Student Report

An Investigation into 30% Post-Consumer Recycled Wood Fiber Paper and Wheat Paper

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APSC 262

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ABSTRACT

This report outlines the feasibility of adopting wheat fiber paper over 30% recycled wood fibre paper at University of British Columbia (UBC) and bringing wheat paper technology into Canada using a triple bottom line assessment (TBL). Minto Roy, from Royal Social Print Paper (RSPP), approached Paula Goldspink from UBC's supply management department, with the proposition of having UBC replace the 30% recycled wood fibre paper they currently purchase from Domtar with a paper made of wheat straw. The company's product is currently being produced in India with hopes of bringing the technology to Canada. The use of a TBL for this report requires the investigation of the environmental, economic and social benefits and fall-backs of using wheat paper on a local and national scale.

Environmentally, the pros and cons of the two raw material options and their associated pulp and paper processes were explored. The ecological footprint of each resource was found along with the amount of air emissions, solid wastes, and water effluent produced for the two alternatives. An assumption made during this analysis is that the pulping process for both materials is different but the paper making process is nearly identical. Economically, the relative cost of wheat paper to wood paper was determined by comparing the raw materials, labour, storage, transportation, pre-processing, pulping, and bleaching costs, as well as the production loss of the two options. Next, bringing wheat paper technology into Canada's pulp and paper industry was investigated by determining the availability of wheat straw along with revenue trends and retrofitting costs. To determine the social benefits two key problems were explored. Whether farmers can make a significant profit by selling wheat straw and what new job could be created in the farming sector along with the social impact wheat paper would have on the current wood pulp and paper mills in Canada.

Overall, the proposal of adopting wheat paper at UBC and potentially Canada was found to have more benefits then disadvantages. The price of manufacturing/operating was found to be similar for both material types and that the price of wheat will be more stable and cheaper than that of wood in the future. Wheat paper will reduce the trees consumed and ecological footprint while producing less air emissions and solid wastes than the conventional wood pulping process. Finally, wheat paper will add an increase in farmer income nationally, help create awareness of paper fibre alternatives locally, and continue to promote UBC's image as a leader in sustainable technologies.

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GLOSSARY

Adsorbable Organic Halides (AOX) - a surrogate measure of the amount of chlorinated organic compounds in pulp and paper effluent discharge.

Biological Oxygen Demand (BOD_5) - The amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present in a given water sample at certain temperature over a specific time period.

Brightness – A designation for the percentage of light reflected by a sheet of paper. As the paper brightness increases, the degree of contrast between the paper and the print also increases. The levels usually range from 84 to 98, which are adequate for most digitally printed applications.

Elemental Chloride Free (ECF) - A technique that uses chlorine dioxide for the bleaching of wood pulp. It does not use elemental chlorine gas and prevents the formation of dioxins and dioxin-like compounds, carcinogens.

Gasification – is a process that converts organic materials into carbon monoxide, hydrogen and carbon dioxide. This is achieved by reacting the material at high temperatures (>700°C), without combustion, with a controlled amount of oxygen and/or steam. The resulting gas mixture is called *syngas* and is itself a fuel. The power derived from gasification of biomass and combustion of the resultant gas is considered to be a source of renewable energy.

Kenaf – Also called Hibiscus cannabinus, is a plant in the Malvaceae family.

Pulpwood –The timber with the principal use of making wood pulp for paper production.

Total Suspended Solids (TSS) – A measure of the suspended solids in wastewater, effluent, or water bodies, determined by tests for "total suspended non-filterable solids."

