UBC Social Ecological Economic Development Studies (SEEDS) Student Report

# An Investigation into Rapidly Renewable Materials: Bamboo and Cotton

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**APSC 262**

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# An Investigation into Rapidly Renewable Materials:

# Bamboo and Cotton

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# ABSTRACT

Sustainable development requires the utilization of renewable resources. Renewable resources, whether it is energy or material, are the ones that can be regenerated within a short period time. Rapidly Renewable Materials (RRMs) are examples of such resources. RRMs are plant based materials that can be renewed within 10 years.  Bamboo and cotton are two examples of available RRMs. These two materials can be used as an alternative to their commonly used construction materials in the new StudentUnionBuilding on UBC campus.

Bamboo is a type of grass with extremely fast growth rate. The average time it takes for bamboo to reach maturity is 5 years. It can be used for flooring, wall covering, ceiling and furniture. Triple bottom line analysis shows that economically, it is much cheaper to purchase and recycle bamboo compared to its competitors such as Steel, Azobe and Robina. Environmentally, it can grow fast and absorb a considerable amount of $CO_2$ and produce Oxygen. It can also restore the degraded lands because its litter feeds the top soil of the land where it grows and its recycling process is environmentally friendly. Socially, it offers a variety of new job opportunities and green communities. There are some local suppliers of bamboo in Canada and hence it can be used in the new Student Union Building.

Cotton is a plant and its fibers are commonly used in clothing industry. However, cotton fibers can also be used as a good insulating material in building construction. Triple bottom line analysis of cotton shows that economically, it is less costly to purchase and implement cotton based insulators compared to its chemically produced competitors. Environmentally, if it is produced organically, not only it preserves the animal habitat and different insect species, but also it has a very limited foot print in terms of water consumption with only 2.6% of the global water use compared to other agricultural products. Socially, cotton can produce variety of green jobs and also alleviate health concerns compared to chemically produced insulators. Local suppliers of cotton insulators are available in Canada and therefore it can be implemented in the new Student Union Building on UBC campus.

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## GLOSSARY

Formaldehyde: An organic compound which produces toxic fumes that affect human health.

Janka Hardness test: A test to measure the hardness of wood (pounds-force). The higher the value, the harder the wood is.

Millipoints: A measure of environmental cost in dollars per weight of material

R-value: A measure of insulation performance. Higher R-value means better material as an insulation.

Volatile organic compound: Organic chemical compounds which have significant vapour pressure and can negatively affect the environment and human health.

## LIST OF ABBREVIATIONS

LCA: Life cycle analysis

LEED: Leadership in Energy and Environmental Design

RRM: Rapidly Renewable Material

VOC: Volatile organic compounds

# 1.0 INTRODUCTION

Today, one of the main challenges facing our civilizations is scarce natural resources, whether it is energy or material. Fast population growth, consumer culture and lack of foresight have resulted in wasteful consumption at an alarming rate. Therefore, sustainable development has become the center piece of every engineering project to slow down this trend.

Sustainable development requires the use of renewable resources. Among material resources, construction materials are the most widely used. Rapidly Renewable Materials are plant based materials that can be re-grown within 10 years. Bamboo, cotton, natural rubber, cork, straw are examples of such materials.

In this report, bamboo and cotton as two of the suitable RRMs that can be used in the construction of the new Student Union Building on UBC campus are investigated. First, each material is introduced and its application is identified. After that, triple bottom line assessment is performed on bamboo and cotton to determine if economically, environmentally and socially they outweigh their non-RRM competitors in the construction industry. At the end, a list of local supplier of these materials are introduced and based on the findings a recommendation for the implementation of these materials are given.

# 2.0 BAMBOO

Bamboo has always been an icon of eastern cultures, but in recent years they have become "synonymous with green design" (Sunset Books, 2010). Despite the common belief,bamboo is not a tree, but a grass, and develops a complex network of rhizomes which sprouts new bamboo shoots. Bamboo has become popular as a sustainable material due to its fast growth rate and that it requires little fertilization and water. Certain species of bamboo can grow up to "121cm over a 24 hour period" (Scienceray, 2009), the fast growth rate also means that it reaches maturity in a short period of time. The average time for bamboo to reach maturity is 5 years, as opposed to wood of comparable hardness which can take 50 or more years to mature. Even though bamboo is commonly used in North America, it is mainly grown in Asian countries and needs to be transported. Furthermore, turning bamboo into building material requires a lot of energy, and "some manufacturers use high-VOC resins and finishes, which negate other green features"(Sunset Books, 2010). Manufacturers that use formaldehyde-based adhesives should also be avoided.  That being said, the sourcing of bamboo must be carefully examined. Bamboo is an ideal material for LEED certification. It qualifies as a rapidly renewable resource for LEED certification under Materials and Resources (MR) Credit 6. Furthermore, bamboo products made without formaldehyde contribute to EQ 4.4 – Low Emitting Materials. This section introduces the application of bamboo, completes a triple bottom analysis, and provides a list of local suppliers.

## 2.1 APPLICATION

Bamboo offers several applications that may be implemented in the new SUB; these include flooring, wall covering, ceiling, and furniture. Flooring is one of the more common applications of bamboo utilized in housing today. There are three selections for bamboo flooring: solid, engineered, and strand-woven. Solid is constructed by pressing and gluing solid bamboo stalks together; engineered "combines bamboo wear layers with fiberboard cores" (Sunset Books, 2010); lastly, strand-woven "consists of shredded bamboo stalk that are pressed and glued together" (Sunset Books, 2010). Apart from the three choices, bamboo floors are also categorized as horizontal and vertical-grain bamboo. Horizontal refers to when bamboo stalks are glued together with the "wider side of the stalk faces up" (Sunset Books, 2010). When the stalks are "glued together on their sides" (Sunset Books, 2010), it is called vertical-grain bamboo.

The Janka hardness scale is an industry wide measurement to rate wood hardness, and is done by projecting a hard, round object against the material and rating the amount of impact needed to create a dent. Horizontal and vertical grain bamboo has a Janka rating of about 1200 (similar to oak), while strand-woven bamboo has a rating of 3000. Compared to wood of equal Janka rating, bamboo wears better since its' "fibers tend to bounce the round object out rather than accepting the impact by denting" (Sunset Books, 2010).

As mentioned, strand-woven bamboo has a Janka rating that is considerably higher than horizontal and vertical-grain bamboo; Thus making it more suitable for areas where heavy pedestrian traffic is expected. Such areas include, but are not limited to: Large Multi-Use Lounge, Pitt Pub, Sushi, Pizza, Art Gallery and all of the major walkways in the new SUB. Horizontal and vertical-grain bamboo is still an option for club rooms or offices inside the new

Student Union Building.

Wall paneling, wall covering and wainscoting can also be done with bamboo. The horizontal and vertical-grain bamboo also applies to bamboo veneers used in wall coverings. It is also possible to use bamboo flooring on walls, and veneers on ceilings. Almost all of the walls in the new SUB can use bamboo wall coverings or panels, the use will only be limited by the style that the architects wish to achieve. Figure 1 below demonstrates bamboo veneer and flooring utilized in Toyota marketing office in Europe.

Figure 1: Bamboo flooring and wall covering
(DMVP, 2011)

Bamboo plywood can be engineered to take different shapes, allowing diverse and creative use as ceiling material. An example is the Madrid airport, shown in figure 2, where bamboo plywood was extensively used in 200,000 square meters on the ceilings. The new SUB can consider using bamboo to decorate the ceiling, or perhaps implement curved bamboo plywood in its interior décor. Examples of interior décor that can use bamboo are: stairs, railings, countertops in kitchens and washrooms, and cabinets in offices. Figure 3 & 4 show the application of bamboo décor in housing.

