How can Beema Bamboo Plantations Benefit Islands and Farmers in the Philippines?

A study in Manila, Marinduque and Romblon, the Philippines

DINA FARAJ

SAAD SHIHAB
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Dina Faraj & Saad Shihab
This study has been carried out within the framework of the Minor Field Studies Scholarship Program, MFS, which is funded by the Swedish International Development Cooperation Agency, Sida.

The MFS Scholarship Program offers Swedish university students an opportunity to carry out two months' field work, usually the student's final degree project, in a country in Africa, Asia or Latin America. The results of the work are presented in an MFS report which is also the student’s Bachelor or Master of Science Thesis. Minor Field Studies are primarily conducted within subject areas of importance from a development perspective and in a country where Swedish international cooperation is ongoing.

The main purpose of the MFS Program is to enhance Swedish university students knowledge and understanding of these countries and their problems and opportunities. MFS should provide the student with initial experience of conditions in such a country. The overall goals are to widen the Swedish human resources cadre for engagement in international development cooperation as well as to promote scientific exchange between universities, research institutes and similar authorities as well as NGOs in developing countries and in Sweden.

The International Relations Office at KTH the Royal Institute of Technology, Stockholm, Sweden, administers the MFS Program within engineering and applied natural sciences.

Katie Zmijewski
Program Officer
MFS Program, KTH International Relations Office
Abstract

This study was conducted as a bachelor thesis at KTH Royal Institute of Technology in the spring of 2019. The study was carried out as a Minor Field Study (MFS) funded by the Swedish agency SIDA (Swedish International Development Cooperation Agency). The study focuses on the potential economic- & ecological benefits of farming bamboo on small islands in the Philippines. Few other countries are so vulnerable for natural disasters as the Philippines. Majority of the farmers in the Philippines live on a day to day payment where the life of a family can be destroyed when a disaster strikes and ruins the crops. Bamboo could be intercropped and supply farmers with a more stable and higher income on the long term. This project examines previous Beema bamboo plantations, the characteristics of Beema bamboo and explores future implementations.

The main type of bamboo that is explored is Beema bamboo, a modified and improved version of *Bambusa Balcooa*. The Philippines have optimal growth conditions for Beema bamboo and could develop industries which can provide job opportunities. Since the research of Beema bamboo is still in early stages in the Philippines this goal is still years away.

Keywords:
Vulnerability, Bambusa balcooa, Beema bamboo, Philippines, MFS, Marinduque, Environment, Bamboo
**Sammanfattning**


Den huvudsakliga typen av bambu som utforskas i detta projekt är Beema bamboo, en modifierad och förbättrad version av Bambusa Balcooa. Filippinerna har optimala förhållanden för Beema bambu och kan utveckla industrier som kan skapa arbetsmöjligheter. Eftersom forskningen på Beema bamboo fortfarande är i tidiga stадier i Filippinerna är detta mål fortfarande många år bort.

**Nyckelord:**
Sårbarhet, Bambusa balcooa, Beema bamboo, Filippinera, MFS, Miljö, Bambu
Preface

We are heartily thankful to Mapúa University for giving us time and possibility to conduct this study. We could not have achieved this without the help of our supervisors Per Johansson, KTH and Delia Senoro, MU. Professor Senoro has dedicated many hours guiding us. We would also like to thank SIDA and the MFS committee at KTH who granted us the MFS scholarship that financed the project.

We would also like to thank Dr. Merian P. Catajay Mani who guided us through the bamboo nursery in Marinduque State College and took her time to take us to Tablas island where she showed us two different plantations.

