JARANA Bamboo Plantation
EWB Challenge 2011

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1. Executive Summary

The 2011 Engineers Without Borders (EWB) Challenge seeks to improve the livelihoods of the community of Devikulam through sustainable and appropriate development in a variety of areas. This report endeavours to do so by proposing the development a Bamboo planation industry that will strive to improve employment prospects and in doing so will give the community a new purpose.

The need for a new, thriving industry in Devikulam is appreciable and must be addressed in a way that is in line with the culture and desires of the community. The industry must be able to generate a stable source of income, which will then allow for poverty reduction and improvement in all aspects of their lives. The design criteria were developed through research of the culture of the Devikulam community in conjunction with the EWB design brief for industry development. (EWBA 2011) The design criteria are henceforth that the industry:

- Will generate income for the community
- Has a low start up and maintenance costs
- Utilises local skills
- Creates stable local employment for a diverse range of people
- Increases the income per capita of the people in the community
- Needs minimal outside help for long term running
- Is sustainable in the long term
- Is environmentally friendly

A variable size plantation of the bamboo species Dendrocalamus Strictus is a viable industry that fulfils the design criteria, as shown by analysis in the report. The treatment of the bamboo is important for longevity and as such, multiple options where considered and a detailed outline of the chosen, Modified Boucherie process, is given. As this proposal is developing an industry another crucial aspect is the business plan. Financing the project and being certain that the plantation would actually make a profit were key. A risk analysis and contingency plan hence were made to ensure that a loss would not be made, as this would hinder, not help the community of Devikulam. The applications of the bamboo, whilst not covered in great detail, are an integral part of the industry and the wide variety of options consolidates a bamboo industry as a feasible choice.

Community consultation was perhaps the most critical aspect of the project because without the
support of the community the plantation would never succeed. As such, it was vital that all possible difficulties in consultation were thought of and handled with sensitivity towards the community. It was also essential to have a well defined community implantation plan which allowed for feedback and tailoring of the plantation to suit the needs and wants of Devikulam.

The design was continually review and modified, evolving as more information was gained and ideas improved. All aspects of the project were evaluated and changed as the outcome of those evaluations saw fit. By doing this and by understanding the cultural differences we were able to come up with a solution that will not only provide a new source of income for the community of Devikulam but also enrich their lives.
2. Acknowledgements

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4. **Introduction**

4.1. **Need**

With 71 out of a total of 86 families living below the poverty line by 2008 (Devikulam information 2008), a range of issues need to be addressed in order to improve the quality of life for the people of Devikulam. The following basic needs that require the most urgent attention are identified by the Engineers Without Borders (EWB) Challenge:

- High unemployment and very low income.
- Low-quality housing and other infrastructures.
- Poor water quality.
- Poor sanitation infrastructures and lack of health services.
- Unreliable power supply.
- Lack of transportation.
- Information, communication and technology (ICT) for educational activities.
- Waste management issues.

Though India boasts high economic growth, it still experiences large-scale poverty. Out of its total population of more than 1 billion, an estimated 25% were living below the poverty line in 2007. Nearly 75% of the poor are in rural areas such as Devikulam, with most of them being daily wagers, landless labourers and self employed house holders (Poverty in India 2010, as cited by EWB Australia (EWBA) 2011). The 2007-2008 Human Development Report published by the United Nations Development Program gives India a Human Development Index (HDI) score of 0.619, which places it in the 128th position among 177 countries (Subramanian & Arivanandan 2009), and within Devikulam, 71 out of a total of 86 families were living below the poverty line by 2008 (Devikulam information 2008).

Despite many existing industrial enterprises coordinated in neighbouring villages, such as the Vermicompost units or the bamboo-based industry, there are currently no industrial activities being conducted in Devikulam (EWBA 2011). The main source of income for the community is self-sustained agriculture and small revenue from a local prawn industry. The wetlands are utilised for the cultivation of rice and coconut while dry lands are utilised for crops like tuber (tapioca roots),
ground nuts and millets. The majority of the villagers work in agriculture and some are tree climbers. However, current agricultural productions are not reliable and do not generate sufficient income per capital due to the changing environment. The prawn industry also created many negative consequences on the ground water and soil, together with excessive use of electricity, which is already in shortage.

It has been reported that many villagers have moved to near by large cities such as Pondicherry and Chennai to search for better employment opportunities. However, with nearly 60 percent of the district population having attained only primary level education or less, the employment choices are limited (EWBA 2011). This indicates that the Devikulam people are willing to work however they lack the necessary skills in industry production.

With the current situation of Devikulam, it is evident that there is an urgent need to develop a sustainable industry in the local community so that the people can generate a stable source of income, which will then allow for poverty reduction and improvement in other aspects of their living such as housing and sanitation facilities. Furthermore, a sustainable industry with appropriate implementation processes can contribute to narrowing the significant difference in the annual income per household and living standards between the two castes. The survey conducted by the EWB in 2011 showed the ‘higher’ caste cultivate on their own lands and earn an income of up to Rs. 60,000 per annum, whereas the residents in the colony work as agri-coolis (labourers for other farms) and only generate an income between Rs. 15,000 and 30,000.

4.2. Proposed Solution

A small bamboo plantation to be managed by the community, with the bamboo being utilised for low cost housing within Devikulam and as a source of income either from the direct sale of culms or value-added products like bamboo souvenirs, woven mats and furniture.
5. Background

Devikulam is a small village located in one of the most underdeveloped districts in the state of Tamil Nadu, a part of the Panchayat region of Southern India. Its closest neighbouring village is Nadukuppam and the nearest major city is Pondicherry (EWBA 2011).

5.1. Culture and Social Structures

Hinduism and the tradition of the caste system have created a culture that strongly emphasizes established hierarchical relationships. Caste rituals have governed the lives of the majority of Indians for hundreds of years and Indians are highly conscious of social order and their status relative to other people, from family to strangers (Sana 1993). Membership to ones caste is given by the status of the family at birth, and since castes tend to be occupationally specific and confined to particular regions or villages, ones occupation is largely predetermined (Osborne 2001). This social aspect thus contributes to the significant disparity in income and living standards between the higher and lower caste.

Despite some inter-dependence, the relationships among different castes are characterised mainly by repulsion. Elaborate rules prescribe which castes can inter-dine or accept cooked or uncooked food, depending upon their respective positions in the local hierarchy. Marriage between members of different castes is especially strictly forbidden (Sana 1993).

There are 2 major castes in Devikulam: the Scheduled Class (SC - formerly Dalit), which makes up the majority of the village’s population, and the Most Backward Class (MBC). The MBC is considered to be ‘higher’ and they live in the Devikulam Village while the SC lives in the Colony or Thoppu areas. Despite being a small community, the caste hierarchy create an apparent gap in the quality of living standards between the two groups. A baseline survey of 70 households of Devikulam conducted by EWBA revealed that most families living in the village have ownership of lands, livestock and facilities such as a motor bicycle, TV and mobile phone while in the colony only about 25% of households have access to these.
5.2. Economy

As shown in Figure 2 and from the above mentioned information, the people of Devikulam are living below the poverty line which leading to poor living standards and low-quality infrastructures. There is currently no sustainable source of income generation for the local community to support themselves and most people lack necessary skills for employment, which further exacerbates the situation.
5.3. **Housing**

Most families in Devikulam live in hut-styled houses, with either cement or mud floors, walls made from mud or burnt brick and the roofs are either thatched or made from palm leaf. Mud-thatch houses are preferred by the community in summer for its coolness, however during the monsoon season the roofs cannot offer protection against strong winds and rain. Also, houses generally have thatched bathrooms without a toilet and the common practice of open defecation leads to serious health issues as well as water contamination (Devikulam information 2008).

There are also group houses provided under the Government scheme, which are made from burnt brick and concrete. However, these houses are only available for the higher caste members living in the village, leaving the colony population living in poor-standard mud-thatch houses. They also have very high heat retention and so are not commonly used by the people (EWBA 2011).

5.4. **Existing Industry**

The main source of income for the community is self-sustained agriculture and small revenue from a local prawn industry. The wetlands are utilised for the cultivation of rice and coconut while dry lands are utilised for crops like tuber (tapioca roots), ground nuts and millets. The majority of the villagers work in agriculture and some are tree climbers. However, current agricultural productions are not reliable and do not generate sufficient income per capital due to the changing environment. The prawn industry also created many negative consequences on the ground water and soil, together with excessive use of electricity, which is already in shortage (EWBA 2011).

In general, there is no sustainable industrial planning for the Devikulam community which greatly impedes efforts in poverty reduction and improvement of living standards for the local people.

5.5. **Pitchandikulam**

Pitchandikulam Forest is an organisation dedicated to the preservation and restoration of the native Tropical Dry Evergreen Forest situated in the Auroville International Township, to which Devikulam belongs (EWB 2011). The Pitchandikulam Forest team is made up of over 100 people from Auroville and the surrounding areas working at the Bioresource Centre, the artists studio, as well as in one of the many community projects Pitchandikulam runs. In 1993 Pitchandikulam Forest became part of a
national Medicinal Plant Conservation Network, co-ordinated by the Foundation for Revitalisation of Local Health Traditions in Bangalore (Pitchandikulam Forest (PF) 2011).

Apart from the office, there is also an education centre. It has a strong focus on restoration and eco-friendly technology and the staff are involved in training village communities in the process of eco-restoration as well as in the use of medicinal plants, with links to and support from traditional healers. Pitchandikulam initiated groups such as the Women’s Self Help Group and the Farmers’ Association, to which they provide technical training of better agricultural techniques and set up income generation projects.

Over the last 30 years Pitchandikulam has been working with local communities in Auroville and the bioregion to identify suitable sites for plantation and reforestation of the endangered Tropical Dry Evergreen Forest. Collaborating with 30 other in-situ and ex-situ conservation areas, detailed programs of botanical and social documentation, conservation and planting initiatives have been developed (PF 2011).

With these generous skills and knowledge not only in agricultural processes that are appropriate for the local region, but also in working together effectively with the local community, Pitchandikulam Forest will play an important role in the implementation and long-term maintenance of our proposed project. Much information on the local environment that we used in developing our project, such as soil quality, rainfall data ... were obtained from the available online resources collected by Pitchandikulam Forest. Their knowledge would also be important in choosing the suitable site for the plantation.

5.6. Literature Review

• ‘Bamboo cultivation popularised in a big way in India’s northeast’ (The Hindustan Times 2009)

The report highlights that the Indian Government is encouraging bamboo cultivation in a big way in the country's northeast region with the aim of improving the lives of local communities. Several steps have been taken to enhance bamboo conservation and productivity in the region. One of these includes the National Bamboo Mission, which started back in 2006. The Rain Forest Research Institute and Indian Council of Forestry Research and Education also established a bamboo
composite centre, which is located in Bangalore and Dehradun, as a place to demonstrate all the technological aspects which are related to utilisation of bamboo. The local entrepreneurs and farmers within the region and nearby can learn of the various uses of bamboo and how they could earn a stable income out of these bamboo enterprises.

India is home to almost 45 per cent of the world's bamboo forest and two-third of the growing stock of bamboo in the country is available in the northeast, making bamboo and its products can be a major potential export commodity in this region. Bamboo cultivation and its proper utilisation are widely anticipated to benefit the local entrepreneurs and bamboo cultivators. In the northeast, bamboo is traditionally used as construction material, household articles, in handicrafts and papermaking, agriculture, fisheries, transportation and village industry.

The report quoted the thought of Jitul Gogoi, a bamboo farmer in Assam, "I took up bamboo plantation because it's very easy, profitable and is not a time consuming job. Bamboo is used for different purposes in our region, in construction, fencing, house, manure, handicrafts etc. These days the demand of raw bamboo in the market is very high. I own 3/4 bighas of bamboo. Whenever financial need arises, I sell bamboo. I earn Rs.2-3 thousand every month. I support my family with this." This suggests that bamboo plantations are widely accepted by people in underdeveloped communities around India as a means of employment and poverty reduction.

- ‘Bamboo cultivation assumes special significance’ (The Hindu, 2009)

Since 2006, the Department of Horticulture, in India, has started the National Bamboo Mission – a scheme that aims to promote the development of bamboo industries in various regions of India, including Tamil Nadu (The Hindustan Times, 2009). The scheme aimed to address issues relating to the development of bamboo and to encourage bamboo cultivation in the northeast region at first, but eventually has spread to other regions in India. By 2009, more than 52 hectares has been dedicated to bamboo cultivation in the villages of Tamil Nadu. The scheme involves the Department providing farmers with seedlings of bamboo species, pesticides and other necessities appropriate for the particular soil and growing conditions of the region. The farmers are also paid Rs. 20000 per hectare subsidy for drip irrigating the grass and training are provided via field trips to other operating bamboo plantations and research centres.