LIST OF ABBREVIATIONS

AOX - Adsorbable Organic Halides

BOD_5 - Biological Oxygen Demand

ECF - Elemental Chloride Free

RSPP - Royal Social Print Paper

TBL - Triple Bottom Line assessment

TSS – Total Suspended Solids

UBC – University of British Columbia

1.0 INTRODUCTION

University of British Columbia (UBC) strives to be a global leader in campus sustainability. As part of the efforts, its Supply Management commits to purchase more sustainable products used around the campus. Paula Goldspink, from the Supply Management, is approached by a company, Royal Social Print Paper (RSPP), with its wheat fiber paper product called Social Wheat Paper. The wheat paper is currently produced in India and is claimed to be more sustainable than the 30% recycled wood fiber paper UBC currently uses. To assist Paula with the purchase decision, this report analyzes the feasibility of adopting the wheat paper over the 30% recycled wood fibre paper using the triple bottom line assessment (TBL). It compares the environmental impacts of producing the two types of paper, and evaluates the economical and social benefits of adopting the wheat paper over 30% recycled wood fiber paper.

2.0 PAPER MAKING PROCESS

The paper making process is fundamentally unchanged since its discovery. However, the materials and technologies involved in each step of the process vary from each pulp and paper mill. This section compares the manufacturing process of 30% recycled wood fiber paper produced by Domtar with the Social Wheat Paper proposed to UBC by Royal Social Print Paper. The technical details of the paper making process are based on the information obtained from these two companies.

2.1 RAW MATERIAL PREPARATION

This section discusses the raw materials used to produce wood and wheat paper.

2.1.1 Woodchips

Woodchips are the raw material used by pulp mills to produce wood fiber pulp. They are made from cutting lumber into small pieces or are the by-product from sawmills. Before pulping, woodchips are screened for certain quality and size. The leftover woodchips are burned as biomass fuel to generate energy to power the pulp mills.

2.1.2 Wheat Straw

The Social Wheat Paper is made from wheat straws which are agricultural waste baled and stored after harvesting. Before pulping, the wheat straws need to be chopped and the leaf and node need to be removed from the stem. The leaf and node, which weight about 50% of the wheat straw mass, are burned as biomass fuel to generate energy to power the pulp mill (Clean Washington Center. 1997). Figure 1 shows the composition of a wheat straw.

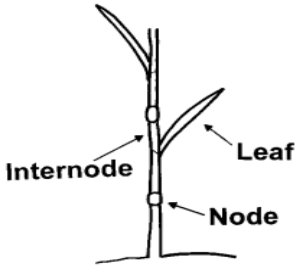

Figure 1: Composition of a Wheat Straw (Clean Washington Center. 1997)

2.2 PULPING

Pulping is the process of removing lignin from fibers. Lignin acts as natural glue holding the other fibers together. Wood contains 23 – 34% of lignin while wheat straw contains 16 – 21% of lignin (Paper Task Force, 1996)**.** Domtar uses a Kraft process for wood pulping. Since there is not enough information obtained from RSPP about their wheat straw pulping process, it is assumed that a soda pulping process, which is the most widely used non-wood pulping process, is used (Paper Task Force, 1996). Both pulping processes can remove 95% of lignin in the fibers.

2.2.1 Kraft Process

In this process, woodchips are impregnated with a sodium hydroxide and sodium sulphide solution and then cooked in huge pressurized vessels. Woodchips turn into wood pulp after lignin is dissolved. The solution, which contains lignin and the spent pulping chemicals, is called black liquor. As an integral part of the Kraft pulping process, the black liquor goes into a chemical recovery system. The chemical recovery system recovers about 99% of the pulping chemicals and the water that comes out of the recovery system is clean enough to be used in other part of the mill (Paper Task Force, 1995).

2.2.2 Soda Process

The soda process is very similar with the Kraft process, except it uses sodium hydroxide and caustic carbonate solution to cook wheat straw. This compound eliminates the need for sodium sulphide and thus is more environmentally friendly (Paper Task Force, 1996).

2.3 BLEACHING

Bleaching is the process of whitening the pulp by removing the remaining lignin in the fibers. The Social Wheat Paper uses a sodium salt and oxygenation process, which is also known as enhanced Elemental Chloride Free (ECF**)** bleaching process (Paper Task Force, 1995). Some pulp mills owned by Domtar also use the enhanced ECF bleaching process (Environmental Paper Network, 2012). Therefore, it is assumed 30% recycled wood fiber paper purchased by UBC is also bleached using the enhanced ECF bleaching process.