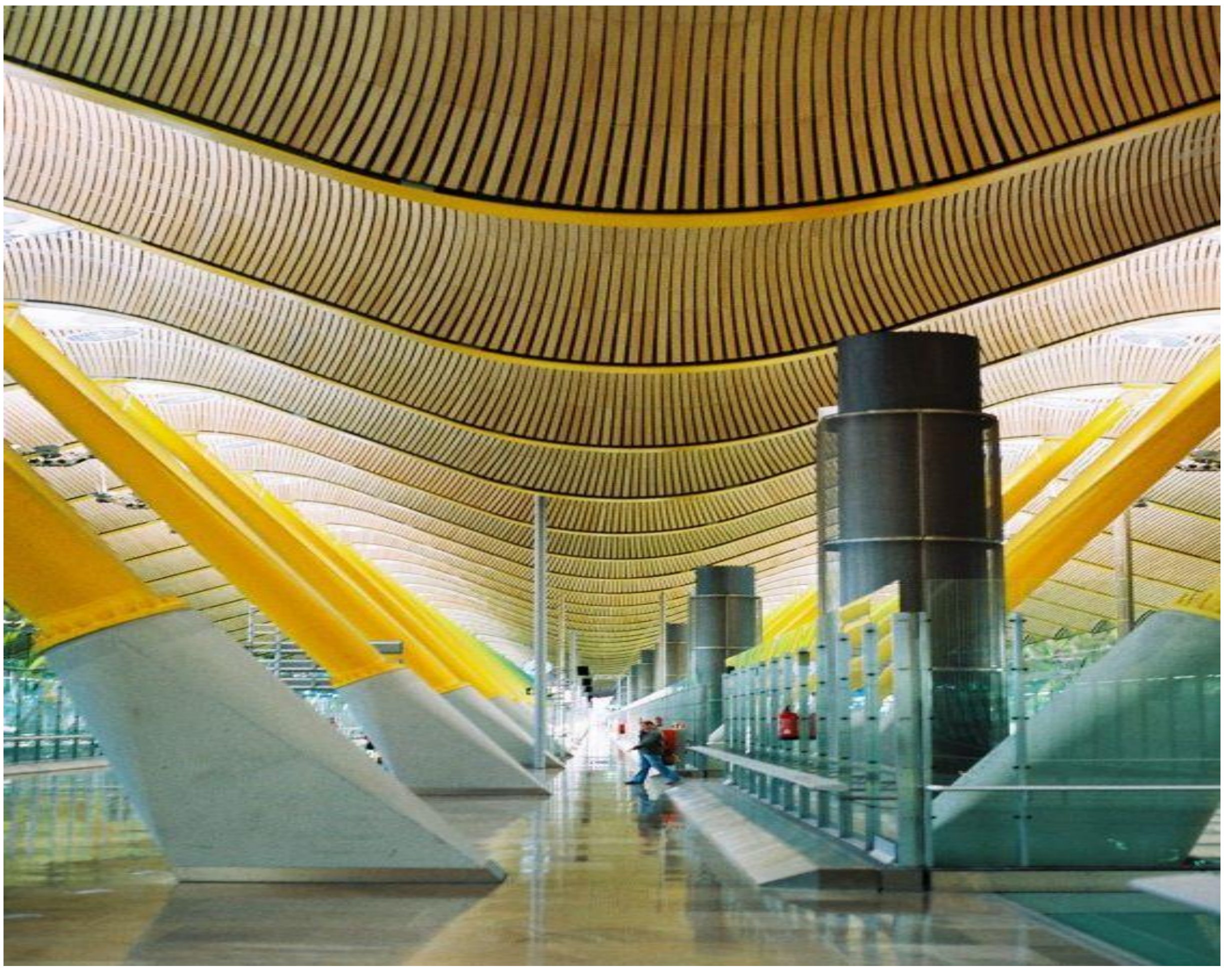

Figure 2: Madrid Airport
(Contemporist, 2007)

Figure 3: Bamboo cabinets, countertop, and flooring
(Mirambil, 2011)

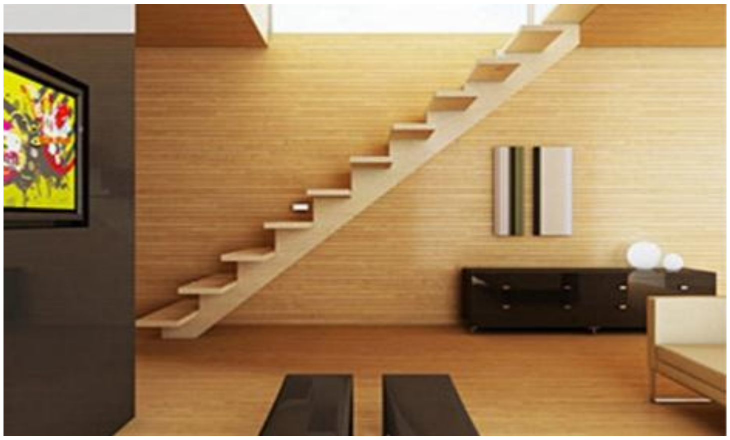

Figure 4: Bamboo wall covering and flooring
(Preston, 2010)

Bamboo furniture can range from a more exotic design constructed by hand with bamboo poles, or can be manufactured with bamboo plywood to create a contemporary piece. Since bamboo plywood can be used to build anything that wood is traditionally used for, many of the new SUB furniture can be fabricated with bamboo. Furniture that the SUB can consider incorporating bamboo into includes: seats and tables used in the cafeteria, club offices, study rooms, or general offices, lamp covers in offices, sofas for the lounges. Figure 5 & 6 shows a few example of bamboo furniture.

Figure 5: bamboo table and chairs
(Zaleski, 2010)

Figure 6: Bamboo lamp covers
(Kumar, 2008)

# 2.2 TRIPLE BOTTOM LINE ANALYSIS

## 2.2.1 ECONOMIC ANALYSIS

Traditionally, financial cost and revenues are the only factors taken into account when deciding on the choice of material for production. The triple bottom line analysis is a concept whereby a business considers its material choice after making environmental, social and also economic assessment. In this section, an environmental life cycle analysis (LCA) method is used for the choice of bamboo for construction. Moreover, all environmental cost and effects during the life cycle of bamboo are analyzed. The LCA method assesses resources from extraction to recycling.

**Purchasing costs**

High quality bamboo costs $3.50 per square foot which is considerably lower than the conventional hardwood (Maistry, 2007). The transportation cost of bamboo is the main concern when purchasing costs are being examined. Bamboo "grows naturally in biologically diverse forests throughout Southeast Asia, South and Central America and the Caribbean" (The Constructor, 2011, para.1). It is hard to find bamboo forests in Canada; however, some local bamboo wholesale suppliers grow bamboo in Canada, for example, Canada's Bamboo World. Therefore, the UBC New SUB project can order bamboo materials from local suppliers and this can also help to improve the local economy. Moreover, according to the research paper, "An Environmental, Economic and Practical Assessment of Bamboo as a Building Material for Supporting Structures," the transportation of bamboo is the least expensive compared to its alternatives. This comparison is shown in Figure 7 (Can Der Lugt et al., 2006).