This article indicated the ongoing support for bamboo plantation by the Indian government as well as the farmers. The spread of the National Bamboo Mission to the southern regions of India shows
that the bamboo industry can create profitable and sustainable revenue which will contribute to improving the quality of life for the people in remote areas of India, such as Devikulam. By showing examples of successful bamboo plantations around India to the Devikulam community, we believe there will be high approval and acceptance from the people of Devikulam for our proposal of developing a bamboo plantation.
6. Design Choice

6.1. Design Criteria

It is important for any project of this nature to set out a list of design criteria that are relevant to the situation in Devikulam. This will create a relatively objective way to judge our possible design solutions. After careful research and consideration of the problems that are plaguing the community of Devikulam we have chosen a list of areas that are of greatest importance to the development of an industry. These have been developed with close reference to the EWB’s industry development guidelines and suggestions. The EWBA (2011) suggests the following targets should be central to a new industry in Devikulam:

“When designing a solution, the following issues have been identified and should be considered as a priority. The proposal should:

• Create a source of revenue for the community.
• Have low start-up and maintenance cost.
• Build upon skills that people in the community already have.
• Create stable local employment for a wide range of people in the community.
• Improve the annual income per capita of the community.
• Be eco-friendly by avoiding contamination of the local environment, or unfairly drawing upon community resources.”(EWBA 2011)

Furthermore, the potential projects were judged against their ability to be self-sustaining in the long term and the amount of outside help they will need for long term running and maintenance. Overall, there are 8 criteria that guided the selection of a proposal. For each there is a description as to what the needs of the criteria are and the overall importance of it, for example the economic viability is more important than the use of local skills as training can be substituted for a lack of previous knowledge but without sufficient cash flow no industry can survive in the long term. The design criteria are:

• Will generate income for the community (Priority: High)

The source of many of the problems of Devikulam can be traced back to their poverty, from the underdeveloped infrastructure to the lack of medical supplies and transport options. Hence, it is crucial to the long term development of the area that there be a source of revenue that is
sustainable and will help the local economy to grow. In turn this will allow the people to access better transport, health care and education which will improve their quality of life.

• Has low start up and maintenance costs (Priority: High)

The initial start-up costs will be an important and determining factor that determines whether the project can go ahead as funding will be scarce. This is because the community themselves do not have wealth to fund a project and hence the funding will need to come from charitable organisations or micro finance loans. Matthew Swibel from Forbes suggests the average microfinance loan size in India is only $100 US which equates to approximately 4889 Indian Rupees (Swibel, 2007) so with this in mind it is important to realise this is a very different option from traditional banks loans and the amount will be limited. However this amount is only a rough guide and because a large part of the community will be applying with the backing of the Pitchandikulam Forest organisation there is potential to borrow much more.

• Utilises local skills (Priority: Medium)

If a solution can build upon skills the people already have then there will be less training required and they will adapt to the change more effectively making the implementation of the design more efficient and permanent. The people of the Devikulam area already have agricultural skills and are currently involved in cultivating a variety of crops (EWBA 2011). Thus, there is potential to both use these skills for an agricultural industry and then develop them for the benefit of others areas such as food production. Furthermore, the local Pitchandikulam forest organisation has many resources available that could help in the areas of crop growth and maintenance.

• Creates stable local employment for a diverse range of people (Priority: High)

Currently the people of the area only work between 11-20 days per month, with many significantly less than this as this figure is only an average value (EWBA 2011). This is problematic as unemployment, particularly when it is involuntary, has many negative impacts on physiological and psychological health (Harris & Isenor 2011). Some of these include a poor self-image, low self-esteem, stress and depression. Furthermore, the Pitchandikulam forest organisation is currently seeking a way to expand employment opportunities in the area (EWBA, 2011). Hence, in the development of any industry for the Devikulam community, the employment opportunities it offers for the people of the area will be a priority. Also, it would be desirable if these employees could come from a diverse range of areas and groups within the community to avoid alienating any one sub group and creating tension which slow down or prevent the implementation of the project. It is
also ethically important that any solution does not discriminate against a certain group within the community.

- Increases the income per capita of the people in the community (Priority: High)

Obviously the income generated would be the single greatest determining factor as to whether an industry is successful. If it doesn’t earn enough to remain viable in the long term then the initial costs and effort to implement the plan will have wasted resources that are valuable to the impoverished community. Furthermore, if the workers do not receive enough money they will not stay working at the plantation and it will have no benefits for them and this is the overall reason for the proposal in the first place. Currently the people of the Devikulam community earn around 15000-30000 Indian Rupees per person per year, to put this in perspective that is equivalent to approximately AUS $300-600 (EWBA, 2011). This figure is for the poorer people in the colony with the average for all of Devikulam being 10000-60000 Indian Rupees. Thus, it would be desirable if the people of the colony received the larger amount of the benefit from any proposal as they are much poorer than the average in Devikulam to begin with.

- Needs minimal outside help for long term running (Priority: High)

It is preferable that the people of Devikulam be able to, after training and education, handle the majority of everyday happenings as well as problems that may occur in an industry. The Devikulam community is relatively isolated and hence if the project needs constant regular external help to maintain the project then this will be both costly and inefficient.

- The proposal is sustainable in the long term (Priority: High)

While the need for long term financial success of an industry has already been discussed as a key goal it is also important the industry will last long into the future. This is so the benefit is long lasting and provides a solution to problems of unemployment and poverty for many generations and not just one. Also, it is likely that in early years of an industry that the income generated will not have reached its maximum and if micro finance is utilised there will be loans to repay. This could mean that the first few years of a project will not be particularly profitable and hence it is important the project lasts long enough to compensate for this and still help to reduce poverty as much as possible.
• The project is environmentally friendly (Priority: Medium)

To ensure the long-term sustainability of a project it is important that it does not over draw natural resources that are not replaceable. Furthermore the Devikulam community already sufferers from poor quality water supplies so any industry that produces harmful waste chemicals which are disposed of into local water supplies, such as boars, would be inappropriate no matter how economically sound.

### 6.2. Design Options

With the design criteria in mind three possible industries were considered. These included:

• A small scale spirulina cultivation.
• A small one to four hectare bamboo plantation.
• A sustainable bamboo housing enterprise.

The disadvantages and benefits of each are outlined in the subsequent section, followed by an evaluation and design choice.

#### 6.2.1. Spirulina Cultivation

The UN has been advocating spirulina as a miracle food particularly in developing countries and there are definite opportunities to create an industry around this in Devikulam (IIMSAM 2006). Spirulina is a blue - green algae consisting of 65-70% protein and numerous other vitamins, minerals and amino acids (EWB, *Pitchandikulam Small Enterprise Options Assessment*). What makes spirulina even more valuable is that it requires less energy input than other protein crops like soy or corn, uses a comparatively small amount of water per kilogram of protein and is also an incredibly efficient producer of oxygen (IIMSAM 2006). The Pitchandikulam forestry group have already begun a number of initiatives to get local groups involved in growing spirulina on a small scale as a dietary supplement in their own communities. However, spirulina is a booming industry in India and there is potential to create a significant source of revenue for the community of Devikulam.

In terms of start-up costs there is no sure figure, spirulina will grow in almost any slow flowing water source and it is possible to utilise local biological waste to ‘feed’ the algae (IIMSAM 2006). Harvesting and packaging are simple processes that require no specific or expensive tools and will
also provide a small amount of employment. Spirulina farming also has the potential to be community run with little outside input however some education and training will be required, especially if production is conducted on a large scale, as there are international standards regarding the quality of food production that will need to be met.

6.2.2. Bamboo Plantation

The establishment of a bamboo plantation within the region has great potential to become a profitable and sustainable industry for the community. Being the second largest producer of bamboo in the world, there is already a well established market for the sale of bamboo and bamboo products throughout India making such a plantation a relatively low-risk investment (Janssen, 2000).

![Mind map showing how a bamboo plantation meets key criteria](image)

With specific regards to the criteria, bamboo plantations have a comparatively low start-up cost, as little as Rs. 15 000 per hectare (Janssen 2000) compared to a return of as much as Rs. 60 000 per hectare per year from the first harvest onwards. In addition, large scale bamboo production will
create a range of employment opportunities in the areas of farming, management, manufacturing and treatment, with this in turn leading to an increase in the annual per capita income of the community.

A small one to four hectare bamboo plantation also meets the criteria of being environmentally friendly. Bamboo draws on very minimal natural resources for its growth, with water being the only significant environmental cost. Bamboo is also documented to improve the quality of the soil, prevent erosion and will create more oxygen than a similarly sized timber plantation (Hoodgendoom 2011).

Above all, it is a design option that is highly beneficial and relevant to the entire community. A bamboo plantation has the potential to be totally community run and managed and this is indeed the long-term aim of the project. The skills required to maintain, harvest and treat bamboo can easily be taught and indeed build on the agricultural and management skills that many in Devikulam already possess.

6.2.3. Bamboo Housing

Bamboo, in addition to being incredibly environmentally friendly, is an excellent sustainable building material. It is very strong with high tensile and compressive strength and because of its flexibility bamboo housing can withstand high winds and even hurricanes without failing (Janssen 2000). Bamboo housing is very well ventilated which is a benefit for the tropical climate in Devikulam and above all is a simple and cost effective building material.

Given the poor standard of housing in Devikulam, creating bamboo housing has the potential to improve the quality of life for much of the community, however, there is also the potential to turn this into a business, developing simple, affordable bamboo housing that can be implemented in other communities throughout Tamil Nadu.

Considering the criteria, the most significant costs associated with such a venture are the bamboo building materials and of course the manual labour component. Initially, such a project would have a very high outlay but given the demand for high quality, affordable housing within much of India there is definite scope to develop a viable business with a sizeable income for the community.
Much of the community has some skills when it comes to building and maintaining houses and although bamboo is a very simple material to build with it requires some specific skills to ensure that the best results are achieved. The opportunity to create stable local employment is a key criterion and there would definitely be jobs created in management and construction area, however, if it became a successful business venture a significant amount of travel could be required on the part of those involved.

6.3. **Design Choice**

Each option has been assigned a point score from 0 to 3 according to how well it meets each criterion. A score of ‘0’ indicates no or low compliance with the criterion, ‘1’ is some compliance while ‘2’ is the highest possible compliance. The option to do nothing has been included in the table as a basis for comparison. It is important to consider this as it is a viable option and while doing nothing creates no employment or revenue, it is still beneficial in that there is no start-up cost incurred by the community and there are no negative environmental impacts. Simply put, it helps illustrate the point of cost versus benefit and ultimately shows that the benefits of any of the possible projects far outweigh the associated environmental and monetary costs.
Table 1: Trade off table of design options

<table>
<thead>
<tr>
<th>Design Criteria</th>
<th>The ‘Nothing Option’</th>
<th>Bamboo Housing</th>
<th>Spirulina Cultivation</th>
<th>Bamboo Plantation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Start-Up Cost</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Create Revenue</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Improve Annual income</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Build on Existing skills</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Create employment</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Environmentally friendly</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Community run</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Self-sustaining</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Outside input required</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4</strong></td>
<td><strong>10</strong></td>
<td><strong>13</strong></td>
<td><strong>16</strong></td>
</tr>
</tbody>
</table>

From the table it is evident that a Bamboo plantation is the best possible option being able to provide a significant source of revenue and stable employment with minimal negative impact on the environment, and comparatively small start-up cost.

### 6.3.1. Ethical considerations

The Australian Code of Ethics (2010) stipulates four key responsibilities of engineers to:

1. Demonstrate integrity
2. Practice competently
3. Exercise leadership
4. Promote sustainability
These four principles of ethics and professional conduct guided the team throughout the design process but were also considered, in addition to the design criteria, as being central to developing a successful design option for a new industry within Devikulam.

Firstly, the project is sustainable in the broadest sense- that is it “balances the needs of the present with the needs of future generations” (Guidelines on Professional Conduct 2010). Environmentally, bamboo plantations make use of minimal natural resources, produce little or no polluting affect from pesticides or waste products and actually improve the environment for future generations – particularly due to its significant, 17 tonnes per hectare per year, oxygen production (Janssen 2000). Bamboo is also economically sustainable and will provide the community of Devikulam with a sustainable source of revenue and employment well into the future. Perhaps one of the most significant reasons bamboo is such an excellent option is that it is also culturally and socially sustainable and beneficial. Bamboo has a great cultural significance in India and indeed the Indian government has been pushing initiatives to bring bamboo back into communities as a means of income generation and also to preserve the traditions of bamboo artisans (Janssen 2000).