In the enhanced ECF bleaching process, the pulp is first treated with oxygen to remove some of the lignin. Then the treated pulp is bleached with chlorine dioxide produced from

sodium salt. The waste water that comes out of bleaching process is treated in a waste water treatment plant process (Paper Task Force, 1995).

2.4 PAPER MACHINE

After the pulp is bleached, it is mixed with water and other types of pulp, such as recycled pulp, and then sent to papermaking machine. On the paper machine, pulp is first spread onto a mesh screen to form a fiber mat. The fiber mat is pressed with sets of rollers to squeeze the water out. The paper sheet is formed after removing extra water through a drying process.

3.0 ENVIRONMENTAL ASPECTS

In this section, the environmental impacts of producing 30% recycled wood fiber paper and wheat paper are analysed. Environmental benefits of replacing wood fiber with wheat straw fiber for making paper, energy consumption and the pollutants produced from the two paper making process are analyzed.

3.1 BENEFITS OF REPLACING WOOD FIBER WITH WHEAT FIBER

According to Paula Goldspink, UBC uses roughly 280 tons of paper per year. One ton of 30% recycled uncoated wood fiber copy paper uses 3 tons of wood, which is equivalent to 18 average trees (Paper Task Force. 2012). In Canada, about 27% of wood fibers received by pulp mills are from pulpwood and the rest from wood residue (Statistics Canada. 2002). If UBC replaces 30% recycled wood fiber paper with Social Wheat Paper, it can save roughly 1361 trees annually.

Further, replacing wood fiber with wheat straw fiber in producing paper signally reduces the demand of forest land harvesting. Table 1 shows the area of agriculture land required to produce one ton of bone-dry pulp. On average, 1.0 hectares of agricultural land is required to produce one ton of wheat pulp. Spruce, accounting for 80% of pulp wood usage, requires an average of 4.8 hectares of forest land to produce 1 ton of wood pulp (Kissinger et al., 2006).

Table 1: Ecological Footprint of one ton of pulp by source and province (Kissinger et al., 2006)

The total ecological footprint of one tonne of chemical unbleached bone-dry pulp by source and province			
	Manitoba (ha)	Saskatchewan (ha)	Alberta (ha)
Wheat straw	0.8	1.2	1.0
Flax straw	2.4	2.6	2.3
Spruce	5.7	3.9	4.7
Aspen	2.5	2.7	2.3

3.2 ENERGY CONSUMPTION

There is no data available for energy consumption of wheat paper pulping and bleaching process. Therefore energy consumption of kenaf soda pulping/ECF bleaching process for non-wood fibre is used to estimate the energy consumption of wheat paper. This assumption is valid because kenaf has similar fiber properties as wheat straws (Paper Task Force. 1996). Energy consumption of wood fiber paper pulping and bleaching is estimated through softwood Kraft pulping/ECF bleaching process. Table 2 shows that energy consumption of pulping and bleaching wheat fiber paper is higher than that of wood fiber.

Table 2: Consumption of Softwood Kraft/ECF and Kenaf Soda/ECF Process (Paper Task Force. 1996)

Millions of BTUs per oven-dried ton of pulp

	Softwood (ECF bleaching) [1	Kenaf [2]
DIRECT ENERGY		
Process energy	22.3 - 24.2	15.2
Bleaching chemical energy	10.2 - 10.2	5.7
TOTAL	**32.5 - 34.4**	**20.9**

3.3 POLLUTION FROM WHEAT AND WOOD PAPER MAKING PROCESSES

This section discusses the release of air emissions, solid wastes, and water effluents into open water sources from the wheat and wood paper manufacturing processes previously described in section 2.0.

3.2.1 Air Emissions

Air emissions generated by both paper manufacturing processes come from burning fuels and the associated chemical processes. The data on air emissions from chemical processes could not be obtained, therefore, only the air emissions generated by burning fuels is compared in this report.