Last but not least, we would like to give to thank our families and friends for supporting and encouraging us throughout the whole project.
## Contents

1. Introduction 1
   1.1 Background 1
   1.2 17 sustainable development goals (SDGs) 2
   1.3 Previous studies 2
   1.4 Problem definition 3
   1.5 Purpose 3
   1.6 Delimitations 3
2. Methodology 4
   2.1 Approach 4
   2.2 Analysis 4
3. Bamboo 5
   3.1 Structure, growth and development 5
   3.2 Beema bamboo 6
   3.3 State efforts to promote bamboo 8
4. Vulnerability 9
5. Interviews 11
   5.1 Interview with Dr Merian Mani, Marinduque 11
   5.2 Interview with German Hugo Gutiérrez Cespedes, WBO 12
   5.3 Interview with Arjan van der Vegte, Moso International 14
   5.4 Interview with Susanne Lucas, WBO 14
   5.5 Interview with Nambi Barathi, Growmore Biotech 15
6. Field trip to Tablas Island, Romblon 17
7. Discussion 19
   7.1 Analysis of study 19
   7.2 Recommendations future work 20
8. Conclusions 21
Bibliography 23
Appendix A, VAPERS Project Flyer 25
## Acronyms and abbreviations

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DOH</td>
<td>Department of Health</td>
</tr>
<tr>
<td>GFDRR</td>
<td>Global Facility for Disaster Reduction and Recovery</td>
</tr>
<tr>
<td>KTH</td>
<td>Kungliga Tekniska högskolan, Royal Institute of Technology</td>
</tr>
<tr>
<td>MFS</td>
<td>Minor Field Study</td>
</tr>
<tr>
<td>MSC</td>
<td>Marinduque state college</td>
</tr>
<tr>
<td>MU</td>
<td>Mapúa University</td>
</tr>
<tr>
<td>SDGs</td>
<td>Sustainable Development Goals</td>
</tr>
<tr>
<td>VAPERS</td>
<td>Vulnerability Assessment and Prompt Emergency Response System</td>
</tr>
</tbody>
</table>
1. Introduction

The first chapter in this document will present the purpose of this case study along with necessary background. This is followed by delimitations that will explain the choice of problem formulation.

1.1 Background

Since 1990, the Philippines has been affected by more than 565 natural disasters. This has caused an estimated $23 billion in damages [Saldivar-Sali, 2017]. Few other countries are so vulnerable for natural disasters as the Philippines. Except from 20 to 30 typhoons yearly the country is also hurt by earthquakes, volcanic eruptions, floods and landslides. Extreme disasters such as the typhoon Haiyan that devastated eastern Philippines are now referred to as the “new normal”. These natural disasters are destroying lives, property and costing the country billions in damages.

The Philippines is located in the Pacific Ring of Fire, and about 74% of its population is vulnerable to natural disasters, including typhoons and earthquakes [Saldivar-Sali, 2017]. The natural disasters has left the country with physical damages and economic losses. The government has now prioritized risk reduction and financial protection to protect lives and communities.

One of the projects financed by the Commission on Higher Education in the Philippines is named VAPERS (Vulnerability Assessment and Prompt Emergency Response System). Professor Delia Senoro is the Project leader of VAPERS and also our contact person in the Philippines. Professor Senoro will also be in charge of an international field study and research program in Marinduque for students from Mapúa University and international students. Marinduque state college (MSC) has opened a Beema bamboo nursery to help absorb toxic substances from a mining disaster in 1996 among other things. There are 32 abandoned mines in the Philippines.

The nursery is led by the Department of Health’s (DOH) Mimaropa regional office, Department of Environment and Natural Resources (DENR), and the Marinduque provincial government [Clarisse, 2017]. Beema bamboo will eventually be planted in several areas of Marinduque to help absorb toxic substances in the air, soil and water.

Marinduque mining disaster

A catastrophic mining disaster struck the island of Marinduque on March 24, 1996. The disaster is to this day one of the largest mining disaster in the history of the Philippines. A fracture in the drainage pipes of a large pit containing mine tailings led to a spill of toxic mine waste into the Makulapnit-Boac river system. This caused flash floods in the areas along the river. Some villages were covered in six feet of muddy flood water. The disaster caused the fish and freshwater shrimps to die, and the water supply is contaminated. This event caused
the Boac river system to be declared non usable. The system has still not recovered and is still toxic. Studies has shown that crops from the island contains large amounts of heavy metals, such as copper and zinc. Attempts to detoxify the island is now undergoing.