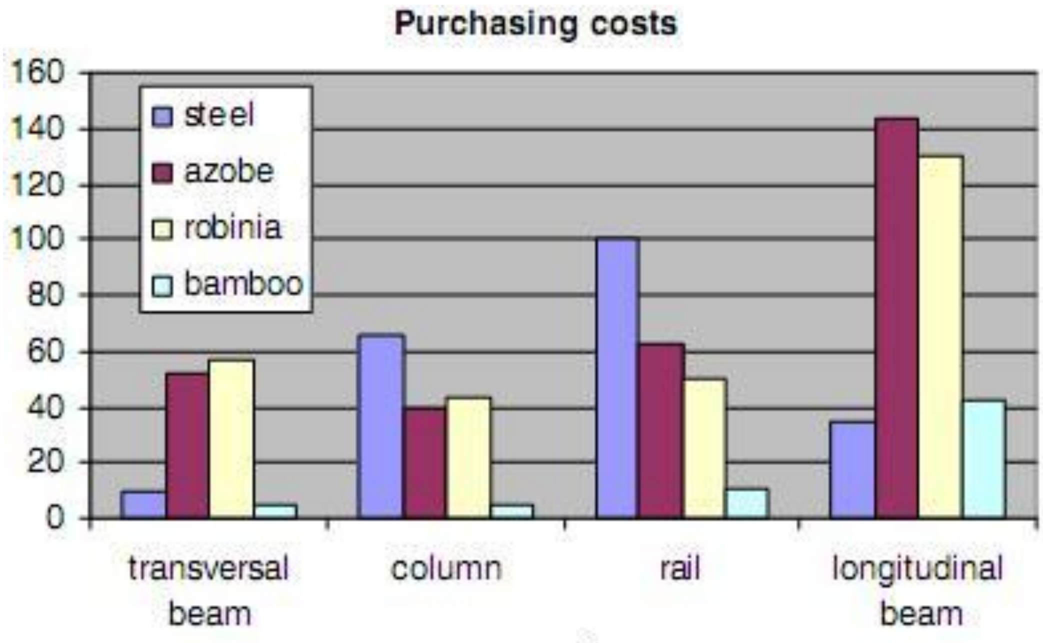


Figure 7: Purchasing costs (in €) of different materials and components
(Can Der Lugt et al., 2006)

**Environmental Cost**

Bamboo has a green reputation as it grows fast, absorbs tons of carbon dioxide and produces oxygen. However, bamboo is not a local material in Canada and as a result, it needs to be transported. The environmental life-cycle load of bamboo is divided into different stages: processing, preservation and transportation. Figure 8 shows the environmental load in Millipoints (mPTs) and the environmental cost of mPTs equals 10 to 13 dollar for one kilogram (kg) of bamboo. The study illustrates that most environmental load and costs are due to transportation. Long distance transportation "[increases] bamboo's carbon footprint due to the fuel burned for shipping" (Stein, 2008, p.196). However, the environmental cost of bamboo is only a tiny fraction of lumber, even when the lumber is sustainably grown (Stein, 2008).

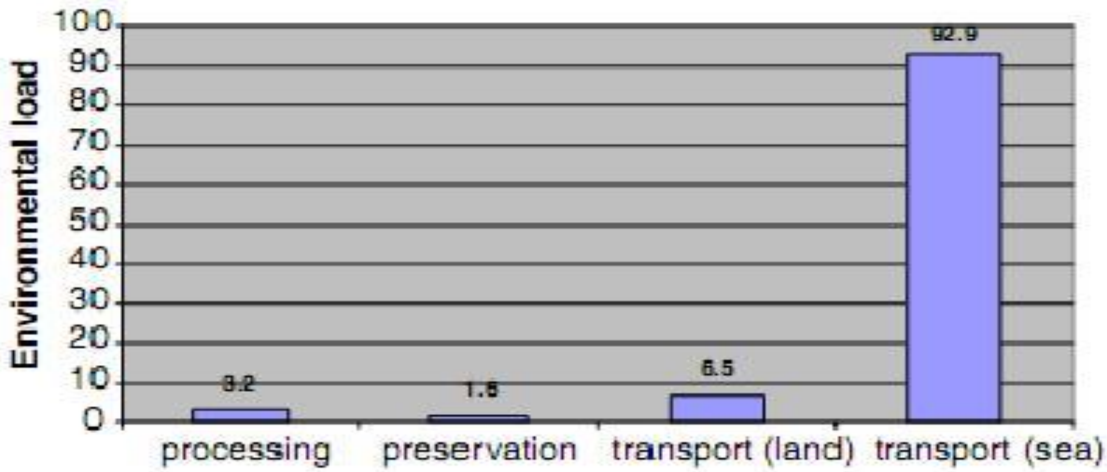

**Figure 8:** Environmental Load (in mPt) of one kg bamboo culm during the life cycle (Can Der Lugt et al., 2006)

As can be seen in figure 9, the environmental cost of different materials such as wood, steel and concrete are analyzed and divided into technical lifetimes. The cost of waste and recycling of the materials are considered and regarded as environmental cost at this point. In comparison to other alternative materials, "bamboo can be considered the most sustainable alternative by far in all functions" (Can Der Lugt et al., 2006). Consequently, bamboo is a low cost material that can be used in different applications in the New SUB project.

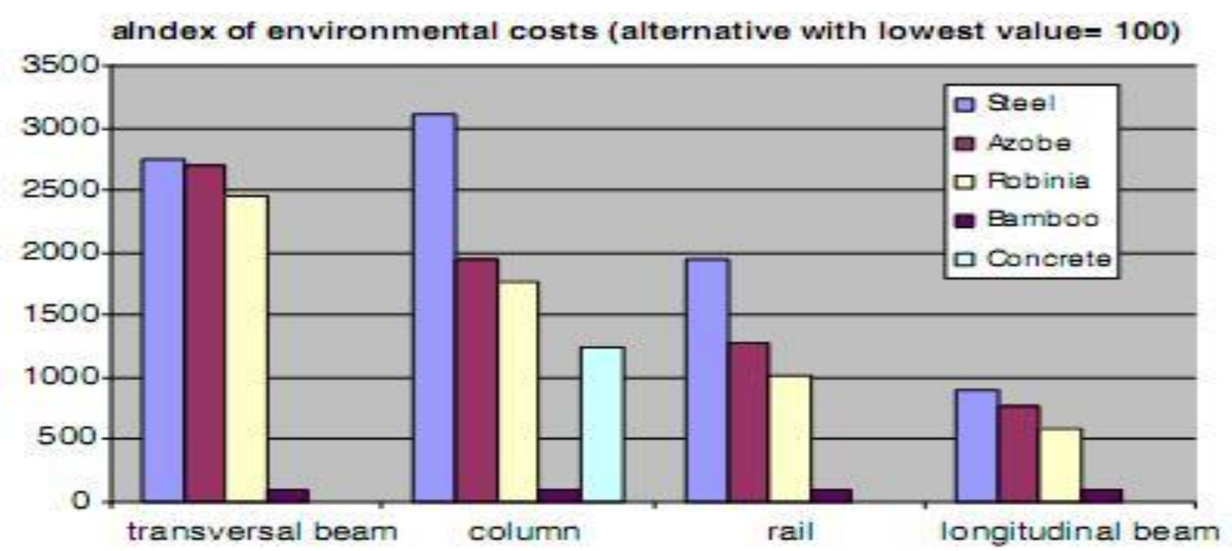

Figure 9: Environmental Costs of Different Materials in Their Entire Life Cycle (Can Der Lugt et al., 2006)