According to Domtar status report, NO_x emissions is 2.6 kg/ton of paper and SO_2 emissions is 1.52 kg/ton of paper. The chemical emissions can then be calculated. Table 3 shows that Social Wheat Paper generates about 50% less air emission compared with Domtar paper (Domtar, 2010a).

Table 3: Air Emission Comparison of Domtar paper with Social Wheat Paper

Air emission	Domtar Paper	Social Wheat Paper
NO_x emissions (kg/ton)	2.6	1.3
SO_2 emissions (kg/ton)	1.52	0.76

Note that this report does not account for air emission from burning biomass fuel which generates 75-80% of pulp mill energy. This is because emission from burning biomass fuel is insignificant compared to that from burning fossil fuel.

3.2.2 Solid Wastes

According to RSPP, wastes produced during wheat paper pulping process is recycled and turned into cardboard boxes to store the paper. In other words, the wastes are not released to the environment. On the other hand, Domtar generates 46.41 kg/ton of paper solid wastes (Domtar, 2010a) from chemical recovery system, wastewater treatment system, and ashes after burning the bio mass fuel. The solid waste is then sent to landfills after treatment.

3.2.3 Water Effluents

RSPP states the water used in their pulp and paper mill is treated and reused many times. Therefore, it is assumed the water is not deposited into open water sources. In the case of Domtar pulp and paper mills, 90% of the water used during the process is returned to open water sources after treatment. Although there are environmental concerns about Biological Oxygen Demand (BOD_5), Total Suspended Solids (TSS), and Adsorbable Organic Halides (AOX)**.** Contained in the released water affecting the aquatic community, studies show that the pulp and paper mill effluents have insignificant effects (Malmberg, Sleep, Lama, Flindlers, 2010). In addition, Figure 2 shows that population and community changes are affected by various factors.

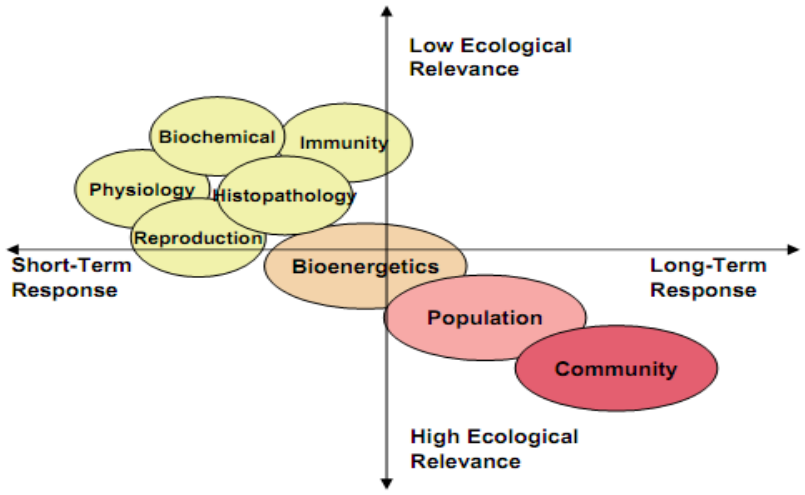

Figure 2: Measured Endpoints for Assessment of Effluent Effects for Ecological Relevance and Response Time (Malmberg et al., 2010)

In summary, replacing 30% recycled wood fiber paper with wheat straw paper at UBC can save 1361 trees annually, reduce forest land harvesting and decrease energy consumption. Producing Social Wheat Paper also generates less air emissions and produces no solid waste and no water effluent to water source. In general, wheat straw is a much greener paper material than wood fiber.

4.0 ECONOMICAL ASPECTS

This section analyzes the cost of producing 30% recycled wood and wheat paper and economics of the pulp and paper industry to evaluate the feasibility of adopting wheat paper.

4.1 RETROFITTING COST

Existing facilities of wood-fibre paper mills need to be retrofitted in order to manufacture wheat fiber paper due to silica content difference between wood and wheat. The retrofitting cost is estimated to be $50 million - $2 billion CAD (Lenz, 2010).