A bamboo plantation is also a project that gives the community as well as the project team a chance to exercise leadership, communicating honestly and effectively to ensure the needs of the community are met and the best possible industry is developed. Furthermore, integrity and competent engineering practice cannot be achieved without thorough communication and that is where this project will succeed. There are however some ethical concerns in establishing an appropriate management hierarchy so that revenue is managed appropriately with the community’s best interests in mind, that high standards of employment are upheld and the profitability of the plantation is maintained.
7. The Bamboo Plant

7.1. Anatomy and Growth

Contrary to its size and appearance Bamboo is actually a grass. Belonging to the *Bambusoideae* family, bamboo is made up of an above ground element consisting of culms, branches and leaves and a below ground element of rhizomes and roots. The most visible parts of a bamboo plant are the tall, vertical poles called **culms**. Culms are largely hollow but are divided into sections by a solid rib or **node**. The area between two nodes is called an **internode**. Most species of bamboo also have branches and these grow from the node.

![Figure 4: Structure of a bamboo culm (Lang 2010)](image)

The root system of bamboo is very similar to a culm in appearance and function but instead of growing vertically, rhizomes grow horizontally underground. Each plant has many rhizomes, which branch out underground and produce new shoots and roots forming at the nodes.

There are two main types of bamboo- running and clumping- and these are classified according to their growth habits and root system. Running bamboo has rhizomes that grow horizontally underground with new shoots forming as much as 3 metres away from the mother plant (Lang 2010). Running bamboo is mostly found in bamboo forests as it is notably an invasive plant and can spread very quickly. On the other hand, clumping bamboo has rhizomes that grow out and up from the base of a plant with new shoots forming close to the older ones. Clumping bamboos expand
slowly out from mother plant and are particularly useful in plantations because of the dense proliferation of culms and easy management.

7.1.1. Propagation

There are a number of ways that bamboo can be germinated and each provides its own challenges and benefits. Bamboo can be planted directly from seed but this tends to be a slow process particularly with the erratic flowering patterns of many bamboos. Many species of bamboo only flower every 25-45 years making viable seed hard to come by (INBAR 2010). More commonly, plants are grown using the culm cutting method. Whole fresh culms can be harvested and taken to a sheltered site where they are buried in the soil. Within six months plantlets should be established and will be able to be planted at the chosen site (Janssen 2000).

Figure 5: Running vs. Clumping Bamboo (Davis Enterprise 2010)
7.1.2. Species Selection

Choosing the right species for a plantation is dependant on a number of things. Most importantly are the soil conditions and access to water in the region. Another is the intended use of the bamboo. For a plantation in Devikulam, a preferable species would be one that is suitable for construction but also smaller crafts and furniture.

Below is a table of bamboo species endemic to Tamil Nadu; data is taken from the National Mission on Bamboo Applications (NMBA 2009).

Table 2: Bamboo Species

<table>
<thead>
<tr>
<th>Species Name</th>
<th>Preferred Growing Conditions</th>
<th>Height (m)</th>
<th>Flowering</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ochalndra</td>
<td>Moist, deciduous and evergreen forests</td>
<td>Up to 8</td>
<td>Every 7-15 years</td>
<td>Basketry, woven mats, decorative handicrafts</td>
</tr>
<tr>
<td>travancoria</td>
<td>Odai</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oxytenanthera Stocksii</td>
<td>-</td>
<td>10</td>
<td>Sporadic</td>
<td>Construction, furniture, ladders and supports</td>
</tr>
<tr>
<td>Dendrocalamus Strictus Kalmungil</td>
<td>Dry, deciduous forests Poor, coarse-grained soils</td>
<td>10 (With a diameter up to 13 cm)</td>
<td>Every 25-45 years</td>
<td>Construction, furniture, mats, basketry and paper pulp</td>
</tr>
</tbody>
</table>

Dendrocalamus Strictus is the most abundant species of bamboo in India making up fewer than 50% of the total numbers; it is also the most promising in terms of yield with one hectare producing 750-1000 culms per year (International Network for Bamboo and Rattan (INBAR) 2010). As with all types of bamboo considerations do need to be made to the quality of the soil and the amount of rainfall, however Kalmungil has been known to grow at temperatures of -5 to 45 degrees Celsius, in relatively poor soils and with minimal rainfall (INBAR 2010). Kalmungil is an established plantation species and would be best for a new business venture, however planting multiple species should also be considered as this provides a more diverse range of uses and can also prevent loss of an entire plantation due to gregarious flowering (Janssen 2000).
8. Establishing a plantation

8.1. Site Selection

8.1.1. Location

The first step in establishing a bamboo plantation is the selection of a suitable site. In terms of practicality, an ideal site would be located on public land close to the village in order to minimise labour and transportation costs.

One hectare is both easily manageable and can provide appreciable income and materials for bamboo craft. Subject to land availability, there is the manpower capacity within Devikulam to run even larger plantations to provide greater employment and income.

![Figure 6: Possible location for a four hectare plantation](image)

8.1.2. Soil Quality

Bamboo will grow in almost any soils as long as they are well-drained. In the area around Devikulam soils tend to be deep, moderately well-drained, clay soils (Seghal 1994). Though soil drainage can
easily be improved by manually loosening the soil around young bamboo plants throughout the first two to three years of growth. Another way to avoid waterlogged soil is by planting on a slope however this may not be practical.

### 8.1.3. Water

*Dendrocalamus strictus* is a particularly drought tolerant species and will grow in regions with less than 750 mm of rainfall and as much as 4000 mm of rainfall. Average annual rainfall for nearby Chennai city over the last 25 years is 1459 mm (Rainfall Data for Major Cities of India), however this can be supplemented by ground water irrigation particularly in the first few months after planting. Beneficially, the cost of establishing a drip irrigation system is subsidised by the Department of Horticulture in Tamil Nadu, which offers Rs. 20 000 per hectare grant for farmers (Govarthan 2009).

### 8.2. Selecting of Plant Stock

As detailed above there are a number of ways bamboo can be propagated. Planting from offsets can be a very good and cost effective means of growing bamboo however for a large plantation it is recommended that planting stock is procured from a nursery where it has been raised under ideal conditions. The planting stock is a significant piece of the start-up cost for a plantation so it is important to ensure plants are healthy and well established. Most importantly, plants should:

- Be hardened for at least two to three weeks at the nursery prior to being transported to the site.
- Be small but with well developed roots and rhizomes.
- Have a good amount of healthy foliage.
- Be watered thoroughly before being transported from the nursery.

It is also important to note that when securing planting stock an additional 20% will be required to cover any plants that may die in the first few years of growing. Given that one hectare with optimal plant spacing requires 200 plants, 250 plants should be secured for every hectare of plantation.
8.3. **Site Preparation**

There are four key stages in preparing a site for Bamboo.

i. Firstly, land must be cleared of all trees, shrubs and weeds. This can either be done by hand or during the dry season it may be possible to do a controlled burn off of the area.

ii. Bamboo plants, particularly the shoots, are quite fragile in their first years of growth and fencing may be necessary to prevent grazing animals and pests from damaging young plants.

iii. The layout of the plantation must also be considered and this is particularly important when it comes time to harvest. Plants should ideally be positioned in a north-south orientation to increase the amount of sunlight caught and should be spaced sufficiently so that they do not become overcrowded. *Dendrocalamus strictus* generally require a 7m by 7m growing area all though it may be advisable to decrease the spacing between rows and increase the spacing between columns so that there is easier access to the plants during harvesting. Kigomo (2007) suggests a 6m by 8m spacing and this is illustrated below.

![Diagram showing recommended spacing for a plantation of *Dendrocalamus strictus* bamboo.](image)

*Figure 7: Recommended spacing for a plantation of *Dendrocalamus strictus* bamboo (Kigomo 2007)*

*Note: although planting bamboo in poorly drained or compacted soils is not recommended, if the site does exhibit some of these problems it may be beneficial to plough and introduce sand into the soil to improve drainage. If so it is best to do this before holes are dug.*

iv. When the layout has been decided upon it is time for the holes to be staked out and dug. In a drier climate like Devikulam it is best to dig holes of at least 60cm depth and diameter to aid in water retention. It is best to plan this so that holes are dug at least one month before the wet season.
8.4. Planting

The most important consideration when starting a bamboo plantation is ensuring that planting coincides with the wet season. Bamboo planted outside this time will have a much lower survival rate, as they require a significant amount of water in their first year to take root. Planting is a relatively simple process that begins one month before the wet season. At this time the pre-dug holes are filled to a depth of 10cm below the ground surface. Up to 2kg of an organic fertiliser or manure are mixed with the topsoil and this is used to fill the holes.

Seedlings should be transported from the nursery at the beginning of the wet season and planted immediately upon arrival. On the day of planting it is good practice to loosen the soil in and around the hole with a pitchfork to improve drainage. The seedling is then planted vertically so that the roots are 10cm below ground level. The hole is then filled completely with soil and mulched with a thick layer of sugar cane or similar mulch.

8.5. Intercropping

During the first two years of a bamboo plantation it is possible to continue utilising the land for growing vegetables and other cash crops. This practice, known as 'inter-cropping', can be an incentive to the farmer to keep the weed and pest population down and as long as crops are adequately managed there is no detrimental effect to the growth of the bamboo.

8.6. Maintenance

The first two years after planting are the most crucial for bamboo and maintenance tasks can be very labour-intensive. The table below (taken from Janssen 2000) gives a rough idea of the kind of tasks and daily labour requirements for a plantation in its first few years of growth.
Table 3: labour requirements per hectare (Janssen 2000)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Labourers/ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clearing shrubs etc</td>
<td>9</td>
</tr>
<tr>
<td>Other work</td>
<td>4</td>
</tr>
<tr>
<td>Weed control</td>
<td>3</td>
</tr>
<tr>
<td>Fertiliser Application</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>18</strong></td>
</tr>
</tbody>
</table>

8.6.1. Mulching and Weeding

Weeding and mulching should be carried out regularly by hand, especially in the drier seasons. Mulching in particular is known to prevent water evaporation while weeding will remove any competition with other plants for water and nutrients. Weeding and mulching should be done at least every month or as often as is required to remove all weeds within a 60cm radius of young bamboo plants.

8.6.2. Soil Aeration and Fertilising

Soil aeration involves loosening the soil in a one metre radius around bamboo plants using a pitchfork or other tool. By manually aerating the soil three times a year the soil drainage is greatly improved and it is less likely that plants will be lost to rot due to waterlogged soils. At the same time, fertilisers can be mixed in with the top soil to ensure an adequate supply of nutrients to the fast-growing bamboo.

8.6.3. Replanting

It is good practice when weeding a plantation to also check plants for signs of damage or rot. Any dead or significantly rotted plants should be removed and replanted with remaining planting stock. However it is important that replanting only occurs during the wet season when new plants will have the best chance of surviving.
8.6.4. Clump Management

By the third year the majority of these tasks is no longer necessary and maintenance at this stage tends towards clump management. Clump management involves cutting back and removing any thin, broken or rotting culms so that plants remain productive and are easy to harvest. The major part of this process involves thinning out the clump so that it doesn't become congested and the quality and quantity of the culms are maintained. After the clumps have been thinned out it is important to dispose of any plant matter away from the plantation as this may lead to rot. However, leaves and small branches can be left on the ground as mulch.

8.6.5. Harvesting

If the plantation has been appropriately maintained throughout the first few years, by the fourth or fifth year mature bamboo culms should be ready to harvest. Bamboo is a very starchy grass, which makes it very appealing to borers so it is important to harvest culms during the dry season when the starch content is lowest (Janssen 2010). Because new shoots tend to grow around the outer edges of clumps, bamboo should be harvested from the inside out. The best way to do this, and indeed to manage a clump, is by creating an opening in the clump and shaping it in the form of a horseshoe (UNIDO 2010).

![Clump Entrance](image)

Figure 8: Horseshow clump harvesting method (Kigomo 2007)

![Cut 35-40 cm above the roots](image)

Figure 9: Where to harvest a bamboo culm (Garland 2003)
Only mature, three to four year old culms should be harvested and a small number of these should be kept in the clump to support the younger culms, which are very soft in the first few months of growth and may otherwise collapse (UNIDO 2010). For the *dendrocalamus strictus* species young culms are green in colour and relatively unblemished, while mature culms are notably yellow and often marked. Cutting of culms should only be performed with a very sharp axe or machete to avoid splitting or damaging the wood, and culms should be cut just above the first node so that water does not accumulate in the hollow stub. Improper harvesting of this kind may result in rotting and is a breeding ground for insects and pests. After culms have been harvested it is important to either store them in a shed away from sunlight and water or treat them immediately using chemicals.
9. Business Model

There are many costs associated with setting up a plantation, particularly in the first year. The following graph gives a breakdown of all the expenditures required for a one hectare plantation in the first year. Values are those provided by NABARD (2007), Samal and Bhuyan (2007) and Krishnankutty (2004). All values are in Rupees, and the labour rate is given at Rs. 65 per man day (one full working day). Costs have been adjusted for inflation to 2012 prices.