## 2.2.2 ENVIRONMENTAL ANALYSIS

"Bamboo, as a fast growing renewable material with a simple production process, is expected to be a sustainable alternative for more traditional structural materials such as concrete, steel and timber" (Can Der Lugt et al., 2006). Bamboo takes three to seven years to grow and become ready for harvesting, which is half of the amount of time required for most softwood and hardwood. Also, bamboo can replenish itself naturally, and it is ready to start growing again after it is harvested. As a result, bamboo can restore degraded lands because its dense litter feeds the topsoil of the forest floor while it is waiting for regeneration. In contrast, conventional hardwood requires replanting after harvesting. Furthermore, bamboo generates 30% more oxygen compared to other trees, and "sequesters up to 12 tons of carbon dioxide per hectare [and this] makes it an efficient replenisher of fresh air." (Stein, 2008)

**Reuse of Waste**

In terms of the environment, reuse of waste plays an important role. During the lamination process of bamboo panel manufacturing, only certain parts of the bamboo culm will be used. The unused portions are planer waste and bamboo chips which are shown in Figure 10 & 11. These wastes can be transformed into bamboo particleboard by using liquid urea formaldehyde glue as a binder. A research paper indicates that the modulus of elasticity and tensile strength of particleboard made from chips are superior and planer wastes are slightly lower (Biswas et al., 2010). Therefore, the stronger bamboo particleboard can be used as floor or wall panel. As for the dimensionally less stable particleboards, they can be used for interior applications. However, while manufacturing the particleboards, emission of carbon dioxide does occur during heat processing. Also, chemical pollution occurs when the urea formaldehyde glue is being applied.

Figure 10: Planer Waste (Biswas et al., 2010)

Figure 11: Chips (Biswas et al., 2010)

## 2.2.3 SOCIAL ANALYSIS

Social assessment is very important during the triple bottom line analysis. The most beneficial quality of using bamboo as a sustainable recourse is that it provides a wide range of applications in building construction. This is mainly the reason why the new SUB project management team should consider utilizing this material. Three aspects of bamboo play an important role during social assessment: job opportunity, green community, and health issue. The founder of economics, Adam Smith, "emphasized that the division of labour is the cause of improvement in economic productivity" (Nishimura,2004, p.527). In terms of job opportunity, more career opportunities are created from the agricultural process to the manufacturing process, namely from growing bamboo as construction material, harvesting and handling it as raw material, and converting it into useful construction material. In other words, bamboo usage provides many job opportunities in various industrial.

Moreover, the world is moving towards becoming a green world community. A statistical study of the projected value of the green building market is shown in Figure 12 (Green Buildings, 2011). Using bamboo as a material helps to accomplish this goal. For instance, there is an award winning design of a bamboo greenhouse at the Tokyo University by Nobuihiro Hirai and Hiohide Kobayashi (Bamboo Greenhouse, 2011). The bamboo greenhouse construction and its interior are shown in Figure 13 and 14, respectively.

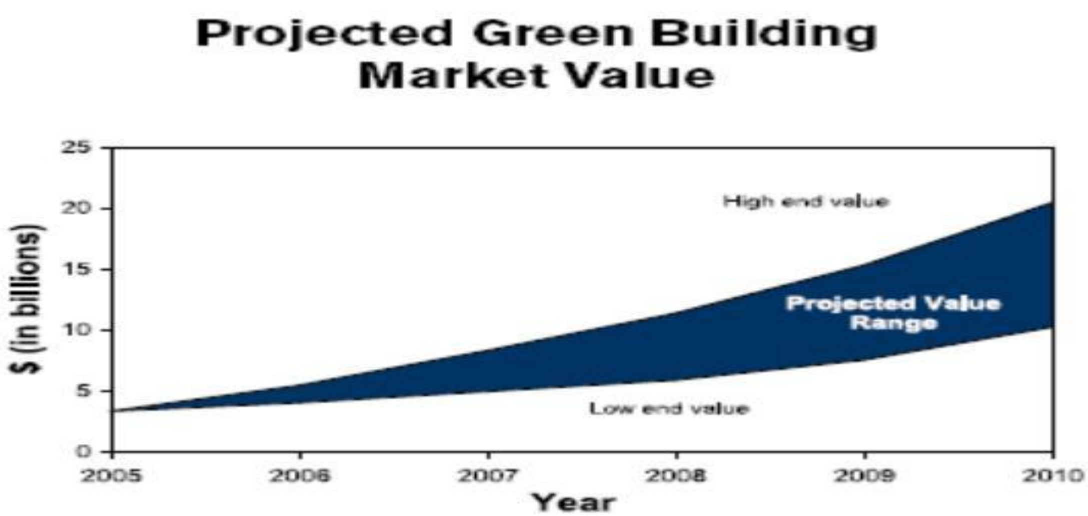


Figure 12: Projected Green Building Market Value from 2005 to 2010 (Green Buildings, 2011)

Figure 13: Building Process of the Bamboo Greenhouse (Bamboo Greenhouse, 2011)

Figure 14: Inside of the Bamboo Greenhouse (Bamboo Greenhouse, 2011)

Last but not least, health issues are everyone’s concern in the 21st century. Automobile industry moves from old gas-consuming cars to hybrid vehicles, and many people try to live healthier. Therefore, creating a green society is important.

## 2.3 LOCAL SOURCES OF BAMBOO

As mentioned previously, most bamboo products are currently being manufactured in Asia, however several local suppliers are available.

Aces Bamboo

604-779-1009

http://www.acesbamboo.com/

Bamboo Direct

604-913-9175

http://www.bamboodirect.ca/index.htm

Mira Floors

604-856-4799

http://www.mirafloors.com/Home

Pretty Floor

604-872-3654

http://www.prettyfloor.com/Bamboo.aspx

The Bamboo Store

info@thebamboostore.ca

http://thebamboostore.ca/index.php

# 3.0 COTTON

Cotton is a shrubby plant with cream-coloured fluffy fibers surrounding small cottonseeds. The cotton fibers possess strong insulation properties. Figure 15 below shows cotton fibers, which can be processed into cotton insulation, suitable for wall and ceiling applications. Furthermore, cotton only takes 140 days after planting to reach its maturity and be ready for harvesting. This short harvesting cycle causes cotton to be one of the quickest growing Rapidly Renewable Materials. Because of their need for a long, sunny growing period, the major cotton-producing countries are those with relatively warm climate such as the United States, China, and India (Cotton's Journey, 2006.).

Figure 15: Cotton fibers, suitable insulation applications [Source: CaraGreen, 2009]

## 3.1 APPLICATION

Why cotton fibers? Let us have a look at their performance and functionality. A study by X. Zhou shows that a strong correlation exists between the cotton fiber density and its thermal conductivity, and that at relatively low density, its mechanical properties are good for applications such as ceiling and wall (Zhou, 2010). As more people become environmentally concerned, cotton fibers could potentially provide an alternative solution for building insulation in construction industries. In fact, some U.S. companies such as Bonded Logic Inc have already utilized the natural cotton fiber to offer a sustainable solution as a material insulation in construction industries. Figure 16 below shows an application of cotton as a ceiling insulation.

Figure 16: Cotton as a ceiling insulation [Source: CaraGreen, 2009]

Cotton fibber insulation is a potential candidate for wall and ceiling insulation as the rapidly renewable materials in the new UBC Student Union Building.

# 3.2 TRIPLE BOTTOM LINE ANALYSIS

## 3.2.1 ECONOMIC ANALYSIS

***COST OF PURCHASE***

Because insulation is a commonly used material in buildings and constructions, most cotton insulation products are readily available for purchase. The price varies according to R-value, which is a measure of how well the material can insulate. The higher the R-value, the better the insulation is. See Table 1 below for a sample pricing from one U.S. distributor. When comparing the prices for cotton insulation to that of the fiberglass in Table 2 below; however, fiberglass insulation has a slightly lower initial cost.