1.2  17 sustainable development goals (SDGs)

In September 2015, world leaders agreed to 17 Sustainable Development Goals (SDGs) for a better world by 2030. These goals have the power to end poverty, fight inequality and stop climate change [UN, 2018]. The Philippines has been colonized by both Spain and the US and was also attacked during world war II. The country is still in poverty and it’s a long way to go until the SDGs are reached. For example, only 31.7% of the population are estimated to meet 100% of the recommended energy intake [PSA, 2015]. Many Filipinos rather work in other countries for higher salaries to support their family. In 2013, the Commission on Filipinos Overseas (CFO) estimated that approximately 10.2 million Filipinos lived or worked abroad. One of the reasons for the remaining poverty are corruption and political oppression. Despite the poverty the country is taking climate action seriously. Plastic straws and plastic cutlery are rarely sold in grocery stores. It is also rare with plastic bags in grocery shops. One of the nation's major tourist destinations Boracay was closed in 2018 for six months as a part of the government's efforts to rehabilitate the islands environment, which was strongly polluted. Hotels and restaurants without proper draining system were shut down. Smoking cigarettes is strictly prohibited in many public locations.

The Global Climate Risk Index 2015 listed the Philippines as the number one most affected country by climate change, using 2013’s data [Climate Reality, 2016]. This is because of its geographical being located in the western Pacific Ocean surrounded by naturally warm waters. The Philippines also lacks natural barriers. There is almost nothing between them and the sea. The mangrove ecosystem that stabilize soil have disappeared by almost half since 1918 due to deforestation [Climate Reality, 2016].

Bamboo could be a potential solution for natural barriers due to its strong roots and fast growth. Bamboo could also be used for replacing single use plastic items that are being banned. This means bamboo could be part of sustainable development goal number 13; Climate action.

1.3  Previous studies

Research on Beema bamboo is limited. There are not many relevant studies to this work which is why a large part of this study is based on interviews with people who are working with Bamboo, Academics and entrepreneurs.

Beema bamboo is developed by Dr Bharathi Nambi, a leading scientist in agricultural biotechnology from India. Dr Nambi has been doing research in tissue culture for about 35 years. About 16 years ago he developed Beema bamboo by tissue culture a variety of Bambusa Balcooa [Fernandes, 2017].
Dr Merian Catajay-Mani, the president of Marinduque state college learned about Beema bamboo during her trip to India 2009 [Urlanda, 2018]. Dr. Mani introduced beema bamboo in the Philippines in Romblon bamboo research center and Marinduque state college.

Tahani Kaldéus a PhD student from KTH supervised two students from the Philippines at KTH when they were working with Beema bamboo. One of the students (Bernice Lorraine Roy) examined how to use Beema bamboo as a membrane for water purifications. Bernice also discovered heavy metals in the bamboo.

1.4 Problem definition

This study will examine the possibility of establishing bamboo plantations in small islands in the Philippines to benefit the local farmers economically and the islands ecologically. The hypothesis is that farmers would have greater yields from their crops, with less manual work. While the environment would benefit from Beema bamboo being a large carbon sinker and the soil would benefit from the rehabilitating characteristics of the Beema bamboo.

The main research question of the study is:

- Can Beema bamboo plantations benefit islands and farmers in the Philippines

Which can be divided into sub questions:

- How can Beema bamboo plantations benefit the soil in the Philippines?
- How can Beema bamboo plantations benefit farmers in the Philippines?