![Expenditure required for a one hectare plantation](image)

9.1. Material Sourcing

We hope to work with the Pitchandikulam Forest Organisation in order to gather the materials requires for the plantation, given that they have both expertise in setting up forests and knowledge of local suppliers. The prices given in this report are based upon reports on the business models of existing bamboo plantations in Tamil Nadu given by NABARD (2007), Samal and Bhuyan (2007) and Krishnankutty (2004), and so the existence of bamboo plantations in the area mean it will not be difficult to find suppliers of bamboo shoots and treatment materials.
9.2. Funding

9.2.1. Group Funding

JARANA will be able to fundraise part, if not all, the capital required for the bamboo plantation here, taking the money over with us for when we implement the project.

Community Barbeques in shopping centre car parks or at university can raise $400-$600 each (personal experience), with collection tins and an explanation of our cause potentially able to raise a little more. Several of these, or a raffle, could go quite a distance towards funding the project.

9.2.2. Charities

A number of charities has been identified that might be able to supply some funding or resources towards the creation of the bamboo plantation. This list is only preliminary and includes some non-ideal suggestions, located some physical distance away from Devikulam.

- The Centre for Indian Knowledge System:
  Is based in Chennai, about 100km from Devikulam, the closest major city, and this charity runs a number of projects similar in scope and purpose to ours, including creating sustainable livelihoods with organic farming practices. They encourage the use of traditional Indian farming practices, aiming to promote organic farming moving away from dependence on chemical free methods. Given the right farming practices, they might be encouraged to provide support to help reduce plantation dependence on chemicals while also funding some of the cost. They also promote building upon the existing knowledge of the people, something else we intend to do.

- Vivekananda Kendra:
  A lot further away (very southern tip of India) however a well-organised, large religious charity that has organised projects with vocational training for women and young people. However, greater focus is on developing harmony between communities and spreading religious messages.

- SAMUHA
  “SAMUHA works with vulnerable people to improve their quality of life within defined periods of time.” They promote the idea of development through interaction between groups of members in a community rather than individual effort. They particularly like to focus on development and
expansion of private enterprise to bring income to the disadvantaged. Our project, promoting the villagers working together to grow, cultivate and market the bamboo as a proper industry, meets their criteria. They are however located further away, about 500km to the Northeast.

- AOFG (Agriculture and Organic Farming Group) India:
Another group with a focus centring on organic farming. Their main office is in New Delhi, with a secondary office in Hyderabad managing agricultural projects of fair-trade and organic natures.

- AADITYA
Aim to lift the poor out of poverty. They offer facilitating services to start up community projects – they do not provide financial stimulus, however, they will organise monetary contributions, loans and resources in the area of the project. They also offer infrastructure and planning services for the establishment of new industry.

9.2.3. Bank Loans
Samal and Bhuyan (2007) put the bank loan interest rate at 12% in 2007. There are a large number of banks available in Chennai and Salem. However, a bank loan for the a full initial amount of Rs. 165,000 requires all profits of the first two years of harvest to go into loan repayments, or smaller amounts over a longer period, to repay the loan and interest accrual, which is not an ideal situation. Therefore bank loans are only to be considered in addition to our own fundraising and any charity contributions.

9.3. Costs and Income

Initial costs:

- Land

While we hope that we can use the location indicated free of charge if it is currently unused, it is possible that there will be existing ownership claims to contend with. If it is government owned land, we would appeal to use the land on the basis of the employment and income it can bring to the people of Devikulam, making it a worthwhile use of the area. If owned by a member of the
community who is not willing to allow us to use the land for free, then we will offer, rather than a fixed rental rate, a cut of the plantation profits to go to the land owner – for example around 10-15%. Given that the land is unused this presents a risk free investment for the landholder, while also meaning the plantation does not start off with land debts to pay.

- **Treatment equipment**

A standard boucherie treatment apparatus that can treat 50 culms a day costs AUD $500 (INBAR, 2008). However, given a harvest of 1600-2000 culms per hectare, this would take more than a month to treat all the harvested bamboo. Treatment of about 200 culms per day is more suitable, making the cost for treatment equipment AUD $2,000, or Rs. 90,000.

- **Bamboo Artisans**

In order for the plantation to receive any income in the first few years of production smaller shoots of bamboo can be used for bamboo crafts – the production of domestic products out of bamboo. While the people of Devikulam might already have some skills in working with natural materials like wood or clay, the presence of a bamboo artisan to instruct them in the use of this material would be beneficial to the quality of products made. While they can be paid for this work, government grant schemes are already in place that pay artisans to live in and work with communities to pass on their skills. Note however that while bamboo crafts and products will produce income, this is separate from the management of the plantation itself and has not been included in the profit analysis in this report.

**Ongoing Costs:**

- **Harvesting**

Harvesting incurs a labour cost of Rs. 1320 to harvest the bamboo culms.

- **Treatment**

Based upon a harvest of 1500 culms of length 7m, with a treatment cost of AUD$0.05-0.08 / m of bamboo, the treatment cost per hectare of plantation is Rs. 37,800.
Ongoing costs – yearly breakdown:

The costs of running the plantation vary depending on what stage it has reached. The following table outlines what costs are incurred in each year and the total expenditure for that year.

### Table 4: Yearly breakdown of ongoing costs

<table>
<thead>
<tr>
<th>Year</th>
<th>2%</th>
<th>3%</th>
<th>4%</th>
<th>5%</th>
<th>Ongoing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs</td>
<td>Irrigation&lt;br&gt; Fertiliser &amp; FYM&lt;br&gt; Weeding&lt;br&gt; Plant protection&lt;br&gt; Soil working</td>
<td>Irrigation&lt;br&gt; Plant protection&lt;br&gt; Soil working&lt;br&gt; Fertiliser &amp; FYM</td>
<td>Plant protection</td>
<td>Plant protection&lt;br&gt; Harvesting Treatment</td>
<td>Plant protection&lt;br&gt; Harvesting Treatment</td>
</tr>
<tr>
<td>Total</td>
<td>5544</td>
<td>1848</td>
<td>330</td>
<td>50226</td>
<td>50226</td>
</tr>
</tbody>
</table>

![Expenses over time](image)

**Figure 11: Expenses over time**
Income:

Based upon a harvest of 1500 culms per hectare, at $290 US per 100 culms of length 7m each (source) we expect an income of Rs. 197,100 / ha/yr.

<table>
<thead>
<tr>
<th>Year</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expenses</td>
<td>14850</td>
<td>5544</td>
<td>1848</td>
<td>53064</td>
<td>53064</td>
<td>53064</td>
</tr>
<tr>
<td>Income</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>197100</td>
<td>197100</td>
<td>197100</td>
</tr>
<tr>
<td>Net value of project</td>
<td>-14850</td>
<td>-20394</td>
<td>-22242</td>
<td>121794</td>
<td>265830</td>
<td>409866</td>
</tr>
</tbody>
</table>

Table 5: Net value predictions

Figure 12: Net projection values
9.4. **Financial Risk Analysis**

There are a number of scenarios that could detriment the plantation.

<table>
<thead>
<tr>
<th>Risk</th>
<th>Likelihood</th>
<th>Consequences</th>
<th>Preventative action</th>
<th>Contingency cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire</td>
<td>Low – Bamboo is naturally fire retardant.</td>
<td>High – Several plants up to whole plantation burnt</td>
<td>Plant spacing Remove dead material</td>
<td>Rs. 15,000 / ha, replacement of plantation.</td>
</tr>
<tr>
<td>Flooding</td>
<td>Moderate – High rainfall in Devikulam area.</td>
<td>Moderate – Immersion in standing water can kill over time</td>
<td>Manual water removal – digging drainage trenches</td>
<td>Rs. 1,000 / ha – for digging trenches Replacement cost shared with fire</td>
</tr>
<tr>
<td>Insects &amp; disease</td>
<td>Low – Bamboo is naturally resistant to many pests and diseases</td>
<td>Moderate – Severely infected clumps must be removed, damaged culms likewise</td>
<td>Insecticide use in first year Plant protection – inspection and removal of dead and damaged</td>
<td>Already budgeted for</td>
</tr>
<tr>
<td>Livestock</td>
<td>Low – Fence keeps livestock out of plantation area.</td>
<td>Low – Some bamboo shoots eaten in early years</td>
<td>Fence around the plantation</td>
<td>Already budgeted for</td>
</tr>
<tr>
<td>Drought</td>
<td>Low – Data indicates high rainfall in Devikulam area.</td>
<td>Low – Less than optimum bamboo growth</td>
<td>Irrigation in first two years</td>
<td>Already budgeted for</td>
</tr>
<tr>
<td>Treatment</td>
<td>Moderate – High volume pumping of chemical solution causes clogging</td>
<td>Low – Bamboo treatment is delayed for repairs</td>
<td>Regular maintenance and flushing of pump and pipes.</td>
<td>Rs. 500 / ha for maintenance of pump and other treatment equipment.</td>
</tr>
<tr>
<td>equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>failure</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weed competition</td>
<td>Low – Bamboo rapidly outgrows weeds</td>
<td>Low – Bamboo growth and quality restricted</td>
<td>Weeding in first two years</td>
<td>Already budgeted for</td>
</tr>
<tr>
<td>Malnutrition</td>
<td>Low – Bamboo grows well in most soils</td>
<td>Low – As for weed competition</td>
<td>Fertiliser and farmyard manure every year</td>
<td>Already budgeted for</td>
</tr>
<tr>
<td>Storm / cyclone</td>
<td>Low – Large roots very stable, culms flexible in wind</td>
<td>Moderate – Loss of plants to uprooting, broken culms</td>
<td>Proper harvesting to allow wind to pass through clump</td>
<td>None allocated</td>
</tr>
</tbody>
</table>
9.5. **Final budget Summary**

The following is an overall perspective of all the costs encountered in creating a one hectare bamboo plantation including the treatment equipment and the first batch of treatment chemicals. The contingency budget is shown as an optional cost, as it is not essential to establish the plantation.

Notice that the per-hectare model basis is used, as community consultation to gauge interest in the project is required before a suitable size can be chosen, although any size is profitable. The other main concerns, of land and the bamboo artisans, are also mentioned.

Table 7: Final Budget Summary

<table>
<thead>
<tr>
<th></th>
<th>Per Hectare</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plantation, first four years</td>
<td>Rs. 75,300</td>
</tr>
<tr>
<td>Treatment Equipment</td>
<td>Rs. 90,000</td>
</tr>
<tr>
<td><strong>Essential Total</strong></td>
<td><strong>Rs. 165,300</strong></td>
</tr>
<tr>
<td>Contingency (optional)</td>
<td>Rs. 16,500</td>
</tr>
<tr>
<td><strong>Total with Contingency</strong></td>
<td><strong>Rs. 181,800</strong></td>
</tr>
</tbody>
</table>

**Other considerations**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Land</strong></td>
<td>Government grants / lease agreement.</td>
</tr>
<tr>
<td><strong>Bamboo Artisans</strong></td>
<td>Government grants / volunteers</td>
</tr>
</tbody>
</table>
10. Treatment

Treating harvested bamboo directly after cutting is vital in ensuring its longevity. As with any natural, organic material bamboo is prone to decay as the natural fibers and constituents of its mass (mainly the cellulose and lignin) break down and therefore weaken the bamboo as its physical properties change. While the natural breakdown of fibers is one of the ways in which the lifespan of structural bamboo is limited, other environmental factors which contribute to the degradation of the bamboo include moulds and fungi as well as termites, powder beetles and other pests.

The natural lifespan of *Dendrocalamus strictus* is between 18 months and 30 months with an average lifespan of 19 months. (Satish, Kanith, & Chauhan, 1998) This is clearly unacceptable as expecting people to rebuild structures and remake goods made from bamboo every 2-3 years is unrealistic and would put an unnecessary strain on resources and construction time.

Fortunately, treated bamboo that is used correctly in construction and kept mostly dry and above ground can last up to ten times the length of identical untreated bamboo. This increased lifespan of twenty five years means that bamboo housing is a realistic, affordable and permanent type of dwelling and demonstrates the importance of treating harvested bamboo.

10.1. Evaluation of Treatment Methods

There are many methods to treat bamboo to make it less prone to attacks from fungi and pests. Treatment methods fall into two main categories, chemical and non-chemical treatment. While non-chemical treatment is more environmentally friendly, it is far less effective than chemical treatment processes. Some treatment processes that we considered were:

- **Chemical:**
  - Modified Boucherie Process: Involves forcing a preservative solution through a length of bamboo using specialized equipment.
  - Steeping: Involves standing bamboo culms up in a preservative solution for two weeks.
  - Soaking: Involves submerging split bamboo in a preservative solution for one and a half weeks (note: this does not work on non-split bamboo).