Table 1: Cotton insulation sample prices in USD [Source: Ecohaus Inc., 2009]

| Rated R-value | Thickness | R-value per inch | 16" wide | 24" wide |
|---|---|---|---|---|
| R-8 | 2" | 4 | $0.80/SF | N/A |
| R-13 | 3.5" | 3.7 | $0.71/SF | $0.71/SF |
| R-21 | 5.5" | 3.7 | $1.13/SF | $1.16/SF |
| R-30 | 8" | 3.7 | $1.74/SF | $1.75/SF |

Table 2: Fiberglass insulation prices in CAD [Source: Home Depot Canada, 2011]

| Rated R-value | Thickness | R-value per inch | 24" wide |
|---|---|---|---|
| R-12 | 3.625" | 3.3 | $0.40/SF |
| R-20 | 6" | 3.3 | $0.60/SF |
| R-31 | 9.5" | 3.3 | $1.06/SF |

### *INSULATION COST AND PROCESSES*

The newer design of cotton insulation has been commercialized such that an ordinary layman can easily install it with just a knife and a measuring tape. The insulation bat comes in rolls of various sizes, from 16” to 24” wide, and can be installed by cutting it to size and fitting it between the studs of a wall or a ceiling. The process does not require any special protective gears or cutting tools, and therefore does not involve special trainings either (CaraGreen, 2009). As a result, the insulation cost is very low compare to other types of insulations such as fiberglass which requires safety equipments.

### *OPERATIONAL COST*

The operational cost of the cotton insulation can be gauged by its R-value per inch. High insulation efficiency in a building means less operational cost in the long run, because less heating and cooling is needed during the summer and the winter respectively. Table 3 below indicates that the cotton overall thermal efficiency is comparable to that of the fiberglass insulation and slightly better than the cellulose insulation. Furthermore because most cotton are made from recycled materials, the product can be recycled at the end of its lifespan

Table 3: Comparison of R-value per inch for insulation materials [Sources: Johns Manville Corp, 2000, and International Code Council, 2010]

| Insulation Materials | R-value per inch |
|---|---|
| Cotton batts | 3.7 to 4 |
| Fiberglass batts | 3.1 to 4.3 |
| Cellulose (loose-fill) | 3 to 3.8 |

## 3.2.2 ENVIRONMENTAL ANALYSIS

As it was mentioned in previous section, cotton, a rapidly renewable material, can be used as an effective insulator in the new Student Union Building on UBC campus. However, in order to investigate the environmental impact of using cotton, first, the commonly used insulating materials in construction industry are identified and their effects are analyzed. Then cotton is investigated for its environmental impact during production on land, water resources.

***COMMONLY USED INSULATORS***

Table 4 shows some commonly used insulators in construction industry with their respective thermal conductivity values. As can be seen, most of these materials contain chemicals hazardous to human health and toxic for the environment. For instance, it was recently discovered that long periods of exposure to asbestos can have serious health consequences ("Asbestos", 2011, para.1).

Table 4: Commonly Used Insulating Materials (Incropera& Dewitt & Bergman &Lavine, 2007)

| Insulator | Thermal Conductivity [W/m. K] |
|---|---|
| Asbestos cement board | 0.58 |
| Diatomaceous Silica | 0.052 |
| Vermiculite | 0.068 |
| Calcium Silicate | 0.055 |

However, cotton insulators such as "Cottons Batts" with the thermal conductivity of 0.03 [W/m. K] ("Thermal Conductivity of Some Common Materials", 2011) has a comparable insulating property to the chemically produced insulators. Although cotton poses no threat to human health, it should be investigated to determine its impact on the environment during production. There are two different methods in cotton production ("Cotton and Environment", 2011)

a) Conventional
b) Organic

## *CONVENTIONAL METHOD*

If cotton is produced with conventional methods, it has a destructive impact on the environment. This impact is due to heavy use of insecticides. Insecticide is a form of pesticide that is used to eliminate different insects. However, these chemicals destroy both the insects harmful to the crops and the ones that are beneficial to the environment. 2.6% of the world's cultivated land is used for growing cotton, but 16% of the entire insecticides produced are used only in cotton fields. According to the World Health Organization, Aldicarb, Parathion, and Methamidopho are among the most dangerous insecticide to human health but cotton producers utilize them widely in cotton production. As a result, the heavy use of the most dangerous chemical to human health and toxic to the environment makes the conventional production method of cotton an unsuitable option for an RRM. However, organic farming of cotton has a very different outcome ("Cotton and Environment", 2011).

## *ORGANIC METHOD*

Figure 17 shows the top 10 cotton producing countries in the world in 2009. Among these countries, United States has moved toward organic farming in recent years thanks to the modern technology. ("Production Ranking", 2011)

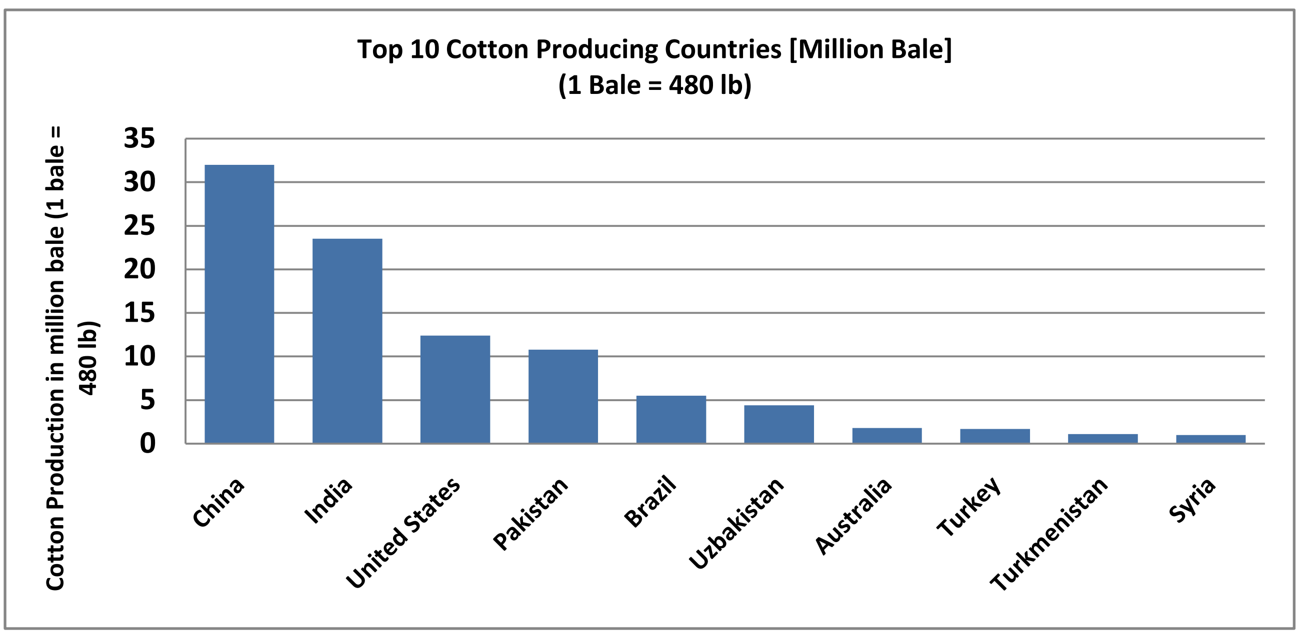


Figure 17: Top ten cotton producers in the world in 2009 (1 bale = 480lb) ("Production Ranking", 2011)

The term organic means that the cotton produced is not genetically modified and strict standards for the use of pesticides are observed in their production (“Organic Cotton”, 2011). The impact of the organic method on the environment can be investigated in 2 categories

a) Land and Animal Habitat
b) Water Resource

### *LAND AND ANIMAL HABITAT*

Figure 18 compares the production efficiency between 1926 and 2006. The blue column is the total amount of land used for cotton farming and the red column is the amount of harvested cotton from the land. As can be seen in 70 years and thanks to the new technologies, the production efficiency has increased by 50% in the United States. This means that 50% more cotton can be produced using the same amount of land which dramatically reduces the land use footprint of the cotton production and translates to preserving more animal habitats (“Cotton production Efficiency”, 2011).