4.2 MANUFACTURING/OPERATING COST COMPARISON

The overall manufacturing or operating cost of 30% recycled wood paper and wheat paper are compared. Note that retrofitting cost is not included for a direct comparison of both manufacturing processes. After consulting Minto Roy from RSPP, and Neva Murtha who is a wheat paper campaigner of Canopy[1], the overall manufacturing cost of both types of paper has no significant difference.

The overall manufacturing cost is composed of the cost of raw material, labour, storage, transportation, pre-processing, pulping, bleaching, and production loss. However, limited information was obtained and the quantitative data of these costs is not known due to limited resources. Table 4 compares the breakdown of the overall manufacturing cost of 30% recycled wood paper and wheat paper.

[1] Canopy is a non profit organization aims to protect forests, http://canopyplanet.org/

Table 4: Breakdown of Overall Manufacturing Cost

	30% Recycled Wood Paper		Wheat Paper	
Raw Material	$150/ton[2] (raw wood)	more expensive	$70 -80/ton[2] (wheat straw waste)	cheaper
	increase in raw wood price by 15% in 10 years (Index Mundi, 2012)	more expensive	less likely to have change in wheat straw price due to abundancy	cheaper
Labour	less labour (Hurter, 2002b)	cheaper	more labour (Hurter, 2002b)	more expensive
Storage	no relevant information	cheaper	high storing density due to short harvesting season of 4-6 weeks (Cooper & Balatinecz, 1999)	more expensive
			requires protection from water and degradation (Cooper & Balatinecz, 1999)	
			15% loss from storage (Hurter, 2001a)	
Transportation	typically far from wood site to mills (Hurter, 2002b)	more expensive	typically shorter distance from wheat straw storage to mills (Hurter, 2002b)	cheaper
Pre-Processing (before pulping)	< 1 % of silica content (Boychuk, 2011)	cheaper	3-7% of silica content and thus requires special clean process (Boychuk, 2011)	more expensive
	more uniform pith content (Cooper & Balatincez, 1999)	cheaper	pith content leads to loss of biomass at screens and fines production (Cooper & Balatincez, 1999)	more expensive
Pulping and Bleaching	similar yield in chemical pulping (To & Chan, 2006)	same	similar yield in chemical pulping (To & Chan, 2006)	same
		more expensive	electrical energy decreases by 50 - 90% compared to wood pulping (BioRegional Development Group, 2006)	cheaper
		more expensive	water usage decreases by 80% compared to wood pulping (BioREgional Development Group, 2006)	cheaper
Production Loss (from raw wood/wheat to pulp)	overall fibre efficiency of 75% (Environmental Paper Network, 2007)	cheaper	overall fibre efficiency of 35% (Enviornmental Paper Network, 2007)	more expensive
		same overall manufacturing cost		**same overall manufacturing cost**

[2] Resources from Neva Murtha of Canopy

4.3 ECONOMICS OF PULP AND PAPER INDUSTRY

This section discusses the economics of the Indian and Canadian pulp and paper industries. The Indian pulp and paper industry is assessed to determine the security of purchasing wheat paper from Royal Social Print Paper (RSPP) as UBC's paper supply source. The Canadian pulp and paper industry and cases of manufacturing wheat paper in India and China are assessed to determine the feasibility of manufacturing wheat paper locally in Canada in the long run.

4.3.1 India

Paper mills in India have been well-developed to produce wheat papers. This is driven by deficient wood sources and very low per capita forest area (Singh, Dutt, & Tygai, 2011). Today India and China are the two main paper manufacturers using agricultural residue (Singh, Dutt, & Tygai, 2011).