- **Non-Chemical:**
o  Clump-curing: Involves cutting the bamboo and leaving it upright with its branches intact.
  o  Soaking: Involves soaking bamboo culms in water for two to three weeks
  o  Smoking: Involves exposing bamboo culms to smoke over a period of time

The criteria under which each of these treatment processes was scrutinized:

•  Scalability: How much bamboo could be realistically treated in a day
•  Effectiveness: By how much would the treatment extend the life of the bamboo
•  Time: How long it takes to treat the bamboo
•  Cost ratio: How much the value of the bamboo would rise against the price of treating it
•  Startup Cost: How much it costs to setup the process

The importance of each criteria were given a ranking which can be seen in the table below and then each treatment process was scored on its merits in each category. Low ranked criteria were scored out of 5, moderate ranked criteria were scored out of 10, high ranked criteria were scored out of 15.

<table>
<thead>
<tr>
<th></th>
<th>Scalability (high)</th>
<th>Effectiveness (moderate)</th>
<th>Time (low)</th>
<th>Cost Ratio (high)</th>
<th>Startup Cost (low)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boucherie</td>
<td>13</td>
<td>10</td>
<td>5</td>
<td>12</td>
<td>0</td>
<td>40</td>
</tr>
<tr>
<td>Steeping</td>
<td>10</td>
<td>8</td>
<td>1</td>
<td>8</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>Soaking</td>
<td>8</td>
<td>7</td>
<td>2</td>
<td>8</td>
<td>4</td>
<td>29</td>
</tr>
<tr>
<td>Non-Chemical</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clump-curing</td>
<td>15</td>
<td>4</td>
<td>2</td>
<td>10</td>
<td>5</td>
<td>36</td>
</tr>
<tr>
<td>Soaking</td>
<td>9</td>
<td>4</td>
<td>2</td>
<td>11</td>
<td>4</td>
<td>30</td>
</tr>
<tr>
<td>Smoking</td>
<td>3</td>
<td>5</td>
<td>4</td>
<td>9</td>
<td>4</td>
<td>25</td>
</tr>
</tbody>
</table>
The modified Boucherie process was the clear winner, mainly because of its high scalability, effectiveness and cost-ratio. It is these features of the boucherie process that makes it the ideal bamboo treatment process to use in a plantation of the scale we are planning.

**10.2. Why it works**

The modified boucherie treatment method falls under the category of bamboo preservation by sap displacement. This type of treatment can also be achieved with more traditional soaking methods but in a less effective and time consuming manner.

Sap displacement is important as the sap contains the starch inside the bamboo which is attractive to destructive pests such as the powder beetle. In addition to removing these starches, sap displacement allows preservative salts to impregnate the entire bamboo culm, further deterring pests and retarding the growth of moulds and fungi.

The water carrying vascular bundles inside the bamboo culm run parallel to the length of the culm and have minimal branching such that the radial permeability of bamboo is almost nil. This, however, does mean that living bamboo has a very high longitudinal permeability (Rao) and is why the bamboo can be treated by sap displacement. Once a culm is cut from the main plant the vascular bundles will soon dry out and close off. It is therefore important to treat the bamboo within 24 hours of harvesting or the preservative solution will not be able to penetrate enough of the culm to act as an effective protection against pests and fungi.

**10.3. Modified Boucherie Process**

The basic idea behind the modified Boucherie process is to force a solution of preservative through a length of bamboo under pressure. This replaces the sap within the culm with preservative salts in under two hours and is therefore the quickest and most efficient method of bamboo preservation available.

**10.3.1. Equipment**

- Strong, sealed container able to take pressures of up to 1.5kg/cm²
- Rubber pipes
- Valves
• Screw-hose clamps (to seal the rubber pipes onto the bamboo)
• Pressure gauge
• Pump (either electric or manual)
• Corrugated sheeting (either metal or plastic)
• Containers to collect preservative at opposite end
• Hydrometer
• pH meter
• Saw

10.3.2. **Raw materials**

• Bamboo culms (freshly harvested 2-3 years old)
• Water
• Preservative, can be any of these three:
  1. Disodium octoborate tetrahydrate
  2. CCB (copper-chrome-boron)
  3. Mixture of borax and boric acid

10.3.3. **Set Up**

The equipment must be set up as below:

![Diagram](Figure 13: Boucherie treatment set up)
The bamboo will rest on slanted sheets of corrugated iron or plastic to catch the preservative that will leak out from the join between nodes. The opposite end of the bamboo culm must also be placed above a suitable container for the collection of leftover preservative solution.

While the above diagram only shows one culm connected to the container of solution, many pipes may branch off the exit pipe with their own respective valves and culms attached, allowing for many units of bamboo to be treated at once.

The lid of the container must also be able to be removed but still have an air-tight seal between it and the container.

Once the equipment is set-up there is only a little more preparation to do before the treatment process can proceed.

### 10.3.4. Preservative solution

The preservative solution consists of a ratio of 9:1 of water to preservative. If a mixture of borax and boric acid is being used as the preservative, mix the two together in a ratio of 3:2. (Ahmed, 2005) The preservative solution should be mixed regularly (between each batch of bamboo preservation) to ensure a homogenous solution.

The diluted solution collected from previously treated bamboos can be reused by checking the concentration of solution with a hydrometer and adding an appropriate amount of preservative to bring the solution back up to 10% preservative content.

### 10.3.5. Treatment

Once the equipment has been set up as above and the preservative solution has been prepared, the treatment process can begin.

I. Remove the lid of the treatment container.
II. Fill with preservative solution to about 2/3 so that there is enough air to pressurize the container.
III. Cut a few centimeters off each end of the culms to remove any dirt that may be have clogged the ends of the vascular bundles.
IV. Fit the rubber hosing around the end of the base end of the bamboo.
V. Seal the hosing around the bamboo using the screw-hose clamps.
VI. Place the bamboo on the corrugated iron or plastic with the uncovered end facing downwards and over a receptacle for the solution as it flows out the other end.
VII. Pressurize the container to 1.5 kg/cm².
VIII. Open both valves until the air has been forced out, then close the second valve.
IX. Wait for 1 hour, maintaining the pressure as solution passes through the bamboo culm.
X. Check the concentration of the solution exiting the culm with a hydrometer until it is almost equal to the initial preservative solution.
XI. Turn the valves to the off position and remove the bamboo from the rubber piping.
XII. Release the pressure from the container.
XIII. Refill and stir the container of solution and repeat steps 1-12 until all the bamboo has been treated.

10.3.6. Storage

Once all the culms have been treated, the bamboo must be stored horizontally and allowed to dry in a well ventilated area that is protected from the rain, sun and raised above the ground. The treated culms must not be stored vertically as the preservative solution will leak out and render the treatment process less effective.

The drying times for the treated bamboo varies depending on the climate of the area as well as other factors. A drying time of at least two weeks is recommended but in humid climates drying times can be up to ten weeks.

The bamboo must also not be allowed to dry too rapidly as rapid dehydration of the bamboo can cause non-uniform shrinking and cause the bamboo to crack and split (Practical Action) which would significantly compromise its structural integrity. It is therefore important to keep the bamboo away from direct sunlight as drying in the shade will be adequately slow for an even drying and shrinking process that will avoid splitting.

10.3.7. Hazards

The hazards of treating bamboo mostly revolve around the use of chemicals. While the preservative chemicals are of low toxicity, contact with the eyes and skin should be avoided as high doses of the
preservative can be lethal. To reduce the risk involved with treating the bamboo a few precautionary steps can be taken:

- PPE must be used when dealing with the chemicals, including gloves and eye ware
- Wait for the culm to stop leaking after the preservation process is over before transporting to a storage area
- Store the chemicals according to the manufactures advice
- Do not eat, drink or smoke during or immediately after contact with treatment chemicals
- Wash hands after treating or carrying treated bamboo
- Wait for the culms to fully dry after being treated and before use
- Do not burn treated bamboo

10.3.8. Benefits

The benefits of treating bamboo have already been mentioned but they all revolve around increasing its lifespan. A typical culm of bamboo will cost 10-15 cents/meter (INBAR) and the treatment of bamboo costs 5 cents/meter once the treatment facilities are established (Rao). This increases the cost by about 40% however, the lifespan of the bamboo is increased from 2-3 years to 25 years. This is a more than 600% increase in its lifespan. While just this figure proves that treating bamboo is well worth it, it also eliminates the labour and time needed in replacing rotting bamboo structures and products.
Not only do the benefits of treating bamboo far outweigh the costs but it will also put less of a strain on natural resources as less bamboo will have be grown to maintain identical bamboo structures.
11. Applications

11.1. Housing

The low quality of housing in Devikulam is a serious issue with most living in well-ventilated but poorly waterproofed mud and thatch housing (EWBA 2011). Other villagers live in government group homes that are made from concrete and are too hot to live in during the summer seasons. These buildings, and others, are also in need of substantial repairs. The biggest barrier to creating or improving housing standards in Devikulam is the cost. Being in a remote area the cost of transporting materials to the village is large and any other labour or material costs associated with a build would push many projects over budget. What Devikulam needs are solutions that are low cost, use local materials where possible to minimise the cost of transport, take into account the climate and culture in Devikulam and be easily maintained and repairable by the community.

A solution to this is using the bamboo grown in the proposed plantation. Bamboo makes an excellent building material as it is very strong and has high tensile and compressive strength (Grewal 2009). It can withstand high winds, such as those of the monsoons, due to its flexibility (Janssen 2000). Bamboo also provides waterproof shealter that will not be swept away during floods or monsoonal rains (Nenova 2010). It is very well ventilated, which is a benefit in the tropical climate of Devikulalm. Bamboo is also relatively easy to work with and requires only basic tools and a small amount of skills training, which could be provided by the Pitchanikulam forest educators. There are, of course, issues with bamboo construction that have dissuaded people from using it widely and that is the relatively short lifespan of bamboo if it is left untreated. Raw bamboo will only last between 1 and 3 years, whilst treated it can last up to 20 or 30 years or even more (Janssen 2000). This is still significantly shorter than the lifespan of concrete and brick houses, however taking into account the low-cost and ease of manufacturing and repairing a bamboo house this is not a huge issue. Also, like wood, bamboo is susceptible to rot and wood-eating insects hence it requires very specific conditions to ensure a long shelf life including correct treatment, storage and harvesting methods, which have been described elsewhere in this report.
11.2. Domestic Products

One of the primary uses of bamboo in idea, and across the world, is in the furniture and handicraft industry. Bamboo is a suitable resource to use for this as it is very strong yet easy to work with and the tools needed are fairly basic. (Cusack 1999) The culms can either be used without further cutting after the treatment process or they can be split, using a culm splitter, to produce thin strips. Both of these can be used to make many household items from chairs and tables to mats and baskets. There is already a strong base industry in India which uses bamboo as their raw material (Rawat & Khanduri 1999). This means that the skills already possessed by the people in Devikulam could be easily built upon, and that if required training would more likely to be readily available. The products made could then be used in the local households, to reduce the cost incurred by buying them from outside the community, or be sold at markets, in nearest towns or city, for a profit. By providing them with a stronger, better material the products produced that stay in Devikulam will potentially last longer than existing items and hence have a positive outcome for the community.

Currently bamboo pulp for papermaking is the greatest use of bamboo in India, and hence is another application of the bamboo gained from the plantation (Rawat & Khanduri 1999). Whilst large scale production of paper in Devikulam at this stage is not feasible their options include selling the culms to existing pulp and paper mills or setting up small scale production from which the paper could be used in the school or community to reduce current costs. It could also be done in the school as part of the community involvement to demonstrate to the community the benefits of having a bamboo plantation, hopefully raising awareness and interest in the project.

Figure 14: Bamboo Model House (Jansen 2000)
11.3. **Water filtration**

Bamboo is a viable resource for use in water filtration systems. The community of Devikulam could potentially use the bamboo from the plantation as part of their water system. Bamboo can be used for piping, for the transportation of water or even as a part of the filter. (Liebman & Einav 2009) A common filtration system involving bamboo is desalination. Water is run through a filter using bamboo charcoal as the cleaning agent. This type of desalination is known as reverse osmosis, or membrane desalination. It works by pressurising the water and forcing it through a membrane, in this case that uses bamboo charcoal, which filters out most salts and minerals. (Terry 2011) This produces purified water, however, further treatment processes might need to be undertaken to further process the water to make it potable. An alternative is using the bamboo as the catchment apparatus instead of say PVC piping, with filtration achieved by what is inside the bamboo pipes. By combining proven filtration systems in the pipe clean water is obtained. This could be made simply with a piece of mosquito or fishing net, some sand, ash and charcoal and a clay filter (Wickramaratna et al. 2009).
12. Community Implementation

12.1. Community Perspective

Regarding business conventions, Indians prefer to do business with those they know and trust (India 2011), and thus local organisations such as Pitchandikulam who has maintained a long-standing relationship with the community will play an important role in the implementation of the bamboo plantation. Indians are non-confrontational; it is rare for them to overtly disagree, although this is beginning to change in the managerial ranks.