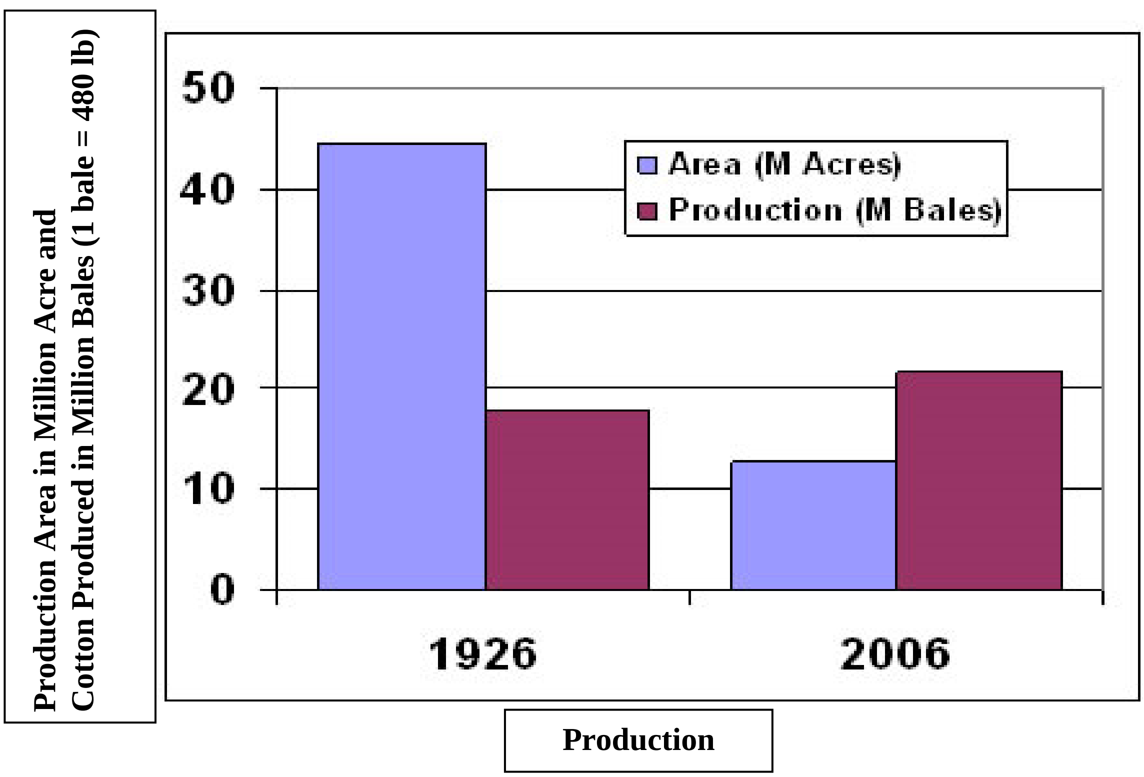


Figure 18: Comparison between production efficiencies in 1926 and 2006 (“Cotton Production Efficiency”, 2011)

In addition to reducing the production footprint in terms of the land use, farmers are now able to preserve the habitat of different insects and animals. Figure 19 illustrates the percentage of the total crop loss if the harmful insects and pests are not eliminated and the actual percentage of the crop loss after implementation of the protective measures against pests. As can be seen, it is necessary to protect the crop against the harmful insects; however, in conventional method the chemically produced pesticides kill all the species, harmful and beneficial. The integrated Pest Management Program can provide a solution to this problem. The Integrated Pest Management Program utilizes the natural pest control mechanism and targets specific pests harmful to the crop and preserves the remaining species ("The Environmental Impact of Cotton Production on Habitat and Biodiversity", 2011).

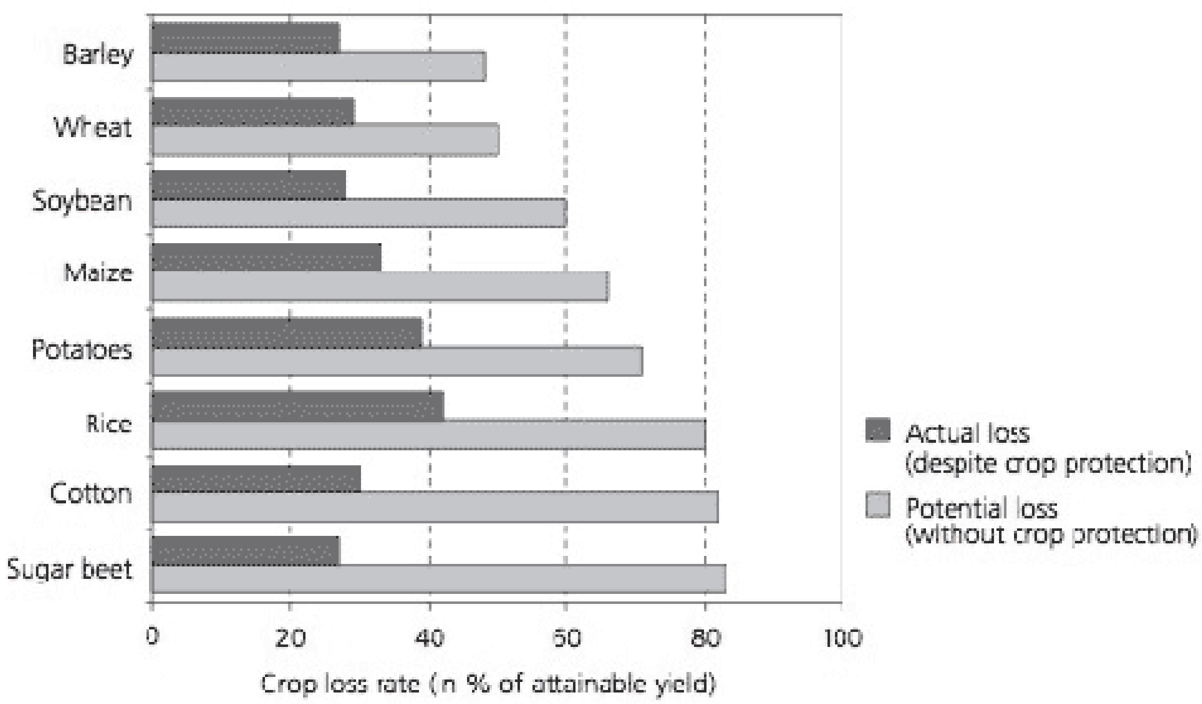


Figure 19: Percent crop loss worldwide with and without protection against insects and pests for cotton and other farming products ("Habitat and Biodiversity", 2011)

### *WATER RESOURCES*

Cotton is very resistant to drought and lack of water. Only 2.6% of the world's water consumption is used for cotton irrigation. Figure 20 compares the amount of water used in cotton production with other agricultural products ("The Environmental Impact of Cotton Production on Water Resources", 2011).