1.5 Purpose

This study examines the possibilities, benefits and use of bamboo production in the Philippines, especially the variety Beema bamboo of Bambusa Balcooa. The focus will be on the ecological and economic impact a developed bamboo industry could have on the Philippines. The bamboo industry is a 68.8 billion USD industry in 2018 where China has the biggest market share and the Philippines is ranked as number 5.

1.6 Delimitations

The study will focus on one specific kind of bamboo called Beema bamboo. Beema bamboo has only existed for 10 years and it was first introduced in the Philippines 2015. The field study is conducted in the areas of Marinduque and Romblon. Both of the plantations are still in an early stage. The interviews will focus on the characteristics of Beema bamboo, previous results of plantations and future possibilities. Research on Beema bamboo is limited.
2. Methodology

The method of how the study was carried out will be explained in this chapter to give better understanding for the reader.

2.1 Approach

This project can be explained as an exploratory research with a qualitative method. The research is based on two main categories of data; primary and secondary data. Secondary data is research data that has previously been gathered for other research purposes. While primary data is collected by the investigator conducting the research. The secondary data refers mostly to reports, online books, scientific articles and websites. The primary data is based on interviews, workshops, field visits and document identification and analysis during a two-month field study in the Philippines. The secondary data will be used as a reference when collecting primary data in the Philippines. The two different categories of data will later be compared and analyzed. The project can also be divided into three main phases: a pre-fieldwork study phase, a fieldwork study phase, and a post-fieldwork study phase.

2.2 Analysis

During the post-fieldwork study phase the conclusion section is based on the authors analysis. The mayor part of the analysis is based on the comparison of primary and secondary data. Another big part is by reflections and discussion, the reader gets an insight of the authors reflections and arguments which forms the conclusion of the thesis.
3. Bamboo

In this section information is presented that will be required for understanding the analysis and conclusions. A larger part of this section aims to describe what bamboo is and what specifies Beema bamboo. The section is mostly based on secondary data.

3.1 Structure, growth and development

Bamboo is the fastest-growing and most versatile plant on Earth [Liese and Köhl, 2015]. For centuries bamboo has played an indispensable part for the people in tropical countries. Bamboo is a group of tall grasses with woody jointed stems (called a culm) similar to grass [Bamboo Botanicals, 2019], each culm segment begins and ends with a solid joint called a node.

![Figure 1, Anatomy Of A Bamboo Culm, [Bamboo Botanicals, 2019]](image)

It grows leaves and branches from the nodes, the segments between the nodes are called internodes. The branches are also divided in nodes and internodes. The underground root system in bamboo is similar to a culm, it can be described as an underground culm growing horizontally in the soil called a rhizome. Instead of growing branches and leaves the rhizome produces new bamboo shoots which grow into culms and roots that grow further down into the soil [Bamboo Botanicals, 2019].

There are two major types of rhizome developments, they either grow in a clumping formation or they grow in a running formation, the different patterns classify bamboo either as clumping bamboo or running bamboo illustrated in figure 2. [Lewis Bamboo, 2002].
Running bamboo have long rhizomes and spread horizontally quickly while clumping bamboos have shorter rhizomes that stay closer to their point of origin and do not spread so rapidly.

Bamboo is a self-regenerating renewable material; due to new shoots its production continues after the culms have been harvested. The initial bamboo produces new shoots that will break through the surface of the soil upwards out of the ground which will grow in height and diameter. The new shoots continue to grow taller and taller until they reach their adult height. Bamboo doesn’t experience secondary growth like for example trees. For example, a young bamboo that is about 2,5 m tall with 4 canes, may produce 3 additional new shoots in the spring that grow to 3 m within two months’ time. Next spring those 7 canes will produce about 5 to 10 new shoots that could reach 4,5 m. Fast forward 4 years, the same plant is now 60 canes and up to 9 m tall. [Bamboo Garden, 2005]

The use of bamboo spans many cultures and has benefited humankind for thousands of years [Brady, 2014], in modern days many manufacturers have seen all the products that can be made from this highly renewable resource and have begun to utilize bamboo in some fascinating ways. Bamboo is used for thousands of applications, wood industry, paper industry, textile industry, bioenergy industry, food industry, automotive industry, sports industry, farming industry, instruments, building materials and construction are just some of many examples [Schröder, 2016].