Decisions are usually reached by the person with the most authority (India 2011), thus it would be important to gain approval from the elders and local authorities in the village in order to implement the industry and it is most likely to be them who will hold the management positions in the business. However, it is important that they do not overtake the community’s business to achieve personal gains.

It is common that decision making is a slow process in India, especially when dealing with the government (India 2011). Furthermore, the fact that the majority of the community do not have an adequate education background to understand all the technical aspects of the project, such as its benefits, risks and opportunities, may propose difficulties and lengthy processes in gaining approval of the people for the plantation.

These factors should be carefully considered and taken into account when planning the community implementation procedures and educational training for the project.

12.2. Cooperation with Pitchandikulam

Apart from their main activities with the restoring the forest, Pitchandikulam Forest also provides education and models in sustainable ecological practices through various community outreach programs and delivering innovative education methods. Traditional knowledge and technologies of the local people are being documented, displayed and woven into the Pitchandikulam landscape. Pitchandikulam Forest operates a Bioresource Centre, located in the Pitchandikulam Ethnomedicinal Forest, which provides an extensive database and resources for the education of conservation, identification and use of indigenous medicinal plants. Thus, the centre can be used as an education
centre where the local community can learn the necessary skills in cultivating the bamboo as well as provide Pitchandikulam Forest with feedback on the planting process.

Pitchandikulam Forest maintains strong connections with the community through collaboration with village leaders, healers, Self Help Groups, youth groups, other NGOs, government departments and students. Our project share this common objective with Pitchandikulam Forest in that we aim to involve the local people into the implementation of the project as much as possible in order to achieve long-term sustainability. By collaborating with these groups through Pitchandikulam Forest, we aim to extend the bamboo plantation and its prospective benefits to other villages in order to increase the size of the project and involvement of the local people.

12.3. **Community Consultation**

The community consultation will happen in three stages. The first stage will involve finding someone who is fluent in both English as well as the native language of the community in which we are working. This person could possibly be found in Pitchandikulam and would be taught about the plantation by reading this report as well as explanation by people from EWB. The EWB team along with their translator will then go into the community and find someone whom the community respects, such as the elders, who will be able to organise a meeting which most people from the village will attend.

Once the meeting is underway, the translator from Pitchandikulam will propose the plantation and generate general interest among the community. Questions will be taken and the EWB team will be there if any specific questions need to be addressed that the translator is not prepared for or needs further clarification to answer. The team will then announce that they will be conducting a survey of each person to determine how much interest there is in the project as well as the proposed date for the next meeting where a tailored proposal will be given.

12.3.1. **Survey**

Additional translators would be recruited from Pitchandikulam and the team of translators would be given the survey and each villager would be surveyed over the course of a week.

1. Current income level
2. What is your desired annual income?
3. How many days a year do you work?
4. Would you be interested in working in the bamboo plantation?
5. How many days a week would you be willing to work?
6. If you are currently employed, what kind of work is it?
7. What skills do you have?
   • Agricultural
   • Trade
   • Bamboo craft / working with bamboo
8. What’s your highest level of education?
9. Do you have any experience in management?
10. What responsibilities do you currently have?
11. Would you prefer community run plantation, as opposed to run by one individual?
12. Would you be interested in running the plantation?
13. Do you have any experience in managing land or a business?
14. What do you think about bamboo?
15. Do you have any questions for the next meeting?

Questions 1-5 will be used to determine the maximum sized plantation we could run with the amount of labour that could be supplied from the village. The size of the bamboo plantation is scalable and virtually any size above a realistic minimum could be established to provide sustainable and stable employment for all the people who were interested. For example, during the first few years, 18 people per hectare will be needed which will grow as harvesting and treatment begins, with this data we can create the perfect sized plantation for the labour available.

Question 6 and 7 will be used to determine how much training the future workers of the plantation will need before they can be effective in working on the plantation. Naturally, everyone will be given training but if there are lots of people will agricultural skills, for example, some knowledge can be assumed and people with those skills can be employed in areas that utilize their skills to the fullest extent.

Questions 8-10 will help determine which people will be best suited to organizational roles and how much training in these management roles each person will need to be given.
Questions 11-13 will be used to find out what kind of business model would be appropriate for this kind of plantation by getting the opinions of the people who will actually be working there as well as the people from the village who have an interest in the project.

The last two questions will allow the people to give us any unforseen opinions on bamboo and address these comments and questions as the next meeting.

### 12.3.2. Refined Proposal of Plantation

Before the second meeting, the data from the surveys will be collected and collated. If it is clear that there is not enough community backing for the project, it will be scrapped, as it will inevitably fail without community support. If it is deemed that there is enough enthusiasm; the size of the plantation, the location, the projected salary, the owner, the projected profits and a simplified overview of the business model will be presented to the community. The questions raised and comments written in the survey will then be addressed by the translator with the help from the EWB team. Once the team is happy with the response of the community and have answered all questions and generated sufficient interest for the project, the implementation stage can begin.

### 12.4. Possible Problems

Trying to organise a project of this size whilst pleasing everyone will be impossible. Some compromises will have to be made but hopefully by getting the opinion of the community we can foresee and hence account for these problems.

Communication will be a key factor in the success of the project. While having translators and not relying on villager literacy will help in the consultation process, it is not a perfect system and extra time may have to be spent in surveying the people to ensure that accurate data has been collected and that nothing has been lost in translation. If there are not enough translators to complete the surveys in the allocated time, the second meeting can be pushed back until sufficient data is collected to make decisions about the plantation.

Ownership of the plantation and division of profits will be a very delicate issue. The income of the plantation will be used to pay the workers a good wage as well as pay off any loans that were taken out to fund the project. Once the plantation starts being profitable, the money will get reinvested
into the community either by direction from the managers of the plantation or by vote of the community.

Response to the proposed project will be very important as if there is not enough interest and enthusiasm the project will not survive. It is therefore vital in these first few stages to really sell the plantation to the villagers and highlight its positive features. Community support is the cornerstone that will hold the project together as it progresses and only once it has been gained can the implementation of the project begin.

12.5. **Community Implementation Strategy**

**Step 1:** Community Consultation

The most important part of successfully implementing our project in the community of Devikulam is the consultation process, outlined above. Further consultation shall be undertaken however after this preliminary consultation to determine who shall form the management of the plantation. This shall be a confidential survey of those who were interested in being involved in the plantation, asking whether they felt confident with the ability of those that volunteered for management roles. The most important consideration here is the trust of the community.

**Step 2:** Education and Training:

- **Training area**

There are two options for the training area, where education on management and techniques for growing the bamboo shall be undertaken. The first is the school in Devikulam outside school hours. As an established learning space it is already set up for teaching, and we can use the space for teaching about bamboo management as well as workers. Given that there is also a spare room currently unused, training could also be undertaken in there during school hours if this was more convenient.

Alternatively, training could be undertaken at the ICT centre established in Nadukuppam - approximately two kilometres from Devikulam, by the Pitchandikulam Forest Organisation according
to a discussion on the EWB site forums. A secondary purpose of this establishment is, as described by the site, to “train various collectives such as the women’s group, famers group”.

- Management training

Based upon the results of the community consultation, a group responsible for managing the plantation and its finances shall be selected. Priority will be given to those that said they want to run the plantation and have some prior financial or business experience, good literacy, and who are also trusted by other members of the community. Those without experience but who are trusted will then receive precedence over experienced but un-trusted individuals, since it is crucial to the long term running of the plantation that everyone is satisfied with how it is being run and by whom.

<table>
<thead>
<tr>
<th>Priority for selection</th>
<th>Trust of Community</th>
<th>Management experience</th>
<th>Literacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>High</td>
<td>High</td>
<td>Moderate</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

The managers then need to be instructed on all facets of the plantation required to make a sustainable, profitable business model. This includes the timeline of what work and how many workers are required throughout the year, and all the financial details included in this report in regards to expenses, risks and forecasted profits.

JARANA will prepare the relevant illustrative information, such as the graphs and tables in business model in this report, and the gantt chart (see step 3), to demonstrate the financial operation of the plantation. Education shall be undertaken with the assistance of the Pitchandikulam Forest Organisation, for this training, as language and potential literacy barriers would make it difficult for us to perform the training directly. We do no predict many issues with conveying this information, as it only outlines when equipment and materials need to be purchased, their cost, and payroll information regarding how many workers are needed, at what rate and for how long.

It will be important to implement some sort of roster for the workers on the plantation, given that the number of workers required varies significantly throughout the year. We will allow the management to come up with suggestions as to what they think would work best, while they will also be responsible for organising distribution of income from the plantation – hence why community trust is essential as this issue could be the source of great disagreements.
• Worker training

Although the people of Devikulam are already quite skilled agriculturally, there are a few points specific to bamboo plantations worth teaching. This includes the timeline of what work and how many workers are required throughout the year, what to look for in terms of insect and disease damage, and proper harvesting practices.

This education would again be conducted with the assistance of the Pitchandikulam Forest Organisation, while JARANA will supply a combination of visual and physical examples pertinent to bamboo care and maintenance, such as samples of healthy bamboo from shoots to more mature ages, samples of diseased and insect infected bamboo, bamboo suffering from waterlogging or malnutrition, and bamboo that is at the right age to harvest. Diagrams would also be used to illustrate proper harvesting practice in the horseshoe shape.

A key part of the training required is in proper treatment. This education shall be undertaken through means of demonstration, by having those workers that will eventually use the treatment equipment construct the apparatus and perform the boucherie process on several culms to understand how the process works. This will also be beneficial for purposes of maintenance as they know how to take it apart and we would outline proper practices for caring for the equipment. Given that the treatment equipment is not required for another three years or so, this set up would only be for demonstration purposes as there is little point leaving it unused for so long. JARANA will consider returning to the community when the treatment equipment is required to assist with the final set up.

• Bamboo crafts

Although not directly part of our project, the number of applications of bamboo in terms of crafts and the production of domestic products was one of the reasons bamboo was chosen as the type of plantation to use. The Craft Revival Trust (2011) lists over 60,000 artisan craftspeople in India, including bamboo workers in Tamil Nadu. We hope that some of these artisans can be arranged to train a Devikulam women’s group in bamboo crafts, including mats, baskets and furniture, which the community of Devikulam can either use or sell for profit. This could be undertaken in the disused school room as it is both enclosed and spacious at 8m x 8m x 3.5m according to a discussion on the
EWB forum site, while there is also a possibility of the artisans working with schoolchildren on activities to promote the plantation, such as making simpler products, or producing their own paper out of bamboo pulp.

**Step 3: Establishing the Plantation**

The physical requirements to establish the plantation have already been described and costed in detail in this report in the Design Details and Business Model sections. Here is a summary of what needs to happen and the timeframe over which it occurs, presented in the form of a Gantt chart that will also be provided to managers and workers on the plantation.

**Table 10: Gantt chart for plantation**

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<td>Intercropping</td>
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<td>Export</td>
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<td>Crafts Training</td>
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<td>Bamboo Crafting</td>
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Step 4: Trade links

By working with the Pitchandikulam Forest Organisation, we plan to line up prospective buyers of the bamboo before the plantation begins. This information would be provided to the managers of the plantation, along with transport information. Suppliers for all materials must also be established and transport of materials required be arranged before the plantation can begin.

Ongoing consultation

Ongoing consultation is important to evaluate the continued success of the project, both financially and from the community’s perspective. Its main purpose is to keep track of the development of the plantation and to provide assistance to smooth over any teething issues encountered in the first few years. By providing advice rather than direct involvement in response to continued feedback, JARANA can gradually withdraw its involvement to allow the community to take over full responsibility.

This ongoing consultation would have a number of components. We would ask the managers whether they believed everyone was doing a good job – that the workers were working effectively and showing up for work, that there was sufficient demand for their materials, that suppliers had been able to deliver required equipment on time and at the cost stated. We would ask the workers whether they had noticed any issues with the plantation, or had encountered anything that they thought needed addressing but weren’t sure what to do in the case of bamboo. They might also be disgruntled with the management and have queries about income distribution, and this is something we can provide advice on.

We would also conduct broader surveys to gauge the community’s perspective, looking for any change in regards to opinions towards the presence of the plantation. Even if there was overwhelming support initially it is still important to ask again to see if opinion has swung, or if it was negatively received to see if we have won more supporters through the provision of income and employment. This survey is to ensure there is no resentment or ill feeling towards the project, which would need to be dealt with, and JARANA would help the plantation to address the communities concerns to eliminate these issues.
13. Evaluation and Conclusions

13.1. SWOT: Project Implementation

13.1.1. Strengths

Employment Opportunities: The plantation will need workers for a variety of tasks. Some of the early labour required is focused on preparing the site and planting the crops, then the plants need to be maintained, irrigated and fertilised and then finally once matured the culms need to be harvested. The final product is then treated. Each of these stages will utilise local workers who are seeking employment. The search for local workers can be assisted by the people of the Pitchandikulam Forest community who are also trying to improve the employment prospects of people in the region (EWBA, 2011). This will make the search for workers much more efficient as this organisation has much more knowledge of the region and its customs than any outside source could possibly have.