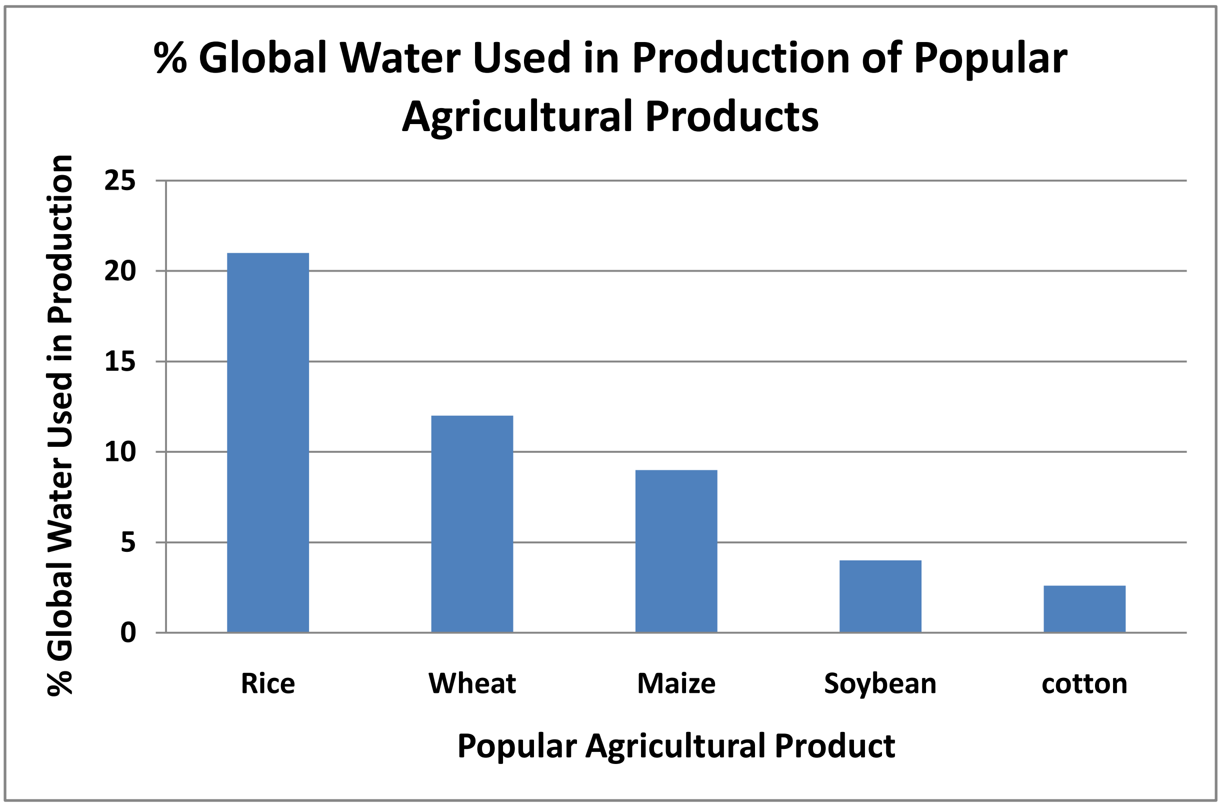


Figure 20: Comparison of water consumption in production of different agricultural products ("The Environmental Impact of Cotton Production on Water Resources", 2011)

As can be seen cotton has a very limited water footprint. Therefore, in many cotton producing countries, rainfall water is used as the main water source for production. In the United States 65% of the entire cotton crops is produced without artificial irrigation. Figure 21, shows the map of annual rainfall in the US. As can be seen the cotton producing states are all located in south where despite the limited amount of precipitation they have the most production of cotton which demonstrates the drought resistance capability of cotton ("Cotton Production Water Requirement", 2011).

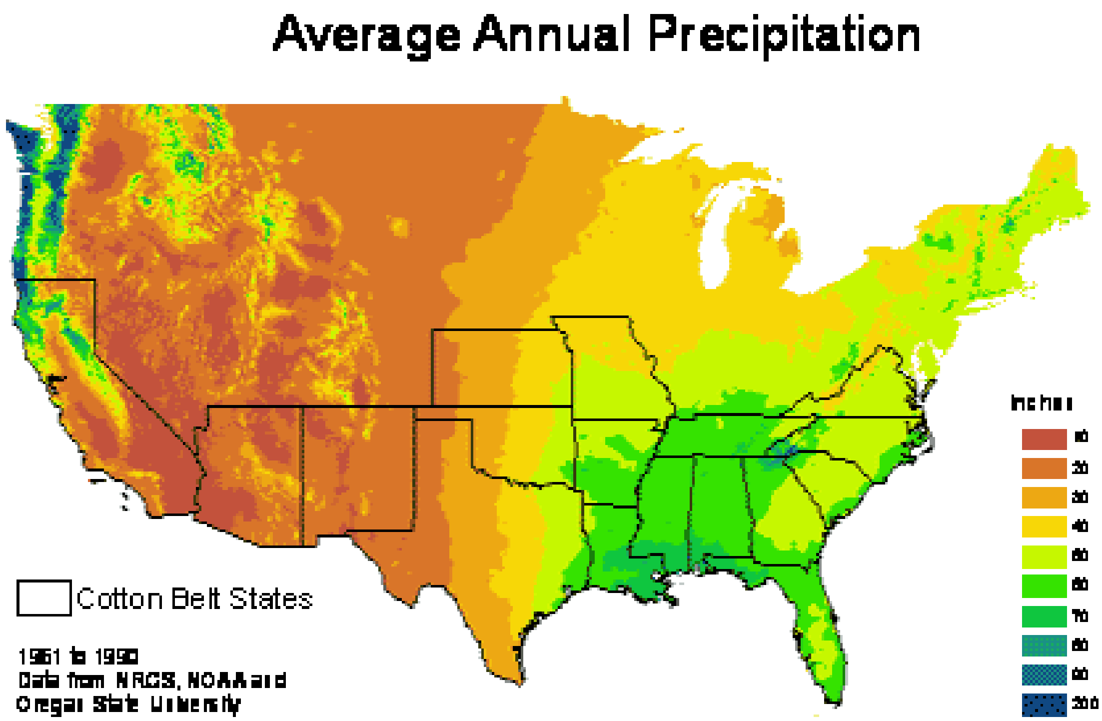


Figure 21: Average annual precipitation in the United States("Cotton Production Water Requirement", 2011)

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### 3.2.3 SOCIAL ANALYSIS

***EMPLOYMENT OPPORTUNITIES***

Because the majority of cotton fibers exports are from the United States, China, and India, higher demand in the use of cotton fibers creates my jobs in those countries, from agricultural to manufacturing to transportation industries.

In the manufacturing industries, where raw cotton is to be processed into cotton insulation usable in construction buildings in Canada, proper processes must be applied with sufficient quality control to ensure that the product meets the specification from the National Building Code of Canada (nationalcodes.ca). This in turns creates further jobs in manufacturing quality assurance and quality control.

In terms of component installation, cotton insulation does not require professionally trained installers, only general labours with given proper instructions would suffice.

***HEALTH CONCERNS***

Poor quality insulation may itch, mold, or have volatile organic compounds which could have a negative impact on human health. Molded cotton will release toxic gas with serious health concerns, while strong concentration of VOCs can be a health hazard. Cotton is also classified as a readily flammable material, and therefore proper precaution must be taken during installation and its lifespan (Health Canada, 2009).