### 3.2 Beema bamboo

Beema bamboo is a modified and improved version of *Bambusa Balcooa*. It was developed by Dr. Barathi Nambi from India. He is the owner and founder of Growmore Biotech. It is a tissue cultured plant, where mother plants with superior characteristics are chosen and cloned with micro propagation [Catajay-Mani, 2019]. The species originates from northeast India, but is cultivated in southeast asian countries, Australia and Africa. *Bambusa Balcooa* is often used as a food source or harvested for its large biomass yield. [RBRCI, 2019].

Beema bamboo has thick walls and the culms can reach up to 20 meters [RBRCI, 2019]. It is the most important species in the villages in Bangladesh as it is used for construction. The culms are nearly solid, see figure 3.
For optimal yield, Beema bamboo should be planted with spacing of 3.2 x 1.2 m, at least 1.2 m deep and topped with good soil [Urlanda, 2018]. It is a non-invasive species, which can be intercropped with other vegetation [Catajay-Mani, 2019].

Beema bamboo can thrive in many different climates. It was proven to be adaptable to the climate in the Philippines by MSC. Like other native species (to the Philippines), it can be grown and will survive on its own. The yield is maximized with precision farming. The plant does not need replantation after a successful plantation in 50 years [Catajay-Mani, 2019] Beema bamboo requires a lot of water the first year. MSC waters their plants with 1 liter of water, 3 times a week the first 10 months and 2 times a week between month 10-12. After the first year, the plants will no longer require watering.

Beema bamboo is heavily resistant to diseases, according to president Mani, it is a disease-free plant [Catajay-Mani, 2019]. The plant has an increased resistance to pests, because it is very hard.

When farming Beema bamboo, it can harvest after 2 years.

In recent years, the presence of toxic heavy metals in the environment has emerged as a major concern on a global scale. Beema bamboo were recorded to uptake big amounts of heavy metals during research at KTH conducted by exchange student Bernice Lorraine Roy. The research was about water purification with Beema bamboo membranes. Bernice examined cellulose nanocrystals isolated from Beema bamboo (4 years old) which she obtained from Tablas island, Romblon Philippines. The starting material was Beema bamboo in powder form and then treated with 4.5 wt% NaOH solution, followed by bleaching treatment with Sodium Chlorite. During the treatment, she noticed that metal ions (in form of black particles) were adhered on the surface of the reaction flask. After those two treatments, she washed and filtrated it. From there, she also noticed that these black particles were attached to the magnetic stirrer bar. However, since the focus of the thesis was to isolate cellulose nanocrystals and create a material for tissue engineering applications, she did not further analyze the effect of these metal ions. [Roy, 2019]

The uptake of heavy metals is one of the characteristics they hope to take advantage of during the rehabilitation of soil in Marinduque.
3.3 State efforts to promote bamboo

There has been recent lobbying by politicians to expand the bamboo industry in the Philippines. For example, senator Cynthia Villar filed bill 716 “Bamboo Industry Act” [Senate of the Philippines, 2018], which is one of many efforts to grow the bamboo industry in the Philippines. She recognized bamboo as being a “cash crop” for Filipino farmers. She has also inaugurated a bamboo processing factory to help spur the bamboo industry in the Philippines. She is also seeking to institutionalize the bamboo industry by creating the Bamboo Industry Research and Development Center (BIRDC) [Senate of the Philippines, 2018].
4. Vulnerability

Vulnerability has many meanings, according to [UNISDR, 2017] there are two essential elements in the formulation of risk; hazard and vulnerability. Where hazard is a potential event that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage and vulnerability is the degree of susceptibility of the elements exposed to that source.

\[
Risk = Hazard \cdot Vulnerability
\]

Vulnerability can be divided in several different factors that shapes people lives,

- **Physical factors**
  The physical factor can refer to the geographic proximity i.e. near the coast lines or lack of access to resources as water and electricity. It can also relate to poor construction of buildings and unregulated land use planning.