Low Start-up Costs: Although there are initially a large number of expenses they are each relatively small and could theoretically be paid for by a fundraiser in Australia meaning there would not be the extra financial burden of loans. Although if this is not possible then the option of applying to previously existing charities and micro-finance organisation is a viable alternative.

Financial: After the initial stages of developing the plantation it should provide a reasonable and long lasting economic boost to the area that will help address some of the many other issues of under development in the community.

Environment: A well-managed bamboo plantation may actually have environmental benefits for the surroundings environment. As mentioned previously it both absorbs carbon and prevents erosion. So where as many other types of agriculture may have negative environmental impacts bamboo may have some positive outcomes on the surrounding ecosystem. Although, it is important that the chemicals used in the treatment of the harvested culms managed correctly and wastes are not dumped into important waterways. Furthermore, the environmental impacts could be lessened with manual maintenance of pests and fungi rather than using unnatural pesticides even though these may be quicker
and easier in many cases and as the plantation grows may become the only viable alternative.

**Sustainable:** The bamboo should continue to produce culms that are harvestable as they reach maturity. Barring any major natural or manmade disaster such as a fire then the clumps of bamboo will all last 25-45 years until the bamboo plant flowers.

**Involves the Community:** a main strength of this project is that it utilises local labour and will help to bolster the employment prospects of people in the region. Furthermore, the plantation should be run by the people of the community, with the assistance of the Pitchandikulam Forest community at first, meaning no outside help is needed to ensure the plantation’s continuing success into the future.

**Outside Help:** After the initial implementation of the project there is very little outside help that the people of Devikulam will need. If there are any problems outside the scope of the above report, the workers can use the resources of the Pitchandikulam Forest. This community of people has experience in growing and maintain cops in the region that will be invaluable to the project’s success.

### 13.1.2. Weaknesses

**Slow Starting:** As the financial projections indicate the initial costs are high and the income is nil till for several years. Thus, there is expenditure with no income and this may demoralise the workers and it may seem that there is a significant amount of work required while no income is being generated.

**Requires Land:** the bamboo plantation requires land that is either clear or can be cleared relatively easily. This land must also be reasonably cheap to occupy, with a lease or by purchasing it. It may be difficult to find suitable land especially from Australia as we have limited access to information regarding land ownership and local development laws etc. The Pitchandikulam forest community will be able to provide assistance in finding a suitable local area that is both close to transport and fits the criteria for the plantation.
13.1.3. **Opportunities**

**Income Generation:** As outlined earlier in this report the plantation should be able to produce long-term sustainable net income of up to $45000. This will be able to provide stable and much needed income for the people of the area and furthermore it means that there is no need for continuing outside funding to supply materials and pay maintenance costs. The income will hopefully be able to address many of the other problems brought about by the poverty in the region.

**Products:** Bamboo is extremely versatile and produces a large range of products. From furniture to paper and even food and medicines there are numerous ways that bamboo can be used meaning that the demand will remain high and hence produces further opportunity for further industry development of bamboo in the region to produce these products for both international and local sale.

**Expansion:** Initially the plantation we are proposing is going to be 4 hectares in size. However, once this has been established and is growing then there is the opportunity for income from this or further finance to fund an expansion of the plantation meaning more income and employment for the people of the region if they find they want this.

13.1.4. **Threats**

**Fire:** Fire is a minimal threat during the monsoon season when there is regular heavy rain but during the dry season the plantation is at risk from fire. This risk is highest after the bamboo has flowered and the bamboo begins to die and then dry out (Sudhi 2010). Although it would not cause a loss to the income of the business, as the bamboo is already dead the fire may cause damage to surrounding infrastructure and hurt people if they are unprepared. To minimise this risk after flowering the bamboo needs to be quickly cut down, or preferably this should be done at the onset of flowering, as there are other associated risks from the fruit that the flowers produce. Furthermore, the surrounding area needs to be maintained and possibly even controlled with small hazard reduction burns. Other simple tasks like weeding, pruning and removing of dead organic matter from around the plantation at times of high risk i.e. hot or dry times or after flowering, will minimise the risk of fire spreading (Hirst 2007). Furthermore the land used should be reasonably flat as every
10 degrees doubles the rate at which the fire may move uphill (Hirst 2007). Also, to prevent fires spreading from or to the plantation there should be a small firebreak maintained around the perimeter of the bamboo.

**Flowering:** The gregarious flowering patterns of bamboo means the plantation is threatened with a mass flowering that would see all crops from the same stock die. As mentioned earlier this should not happen for 25-45 years but would mean that the plantation would need to be replanted.

13.2. **Community Implementation**

The strong element of cooperation with the Pitchandikulam community proposed in the community consultation will allow quick and effective access to information regarding the hierarchy of Devikulam. This will be effective in efficiently getting to know the community and the social landscape of the area from a local perspective. This level of cooperation will also be most effective in finding people who can speak English and community liaisons.

Although, it is important that as many of the people as possible are involved, the community meeting could create an environment where there is tension between people with differing viewpoints and if the majority of the people are uneducated they are unlikely to fully understand the solution being proposed.

The survey is an effective way of gathering information about the people needs and wants. Furthermore, it would be a useful tool in helping to find the people with the right skills and motivation to be employed in the project. However, it is important that care is exercised when the survey questions are translated for the people and then back again to ensure there is no confusion. In some cases it may be more effective to interview some people who are illiterate as their writing would provide little to no helpful feedback.

Finally, it is of crucial importance that these results are seriously considered for he refined proposal and it may be necessary to repeat certain parts of this consultation again once the results of have been gathered and analysed as there may be opposition to the changes made. It is important that right throughout the implementation that the consultation is continuous in this fashion, whilst it is not necessary to conduct more than one of these large
surveys, constant feedback from the community will allow the project developers to understand how the community feel about the project once they see it start to take shape.

13.3. Conclusion

Our proposal of developing a bamboo plantation at Devikulam aims to address the needs of the local community, which involve a stable and sustainable industry as a main income source in order to overcome poverty and improve other important aspects of their living. The project will create a bamboo plantation from which many possible industries stemming from the bamboo resources can be initiated, including construction materials and household applications. The plantation was designed to suit the financial, environmental and social constraints of Devikulam and to be sustainable by the local community in the long-term. The technical details of the solution were developed based upon careful considerations for the community, the EWB criteria, possible risks and benefits associated and the codes of ethics for engineering practices. We hope the Devikulam community can benefit from our project and able to improve the quality of their lives.
14. Reflections

14.1. Team Reflection

Our biggest challenge was writing a cohesive report. Each team member had their own roles and were ‘experts’ in a number of fields and this had positives and negatives. It meant that when one member needed to know some additional information to link in to their work, they could ask another team member that had researched it more heavily, and saving time. However, it also meant there was some duplication of effort, as several people might have been researching and writing about the same topic. Collaboration and constant communication through the use of social media assisted this, however we still needed to go over the report as a group to tidy up duplicate information and ensure we linked our sections in to each other so the report flowed nicely.

One thing in particular we learnt the benefit of was planning in advance, having an overall structure to the report guided our writing and made it easier to link all the required components together in a readable and logical fashion.

Constant referencing to the client’s criteria, analogous to the marking scheme in our case, was also found to be very important, particularly following feedback from the draft report. At times we were distracted by the details of the design that we were creating, and forgot to reference to the clients criteria (marking scheme) to see if we were actually meeting specification – particularly in regards to community consultation. Greater reference to the EWB website earlier in the writing of our report would have been advantageous in enriching our understanding about the community of Devikulam, and would have directed our attention to the issue of the community’s perspective far earlier as this was something we considered quite late in the project.

This led to another challenge - appreciating the cultural differences between India and Australia. When we evaluated our proposed solutions we not only had to consider the technical implications of our design but also the way our design would be received by the community for which we were designing.
Throughout the project we were lucky to have an enthusiastic, committed team who worked well together. We got to know each other outside the project which helped us bond as a team and improved our ability to work together. Because of this we all performed to our best ability, not wanting to let the team down, and took responsibility for our roles which were as follows.

Amelia was our organiser and editor and was responsible for compiling our final reports. She made sure everyone completed their tasks on time and ensured our report was cohesive and to a high standard. Because of this ...

If anyone needed any background information on Devikulam, EWB, pitchandikulam or existing projects, An was the person to go to. An brought a different cultural perspective to our team which enhanced our appreciation of the cultural differences between India and Australia.

Rob continually evaluated our project against the design criteria and identified areas where we could improve. Rob was also noted for his constant eating of sustainably farmed tuna.

Nina was known for her passion of bamboo and instilled within the rest of us the same appreciation and respect for bamboo. She was responsible for researching and writing of the technical aspects of bamboo production and applications.

Another important factor of our solution was the treatment of bamboo for which Jesse was responsible. His understanding was crucial to the development of our prototype, a simplified version of the modified boucherie process.

Finally, Alex was the businessman. He was intimately familiar with the budgeting and business plan - possibly the most important part of our report. Alex brought a unique enthusiasm, determination and expertise to our design and was the lynch pin of our team.

Most groups dread team meetings however for us it was the highlight of the EWB challenge. Our shared interests meant there was never a dull moment, all though this was often detrimental to our productivity, as were the delicious cookies from the organisation known as Subway.
The EWB challenge has expanded our view of the role we as engineers have to play in improving the quality of life for people the world over. It has taught us to appreciate the difficulties of working in a real world situation and designing solutions within a range of cultural, ethical and technical constraints. We learnt the importance of non-technical skills as well, particularly the advantages of effective communication and collaboration within a team environment.

Overall the challenge has been an enjoyable journey which has given us a range of different skills that will help us along the way to becoming great engineers. It has also given us the opportunity to design a solution that has the potential to make positive changes in the community of Devikulam.
14.2. Personal Reflections

Alex Bunting:

I greatly enjoyed working in the team, to the point that I think some of our team meetings were more enjoyable than productive, however not wanting to let the rest of the team down provided strong incentive to do the work required on time. Although we conducted a fairly even division of labour, brainstorming and group discussion I thought were particularly helpful when a decision had to be made regarding some aspect of the implementation or other. Having a number of opinions and viewpoints produced a much better, well thought-out result, and much more quickly, than could have been achieved individually. Perhaps it was just the vocalisation of the problem that was beneficial, but team meetings I found vital to resolving the doubts and confusions that strike as a deadline approaches.

This project was not what I had expected, focusing far more on issues of community acceptance, implementation and social and ethical issues rather than the technical side of the design. While my role in the team as business manager was of a more technical nature, community consultation and implementation became important when trying to figure out who would be part of the workforce and who would manage the plantation, and I found considering this quite a bit more difficult than working out the budget. Although it seems obvious now, I had never really thought about the idea that the people who use an engineering solution are just as much a consideration as the design itself. If it doesn’t work for the users, then it doesn’t matter how well you think it meets whatever specification you’ve set, it will fail.

Another challenge I encountered was finding out information about the region. Pricing in particular was difficult to come across, and I trusted a number of journal articles detailing bamboo plantations rather than prices listed by local suppliers. This was the first time since year 11 of high school that I had needed to do any research beyond an equation in a text book, and the discovery that the library – in particularly the ‘Summon’ online journal article resource, could contain vast amounts of useful, relevant information was something of a revelation that stemmed from this project.

Although perhaps a little trivial, I gained a great deal of satisfaction from the presentation of the report. Our final style, with themed colours in the graphs and tables, looks to me very
professional and made me feel like I had worked on an actual industry project. But then this feeling had occurred a number of times, as we sat around a table, evaluating ideas, talking of how the community would respond, of figures of profits and expenses, or of what sort of equipment was needed for the treatment process – at these times I couldn’t help but feel professional, not just a first year but a working industry engineer. Maybe it was just delusions of grandeur, but it was a pleasant sensation nonetheless.

I was surprised by the length of the finished report; it seemed immense, but then considering that every team member had contributed made it seem more achievable – and all of it seemed necessary. This in particular gave me an appreciation that what can be very difficult for the individual becomes a lot more manageable in an effective team.
Amelia Innes:

When I first started, the thought that at the end of this process we, a group of six strangers, would together create a design, and report for it, was daunting.