However, most modern manufacturers have already overcome these issues and now offer quality cotton insulation which does not have these concerns. For instance, Bonded Logic Inc. offers high quality insulation which is mold resistant, fire retardant, and has no VOC concerns. One of its products, called UltraTouch Insulation, is a well designed insulation with Class 1 Fire Rating, corrosion and fungi resistance and has less than 15% moisture absorption. A sample of UltraTouch product specification is presented in Appendix A.

## 3.3 LOCAL SOURCES OF COTTON

From the research conducted, a potential candidate for cotton insulation product is found called UltraTouch Insulation, which consists almost entirely of natural denim and cotton fibers made from “90% post-consumer recycled and 85% rapidly renewable.” It contains no chemical irritants and no harmful airborne particulates, which eliminates the need for special safety gears during installation (Caragreen.com, 2011).

Furthermore, UltraTouch satisfies several criteria for Leadership in Energy and Environmental Design (LEED) credits, including:

- EQ Credit 4.4: Low Emitting Material
- MR Credit 4: Recycled Content
- MR Credit 6: Rapidly Renewable Materials

(BuildingGreen.com, 2011)

Even though the product is developed by a U.S. sustainable manufacturing company, Bonded Logic Inc., UltraTouch insulation is actually available in most Canadian home equipment outlets, such as Home Depot.

Due to high performance, safety, and its availability in the local store, UltraTouch is a strong candidate to provide solution for wall and ceiling insulation for the UBC new SUB building.

# 4.0 CONCLUSION AND RECOMMENDATIONS

As the new Student Union Building at the University of British Columbia is entering its final design stages, many choices are available for the new SUB to become an icon of sustainable design and inspire future projects. The objective of this report is to inform the UBC Alma Mater Society to the potential use of the rapidly renewable materials, namely bamboo and cotton, by utilizing the method of triple-bottom-line analysis, which facilitates decision making by addressing the product economic, environmental, and social impacts.

***BAMBOO***

Considering the environmental aspects of bamboo, it is much more sustainable and leaves a smaller environmental foot print compared to popular materials used today. The major issue is to ensure that the production was done in a sustainable manner, and the method and cost of transportation must be carefully planned to minimize waste. Bamboo is also cheaper than its alternatives, such as hardwood; however it is typically not grown locally and does not benefit local businesses compared to using lumber. There are, however, local suppliers that sell bamboo products and can greatly benefit from the new SUB project. Not only does using bamboo creates a green and sustainable icon for the new SUB, it also generates job opportunities and a greener community.

***COTTON***

Due to its fast growth and low water consumption, cotton has a limited environmental footprint and indeed is an environmentally friendly product in which its fiber is suitable for wall and ceiling insulation in buildings. Looking at the social aspect, high quality cotton insulation is mold resistant, fire retardant, and has no VOC concerns. Moreover, higher cotton demand produces more job opportunities in agricultural, manufacturing, and transportation industries in those countries exporting cotton, namely the United States, India, and China.

From an economic point of view, the average price of cotton insulation is approximately $\$1.10/ft^2$, which is slightly more expensive than that of fibreglass insulation ($\$0.70/ft^2$). However, the difference in cost may be compensated by the installation requirements, as cotton is completely safe and easy to install, it does not require special tools or protective gears during installation, which may result in less cost in safety equipments and training. In terms of its performance, the R-value of cotton insulation is comparable to that of the fibreglass, which yields relatively high insulation efficiency, and therefore reflects on the operational cost of heating and cooling of the building.

A viable cotton insulation product found is called UltraTouch Cotton Insulation which is made from “90% post-consumer recycled and 85% rapidly renewable” (Caragreen.com., 2011) Not only is the product completely safe, it also meets several criteria for LEED credits including Low Emitting Materials, Recycled Content, and Rapidly Renewable Materials credits. As a result, UltraTouch is certainly a strong candidate to provide solution for wall and ceiling insulation which helps the new SUB become an icon of sustainable design.

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# APPENDIX A

UltraTouch Insulation: Product Specification [Source: bondedlogic.com]

specifications

**UltraTouch™**
**Denim Insulation**

## physical properties:

| | PERFORMANCE | TEST METHOD |
|---|---|---|
| Surface Burning Characteristics | Flame Spread 5 (Class-1) | ASTM E-84 |
| Fire Hazard Classification | Smoke Developed 35 (Class-1) | UL-723 |
| Corrosion Resistance | Passed | ASTM C-739 |
| Fungi Resistance | Passed: No growth | ASTM C-739 |
| Bacteria Resistance | Passed: No growth | ASTM C-739 |
| Moisture Absorption | Passed: Less than 15% | ASTM C-739 |
| Fire Test of Building Material | Passed: 1-hour rating | ASTM E-119/UL-263 |

## technical information:

| PRODUCT NO. | R-VALUE* | THICKNESS | (MM) | WIDTH | (MM) | LENGTH | (M) | SQ. FT. | PIECES/BAG | WEIGHT |
|---|---|---|---|---|---|---|---|---|---|---|
| 10002-81632 | 8 | 2.0" | 51 | 16.25" | 413 | 32' | 9.75 | 129.99 | 3 | 22 lbs. |
| 10002-82432 | 8 | 2.0" | 51 | 24.25" | 616 | 32' | 9.75 | 129.34 | 2 | 22 lbs. |
| 10002-01316 | 13 | 3.5" | 89 | 16.25" | 413 | 94" | 2.34 | 84.88 | 8 | 35.6 lbs. |
| 10002-01324 | 13 | 3.5" | 89 | 24.25" | 616 | 94" | 2.34 | 126.63 | 8 | 54 lbs. |
| 10002-01916 | 19 | 5.5" | 140 | 16.25" | 413 | 94" | 2.34 | 53.04 | 5 | 31 lbs. |
| 10002-01924 | 19 | 5.5" | 140 | 24.25" | 616 | 94" | 2.34 | 79.15 | 5 | 46.5 lbs. |
| 10002-02116 | 21 | 5.5" | 140 | 16.25" | 413 | 94" | 2.34 | 53.04 | 5 | 35.5 lbs. |
| 10002-02124 | 21 | 5.5" | 140 | 24.25" | 616 | 94" | 2.34 | 79.15 | 5 | 52.5 lbs. |
| 10002-03016 | 30 | 8.0" | 203 | 16.25" | 413 | 48" | 1.22 | 27.10 | 5 | 24.5 lbs. |
| 10002-03024 | 30 | 8.0" | 203 | 24.25" | 616 | 48" | 1.22 | 40.40 | 5 | 36.5 lbs. |

*Tested in accordance with ASTM C-518 at a temperature of 75° F. Higher R-values equal greater insulating power.
Note: Full recovery may take up to 72 hours after removal from package.

## product compliances:

UltraTouch™ Insulation regularly meets the requirements, specifications, standards and building practices of the following organizations.

**Environmental Spec.** #1350 **ICC Evaluation** Report #1134 **LARR** ICC ER #1134 **BOCA** Building Officials & Code Administrators
**CABO** Council of American Building Officials **ICBO** International Conference Building Officials **LEED** Leadership in Energy & Environmental Design
**SBCCI** Southern Building Code Congress International **California Bureau Thermal Insulation** License # TI-1367, Reg. # CA-T367AZ

**UltraTouch™** can be used in both interior and exterior walls as well as most ceiling applications. The product easily installs in either wood or metal framing cavities by using a simple friction fit. The product is safe to handle and install without the need for protective clothing or special respiratory equipment.

- Environmentally Safe
- Class-A Fire Rated
- Maximum R-value
- Superior Acoustics
- Resists Mold and Mildew
- No Formaldehyde
- No Itch or Skin Irritation
- LEED™ Eligible Product

Seal and Insulate with ENERGY STAR