In 2011, India produced 5.6 million tonnes of paper, accounting for 1.6% of world production (Singh, Dutt, & Tygai, 2011) with an annual growth of 6-7% (Indian Paper Manufacturers Association, 2012). In 2010, 60% of Indian paper mills uses agricultural residue including wheat straws. In terms of wheat straw availability, India is the second largest producer of wheat in the world, producing 68 – 75 million tonnes of wheat straw annually (Singh, Dutt, & Tygai, 2011). With 35% yield of wheat straw (Environmental Paper Network, 2007), there is enough wheat straw wastes to support Indian pulp and paper industry even if all papers are made of wheat fiber as shown in Table 5, assuming the supply of wheat straws is constant.

Table 5: Annual Estimation of Paper Production of India

Year	Annual Paper Production [million tonnes]
2011	5.6
2012	6.0
2013	6.4
2014	6.9
2015	7.3
2016	7.9
2017	8.4
2018	9.0
2019	9.6
2020	10.3
2021	11.0
2022	11.8
2023	12.6
2024	13.5
2025	14.4
2026	15.5
2027	16.5
2028	17.7
2029	18.9
2030	20.3
2031	21.7

The supply of wheat straw wastes is greater than the demand and the Indian agricultural residue based pulp and paper industry grows annually. Therefore, the supply of wheat paper from RSPP should be stable and secure.

4.3.2 Canada

There is currently no paper mills in Canada producing wheat fiber paper but the drive is growing as the cost of wood increases by 15% in the last 10 years (Index Mundi, 2012) and the availability of old-grown fir, a key pulp resource, diminishes (Broten & Ritchlin, 2011). Moreover, the Canadian pulp and paper industry suffers a -41% change (loss) in revenue from 2000 – 2009 and a further -16.5% change (loss) in revenue from 2008 – 2009 (Industry Canada, 2011). The drastic drop in revenue between 2008 – 2009 is believed to be caused by the economic recession in 2008.

To increase revenue, the cost must be reduced and this can be accomplished by decreasing materials and supplies cost which accounts for 69% of total manufacturing cost as shown in Figure 3 (Industry Canada, 2011). According to Neva Murtha of Canopy, the current cost of wood chips and wheat straws are $150 CAD/ton and $70–80 CAD/ton respectively. Therefore adopting wheat paper is a viable option because wheat straws are cheaper and more abundant. Unlike wood chips, wheat straws are wastes and have no relevant useful purposes and thus the price of wheat straw is likely be stable and cheaper than wood in the long run.

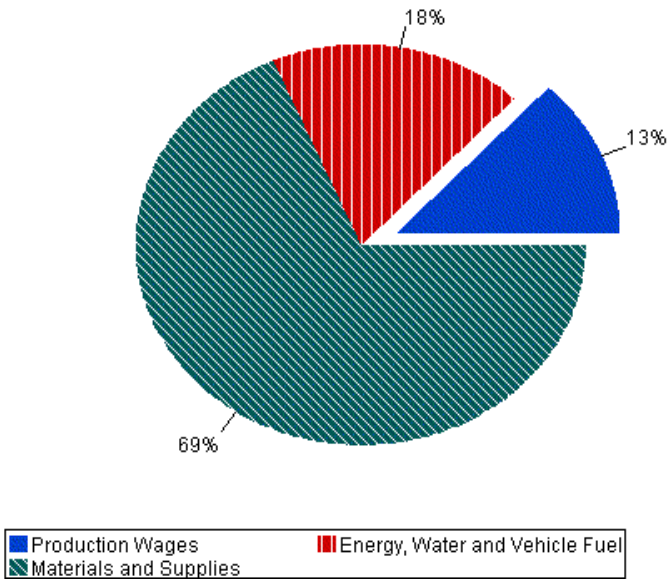

Figure 3: Manufacturing Costs of Pulp, Paper and Paperboard Mills (Industry Canada, 2011)

There are enough wheat straw wastes available to meet the paper demand in Canada. 2.9 million tons of paper were consumed and 6.46 million tonnes of paper were produced in Canada in 2003 with an estimated annual growth of 3.2% (Statistics Canada, 2009). Further, 45million dry tonnes of wheat straws are available annually in Canada (Cooper & Balatincez, 1999). With 35% yield of wheat straw (Environmental Paper Network, 2007), Table 6 shows that Canada has enough wheat straws to support the paper demand in the next 25 years even if all papers are to be made with wheat fiber, assuming the annual supply of wheat straw is constant. In addition, no expansion of agricultural land will be needed since wheat are grown and harvested annually. Further, minimal fluctuation of the price of wheat straws is expected because the wheat straw waste supply is greater than the demand.