I began not knowing if I wanted to continue this subject however I quickly realised the potential fun and learning that could be had from it. I am very glad I kept it as I have not only enjoyed the journey that took us from our very first idea to finishing the report but I have also made good friends and learnt much about the importance of the social and ethical side of engineering. The idea that engineering was more than just building things had always been in my mind but this project has given me the opportunity to think about how to make that a reality. I have had to think about and subsequently have learnt how an engineer must consider every aspect of a design from the technical, to the cultural, the environmental, the economic and the ethical. I had to learn how to reconcile the wants and needs as we, people from a western culture, identified them with how the community of Devikulam saw them. These were often very different and having to balance these also with the technical aspects of design has been a difficult process. We as a team helped each other work through our difficulties, producing a better end solution and developing our teamwork skills. Although this process has been challenging I have learnt much that I will be able to carry on into the rest of my degree and further into the workplace.

As the team member responsible for organising and collating all the parts that others had written I came to realise the importance of preplanning. Quite late in the process we looked at the marking criteria and became aware that we needed to change the direction of our report. If we had looked at this closer to the beginning and planned a little more, a lot of time and extra effort would have been saved. Also, organising before the writing had started would have saved time as overlaps often occurred and I spent a lot of time figuring out what went where. I was also responsible for writing up the application section and summaries for the report. Whilst reading through the entire report and by researching the uses of bamboo I discovered how versatile it is, consolidating in my mind our choice of bamboo as being a good one.

Our team has worked well together with fairly even distribution of tasks and people each doing what they were assigned. We would always enjoy ourselves at team meetings, even if
the desired amount of work and planning were not achieved during that time. However, this was not so much of an issue as I trusted that everyone would work in their own time to meet the goal of the group. I am glad that us six strangers who went on to become JARANA happened to sit next to each other in class on the day we chose groups. Together, we have faced the challenges of compiling a report for our solution, researching and developing that solution and have learnt how to make a good idea into a great one, which will actually work.
An Truong:

The Engineers Without Borders (EWB) Challenge has been an enjoyable and meaningful experience, from which I have gained many valuable skills and knowledge in the field of humanitarian engineering as well as great memories working with my team members.

One aspect of humanitarian works which has surprised me the most is the significant amount of work and multitude of considerations that need to be put into planning a development project. Some of these include budgeting, ethical and legal aspects, community implementation methods, risk management, and many more. I was very unfamiliar with many of these areas and how to incorporate them into our project, especially in the fields of finance and community management. Fortunately, I was able to gradually develop thorough knowledge in these fields from continual research and evaluation of previous works and especially from my wonderful team members who were very skills in these areas. By learning from my team members, I appreciate more deeply the importance of communication and team work in order to collaborate different strengths and expertise from each individual. I also enjoyed learning many innovative and interesting ideas that other teams have derived for the Challenge. Through evaluating and comparing these ideas and our own different options at the beginning of the project, I learnt that the solution with the best technical aspects is not the ‘ultimate’ solution to a problem but rather, it is what suits the needs of the community and what works best under the social, environmental and financial constraints of the community.

I was responsible for researching various background information in order to identify the criteria and direction for the project, including information on the Devikulam community, Pitchandikulam, the EWB ... I also reviewed literatures on previous and ongoing humanitarian projects, such as the development of ICT facilities in Village knowledge Centres in rural Southern India or building micro-hydroelectric power in northwest Vietnam, and identified their strengths and weaknesses, their goals and design. By doing so, our project can build on these previous knowledge and provide a better solution. Through this process I also became more aware of the current inequality in living standards of many communities around the world and the urgent need to improve the lives of many disadvantaged people. More importantly, I learnt of the vital role of engineering in carrying out this great challenge and the skills that I will need to develop through my studies, both non-technical and
technical, in order to contribute my part in improving the livelihood of those in need. It was very fulfilling to know that even though our solution might not be the best one but it has the possibility of changing the lives of people in Devikulam from negative to a more positive one. With this thought in mind my team members and I had a worthwhile experience doing the Challenge and it has also strengthen my enthusiasm to become an engineer.

Overall the Challenge was a great opportunity where I got to meet and work with great people towards the common goal of improving the livelihood of marginalized communities, in particular the people of Devikulam. I hope our project has positively contributed to the efforts of EWB and Pitchandikulam and will bring positive changes to the community. I look forward to continue to participate in other humanitarian programs offered by EWB Australia through the Chapter at the University.
**Jesse Gibbs:**

My understanding of the field of engineering has grown and widened since undertaking the EWB challenge. The advanced engineering course has shown me how much more there was to consider other than maths and the sciences by revealing the benefit and importance of economic, cultural and social awareness.

Throughout this project I have learnt a variety of new skills and come to an understanding about teamwork, large projects as well as EWB and humanitarian engineering. When we started the project and had the tutorial where we used evaluation sheets to work out what roles each of us would be playing in the group. I thought that these roles were a bit useless and that everyone would be doing a little bit of everything. As the project progressed, however, we naturally all took interest in different areas of the project and began to 'specialize' in our own parts. Looking back on this I realized how important this had been as no one person would be able to understand and articulate all the vital features of our project to the same depth in the relatively short time we were given for the project.

Of course we didn't just work completely separately but consulted each other for the major decisions as well as when someone else's specialty applied to our own part. For example, I didn't have to hunt through resources to find how tall the bamboo grew as I could just ask Nina, our bamboo expert. Likewise, when I needed pricing information I could ask Alex, our financial expert, on advice as to where to find suppliers as well as the value of money in India without having to waste time doing research in areas that he had already researched. This reduced the workload on all of us and allowed us to create a better and more thorough report through our teamwork. There were times when some of us wanted to go different ways or take a different approach to others but we generally worked out a compromise after (lengthy) discussion at our group meetings. While this difference in opinions created some tensions, working our issues out eventuated in a better and more well thought out feature of our project and revealed the value of teamwork.

I have also learnt a lot about EWB and humanitarian engineering. When I enrolled in engineering the two factors that influenced my choice of degree were:

1. A job that I could enjoy and perform well at that was geared to my interests and skill sets (physics, computing, maths)
2. Money
To be honest I never even considered engineering in places of need and had not heard of EWB. Upon doing this project I learnt a lot about humanitarian engineering and how helping a community in India would not only benefit humanity but how I could experience a side of engineering that had more creative freedom while helping people in need. When I started this project I was a little cynical about how much it could actually help and thought that it was a waste of time because I didn’t want to be an engineer in India working for free. However, coming to the conclusion of the project I actually want to win the EWB challenge so our team can go to India and benefit from the experience there while simultaneously helping people. Even if we don’t win I think it is something I may want to do further down my career path which shows how my attitude towards humanitarian engineering has shifted dramatically.

One of the biggest challenges that my group and I came across was bringing together all our parts into one report. We each had our own writing styles and one their own they were fine but together they didn’t mesh as well as they could have. Sometimes we would even have conflicting ideas in our writing which had to be resolved before the final copy was put together. Having one editor edit the final copy definitely helped with this but it still presented as a major challenge.

Overall the EWB challenge has been a fun, stressful but overall rewarding experience and I would recommend the advanced engineering course to anyone especially if they are able to work with a bunch of people as smart and as talented as I did.
Nina Van Vuuren:

For me, the EWB challenge has been one of the highlights of my first year at university. In first year engineering it can be hard to maintain enthusiasm for your degree through the overwhelming maths, science and computing subjects, which all though totally necessary are not always the most inspiring. However the challenge has really given me a taste for what I can do with my degree in the future and has shown me what engineers are capable of and the positive role they have to play in improving the quality of life around the world. It has taught me a lot about looking at the whole picture and that engineers have a lot to deal with in the real world- working within limitations and dealing with unending cultural, language and ethical barriers.

However, for the most part I believe we dealt with these obstacles well. From the beginning I realised teamwork was not going to be an issue. I had a diverse group of people that were all equally as enthusiastic about the project and were willing to put in the time and effort to come up with the best possible design. However we quickly discovered that if we were to get everything completed on time we would need more than just regular meetings and tutorial time to discuss the project. Googledocs and facebook were invaluable as a means of communication, especially given our hectic timetables, and proved to be a great way of compiling the report and sharing ideas and articles that we found along the way.

This teamwork, for me, was also my favourite part of the challenge. I was fortunate enough to have a group of people who all got along incredibly well, and all though this sometimes came at a detriment to actually getting work done it helped us pull together as a team and made the project that much more enjoyable.

Being first year engineers with basically no experience in our chosen field I believed our biggest challenge would be understanding the technical aspects of an engineering design. In actuality it was working with a different culture that I found hardest. Particularly, trying to find ways to communicate our idea to the community and to make sure it was relevant to them and their needs. Taking these cultural differences into account we had to ensure that we were constantly evaluating our ideas and direction because what we saw as a great idea and what worked in our own community may not work in Devikulam. However despite the difficulties it was working within a real context with real people and real problems that gave
us even more incentive to do well and to develop a project that we believe in and are truly proud of.

If there is one area in which our project suffered it was a little too much enthusiasm. Especially early on in the design process we had a tendency to think big- we didn't want to solve just one problem, we wanted to solve them all! This kept leading us back to what we called the 'super solution', some solution that would single-handedly solve all the problems facing the people in Devikulam. However we quickly came to realise that in the real world our massive over-arching solutions were not the best way to go, that with limited resources and limited time we needed to focus on one very specific, achievable project. If we had more time I would definitely go back and be more specific in our solution, particularly spending more time on the community implementation and consultation side of things. However, overall i’m happy with our report and the time, effort and enthusiasm we have put in to making it work.
Robert Mahony:

Throughout the process of developing our submission for the Engineers without Boarders Challenge there has been a significant change in the way I perceive the field of engineering.

Firstly, the ability to work effectively in a group is clearly a very important skill for engineers and is much more central to the profession than I first expected. Clearly it is impossible for engineers to work alone as even on the smallest of projects there will always need to be communication with the client. In this case the client was synonymous with the marking criteria and the design brief and in the later stages of the project I struggled as I did not closely reference this during the initial stages and so I had to do a lot of restructuring of my work.

The biggest challenge that I, and many of us, faced was putting together a cohesive final report that included all the many ideas that we have talked about. Since we all had similar areas it was difficult not to overlap and present conflicting perspectives on areas than that which others had already reported.

However well a team gets along though it is always difficult agreeing on a final solution as all members will have different ideas and believe that certain ideas are better than others and hence the ability to compromise and work on another’s ideas is an important skill. I found though that the easy going and friendly attitudes of my group made this very easy and once I heard their ideas I often thought they were much better than mine and was glad to work with them. I have learnt a lot from my fellow team members and will incorporate many of their ideas about engineering into my work in the future. Working with a group of such motivated and talented people has definitely given me new knowledge and skills and has shown me I need to expand my horizons and think more laterally.

The profession of engineering is much broader than I initially thought and there are many jobs engineers must do which I did not even consider. For example there is a much greater need for economic awareness than I expected and in hindsight this is obvious as there are financial restraints on all projects. This has motivated to expand my interests into other areas of study to supplement and strengthen my degree and hopefully in the future I will find other ways to study some of these areas, possibly through business courses. Engineers
work not only on the technical side of projects but are responsible for the entire process from start to finish and now I realise that maths and physics skills, while necessary are not alone sufficient. I hope that in the future I find ways of expanding my skills so I can be a well rounded engineer.

Social media in particular Facebook and Goggle Documents allowed us to communicate very effectively over distances and this made working together much easier than it may have been. Since we all got along very well though we were often distracted and this lead to us taking longer to some tasks than expected.

Overall, I found the experience of working on the EWB project very helpful as it gave me a chance to experience engineering work in a practical and self driven way. Learning from fellow students was a welcomed change from lectures.
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APPENDIX I – Prototype: Bamboo Treatment

Aim:
To infuse a length of bamboo with dye to demonstrate the modified Boucherie process in treating bamboo.

Equipment:
- Freshly cut bamboo
- Screw hose clamps
- Thick rubber glove
- Duct tape
- Pressurizable weed spray container
- Water
- Food dye
- Container
- Screwdriver

Method:
I. Cut the tip off a finger of the rubber glove
II. Connect to the nozzle of the spay container with duct tape and screw hose clamps
III. Connect the handle of the glove to the base end of the section of bamboo with duct tape and screw hose clamps

IV. Mix food dye into a container of water

V. Pour coloured water into the weed spray container

VI. Screw the top of the container on to attach to the bamboo and rubber glove

VII. Pressurize the container to force the coloured water through the bamboo
VIII. Continue to pressurize the container as the water moves through the bamboo
IX. Wait until coloured water seeps out the far end
X. Cut the treated bamboo to inspect the depth and consistency of penetration

Conclusions:
The treatment process works quickly and effectively and should be suitable for treating bamboo culms in India. Obviously better, more robust equipment would be used, however this experiment is a proof of concept for the actual process.

Possible Improvements:
• Use adequately thick gloves so a higher pressure can be maintained.
• Ensure the screw hose seals are on a flat surface of the bamboo to prevent leakage.
• Use a larger container so pumping would not have to be done so.