- **Social factors**
  The social factors relate to poverty, inequality, discrimination by gender, access to political power, unequal participation in leadership and decision making, age, social status, disabilities etc. In societies where the decision-making is only made by men, ignoring the wisdom and experience of women contribute to women’s vulnerability in terms of economic security and well-being. The weaker social groups such as children, women, elderly and disabled people contribute to vulnerabilities in situations such as evacuation, sheltering etc.

- **Economic factors**
  Vulnerable rural livelihoods, dependence on single industries, the availability of natural resources, the gap between rich and poor.

- **Environmental factors**
  Overconsumption of natural resources, poor environmental management, climate change, seasonality, temperature, rainfall patterns, occurrence of typhoons, floods, earthquakes, tsunamis, volcanic activity, etc.

- **Political factors**
  Regulation control, political tensions, lack of local institutions or preparedness measures, corruption etc.
Poverty is a major contributor to vulnerability as poor people are more likely to live and work in vulnerable areas exposed to potential hazards and are less likely to cope when a disaster strike. One of the primary outputs of the VAPERs project is making a data framework where vulnerability is divided in three different sections; exposure, resilience and sensitivity. Under each section different problems are mapped out under three different subdivisions; Household, Barangay (Community) and Municipality. By determining the vulnerability it’s possible to calculate the disaster risk.
5. Interviews

In this section the gathered information from the field study and the interviews are presented. The result chapter is mainly primary data gathered by the authors.

5.1 Interview with Dr Merian Mani, Marinduque

Dr. Merian Catajay-Mani is the president of Marinduque state college and the previous director of the Romblon State University. Dr Mani went to India to learn how to propagate a new species of thick-walled bamboo (Beema bamboo) developed by Dr Nambi. She ordered 1000 tissue cultures samplings and provided and maintained perfect growth conditions in Romblon together with Romblon bamboo research center 2009. The purpose was research and development. The reason Dr Mani chose specifically Beema bamboo is because it has improved DNA through a natural process and triple DNA compared to other species, she also claims maturity of native species is 7-8 years before you can harvest, but Beema bamboo takes 3 years before you can have the first harvest. She points out that one main purpose was to see if it was adaptable to the Philippines condition, and they were able to do that.

Dr Mani is now waiting for funding for a precision farming so they can process Beema bamboo plantations in a bigger scale (commercially). Precision agriculture is a method in which farmers optimizes inputs such as water and fertilizer to enhance productivity quality and yield. Dr Mani brings up that just as wild bamboo and other native species you can leave Beema bamboo on its own but with precision farming you can maximize the outcome.

According to Dr. Mani, Beema bamboo has a very high potential for economic growth for farmers in small islands. This is because you can produce lots of products from bamboo. It takes 3 years before the plantation can be harvested the first time. After that, it can be harvested every three years, without replantation in the next 50 years. Because Beema bamboo is not invasive, it can be intercropped. This means that the farmers can harvest and farm other crop that will yield harvest between the bamboo cycles.