Table 6: Annual Estimation of Paper Production of Canada

Year	Annual Paper Consumption [million tonnes]	Annual Paper Production [million tonnes]
2003	2.9	6.46
2004	2.99	6.67
2005	3.09	6.88
2006	3.19	7.10
2007	3.29	7.33
2008	3.39	7.56
2009	3.50	7.80
2010	3.62	8.05
2011	3.73	8.31
2012	3.85	8.58
2013	3.97	8.85
2014	4.10	9.14
2015	4.23	9.43
2016	4.37	9.73
2017	4.51	10.04
2018	4.65	10.36
2019	4.80	10.69
2020	4.95	11.04
2021	5.11	11.39
2022	5.28	11.75
2023	5.44	12.13
2024	5.62	12.52
2025	5.80	12.92
2026	5.98	13.33
2027	6.18	13.76

4.3.3 Cases of Manufacturing Wheat Paper in India and China

In India, paper mills using wheat and other agricultural residue makes up 60% of paper mills in 2010 (Singh, Dutt, & Tygai, 2011) and the Indian paper industry has grown 6-7% for the past few years (Indian Paper Manufactures Association, 2012). In the case of China, 20% of paper fibre comes from wheat or rice (Lenz, 2011) and the Chinese pulp and paper industry is

growing at 2.5% annually (Zhuang, Ding, & Li, 2005). Success adoption of wheat paper manufacturing in India and China suggests that wheat paper adoption in Canada is feasible. Although no financial data is available to determine the existing facility retrofitting break-even time, it's believed that adopting wheat paper is beneficial in the long run due to increasing price of wood sources and the abundance of wheat straw waste.

5.0 SOCIAL ASPECTS

In this section the social aspects of adopting wheat paper will be discussed. The two key features are the impact wheat paper would have on the farming industry and the effects it would have on the wood pulp and paper industry. Before addressing these topics a few smaller issues are investigated. First the performance of wheat paper was evaluated. As informed by Paula Goldspink, the majority of paper purchased by UBC is a copy paper made by Domtar. This paper, supplied by Unisource, is required to have a minimum brightness level of 92 (Unisource Canada, 2012). The package of wheat paper supplied by Minto Roy proved to meet this level of brightness. Additionally, the paper was tested in a laser and inkjet printer and performed just as well as the 30% recycled wood fibre paper. Next the labour laws in India were scrutinized to determine if they meet UBC's code of conduct. It was found that India has very strict labour laws and indeed corresponds to UBC's standards (Government of India, 2011). Finally, it's insured that there is enough wheat straw to meet Canada's paper production while not taking away for any of its other uses. It is found that 45 million tons of wheat straw is produced annually in Canada, mainly in the prairies (Copper & Balatinecz, 1999, Wheat Straw, para. 1). Taking a conservative estimate that half of this is distributed to animal feed, bedding, and returned to the soil, this leaves 22.5 million tons of wheat straw waste that is burned every year. This is enough wheat straws to meet much of Canada's book, magazine, catalogue and copy paper needs.

5.1 BENEFITS FOR FARMERS AND FARMING INDUSTRY

As mentioned there is a large amount of wheat straws that is unused in North America. Instead of taking advantage of this resource, millions of dollars are burned away each year. It is predicted that selling this wheat stalk could add a 20% increase in farmer's income (Hayes, 1997). Farmers currently make very little profit on their crop sales and rely on government subsidies. According to Hayes (1997), wheat straw sells for $40/ton (delivered). Assuming the price of wheat straw has not increased much over the last 15 years, this would create approximately $900 million dollars in revenue for farmers in Canada.

Since farmers wouldn't be able to handle all the work required to collect and distribute the wheat straw a new farm-based resource sector would be created. This sector would create new jobs in rural communities in collecting, storing, grading, and utilizing the wheat straws. An example of this vast industry can be seen in India. The paper industry in India, which uses a variety of agricultural residues, provides employment to approximately 460,000 people and since

the demand of paper is always increasing more employees will be required (Indian Paper Manufactures Association, 2009). Although the number of new positions that could be created in Canada will not be in the hundreds of thousands (since pulp and paper mills positions are already filled), a significant amount of jobs could emerge in the farming sector.

5.2 SOCIAL EFFECTS ON THE PULP AND PAPER INDUSTRY

Aside from the new jobs that could be created if new pulp and paper mills were to be created for wheat paper production, this section examines the social impact of introducing wheat paper technology on current wood fibre pulp and paper mills.

Although it had been mentioned in section 4.1 that wood pulp and paper mills can be retrofitted to adopt the use of wheat stalk, it is believed that some companies will continue to use trees for paper production. To look at the impact of wood fibre paper companies losing consumers it was assumed that UBC is willing to make the switch to wheat paper. According to Paula Goldspink, UBC uses approximately 56 million sheets of paper annually. This value translates to roughly 280 tons of paper (Environmental Energy Technology Division, 2012). It was then found that Domtar's Windsor paper mill location creates 665,000 tons of paper a year (Domtar, 2012). Assuming that only 10% of the total paper production goes towards copy paper, losing UBC as a customer would result in a 0.4% loss in sales. Since Domtar alone controls 10 paper mills, losing UBC as a customer would be insignificant. However, a raise in awareness of using wheat fiber as an alternative to wood fiber can be accomplished if UBC, as a leading university in sustainability, switches to wheat paper. This could lead to a wide adoption of wheat paper.

Assuming there was a drastic switch to wheat paper in North America and some mills were retrofitted to use wheat straw, wood pulp and paper mills would still be used since they are already well established and would be needed to produce items where the strength of wheat fibre is inadequate. These mills would still be able to strive while potentially making extra income. This would be accomplished by using only wood chips to make their products and using the excess wood chips for power and heat generation. A process known as wood-chip gasification, which is already being used in pulp mills, could be used to power the plant and potentially supply local communities with inexpensive electricity (Teislev, 2002).

In summary, wheat paper technology could create new job opportunities and extra income for farmers while having little effect on the current pulp and paper mills. If wheat straw

as a fibre alternative is widely adopted in Canada, current pulp mills could still benefit by cutting down cost by using strictly wood chips for paper production and selling local communities power at a reasonable cost by converting this new excess of wood chips into energy. In addition, for UBC adopting wheat paper would help create awareness of these alternative materials for paper production while helping promote UBC's image as a leader in sustainability.

6.0 RECOMMENDATIONS

It is recommended that UBC replaces its current 30% recycled wood fiber paper to wheat fiber paper produced by Royal Social Print Paper. This will increase UBC`s image of sustainability and act as a critical step to introduce wheat paper into Canada.

In general, wheat paper has more advantages than wood paper. In the environmental aspects, producing wheat paper as opposed to 30% recycled wood paper reduces tree consumptions, ecological foot prints, harmful air emissions as well as eliminating solid waste and water effluent. In the social aspects, producing paper from wheat straws can significantly increase farmers' income and support the farming industry while decreasing government subsidies.

In terms of feasibility, the supply of wheat straw wastes can meet the demand of paper in Canada and worldwide and thus it is feasible to adopt wheat paper. Moreover, producing wheat paper is economically beneficial because wheat straw source is abundant and unlike wood source, it has no other relevant usefulness. This will result in a more stable and lower cost than wood source in the long run.

In addition, several mills in the US are already looking into adopting wheat paper (Lenz 2010). This suggests that wheat paper manufacturing is feasible technologically and economically and thus Canada should adopt wheat paper to remain price competitive in the global market.

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