Dr. Mani plans to help local farmers in Marinduque to transform their traditional crops from what they are farming today, to bamboo. This project is undergoing and the first farmers to start harvesting bamboo is at minimum 5 years away, year 2024. A lot of simple products which are imported from neighboring countries can be produced with bamboo by locals in the islands. For example, matchsticks and toothpicks. The farmer would also need less manual labor in the fields. Farmers would need to create collectives in order to process the bamboo into more valuable consumer products. If sold as raw bamboo, it would not even cover the cost of labor. The plantations are planted in rows of 4 lines and provides space for mechanical harvesting, but in the Philippines, they rather encourage manual harvesting according to Dr Mani. She also thinks that in terms of farmers making profit of bamboo plantations they need to form cooperatives and farmer associations which they are engaging them into so they can access funds from the governments.
According to Dr Mani Beema bamboo is one of the highest carbon sinkers on record and can produce more oxygen than other plants/trees. Dr Mani says that Beema bamboo is a water eater the first year and especially during summer time. Beema bamboo only requires organic fertilizer and root enhancer the first year. The plant will survive without any fertilizer after the first year. She claims that Beema bamboo does not need any pesticides, as it is very resistant to pests and infection. It is a disease-free plant, based on the previous 10 years of raising Beema bamboo. There is a certificate from India that attest that Beema bamboo is disease free.

There is an ongoing project with Dr. Mani and Romblon state university to rehabilitate mined out areas in Marinduque with Beema bamboo. They have gotten funds from the department of agriculture and the department of health. Dr Mani has also received a 5-hectare donation from Consolidated Mines Incorporated (CMI). Dr Mani just signed a contract of 5 million PHP to start expanding their nursery and improving the facility, it will be a trial on the ecosystem in Marinduque. There are 32 abandoned mines with zero rehabilitation but since the land is still owned by the industry private institutes can’t do whatever they want.

Dr Mani’s target is to primarily plant bamboo in mined out areas or abandoned areas and not where there already are other plantations. The reason is that bamboo is a grass that can survive even the most acid soil, when no trees survive bamboo can. Also, the strength of bamboo cannot be compared to trees, because bamboo has a lot of roots and the rooting system is very rich but it cannot penetrate deeper than the Narra tree for example. According to Dr Mani the main purpose is therefore to improve the condition of the soil, the leaves that falls from the bamboo doesn’t even need to be removed, they become a new top soil. She also mentions that bamboo has the capacity to hold a lot of water because of its many roots (depending on how it is planted), that’s why you need to have a precise farm management when dealing with bamboo plantations.

5.2 Interview with German Hugo Gutiérrez Céspedes, WBO

German Hugo Gutiérrez Céspedes is a forestry engineer from Colombia with 18 years of research experience to optimize large commercial bamboo plantations. His current position is as forestry consultant working for World Bamboo Organization (WBO) in Brazil and Colombia.

Mr Céspedes has previously worked with Bambusa Vulgaris for pulp manufacturing. Bambusa Vulgaris is part of the genus Bambusa just like Bambusa Balcooa (Beema bamboo). He is also well familiar with the species Dendrocalamus Asper and Guadua Angustifolia. Mr Céspedes points out that they get their bamboo from Northeastern Brazil where they have 30.000 hectares of Bambusa Vulgaris used for cellulose purposes and also from Ecuador and Colombia for making boards.

Mr Céspedes view of the bamboo industry and the demand for bamboo is that planting bamboo is one thing but making a resource-efficient production is something else. He claims there are many bamboo plantations but that it’s a problem to harvest the bamboo cost-
effectively. He also claims that to make bamboo competitive in price, you need commercial bamboo plantations since your harvest is cheaper. In general the main problems according to Mr Céspedes are

- Lack of business mentality of producers and in some cases of governments.
- Lack of market research that allows us to define the reason why we are going to plant bamboo.
- Lack of studies to optimize the productive chain of several bamboo species; in their planting, management and exploration.

Mr Céspedes thinks the demand for bamboo will increase but tells it’s impossible to estimate how much. The reason why he thinks the demand will increase is that bamboo is a “fiber that grows fast” when compared to wood and has multiple applications. Another main reason is that the world and people are starting to be more aware of the environment and what they purchase. If this awareness continues the demand for alternative materials will increase and bamboo will be a potential candidate for modern design and building structure.

Mr Céspedes claims bamboo plantations are not yet more effective than other traditional crops in terms of economic gain. He mentions that the wood that are cultivated on a commercial scale, comes from a constant process of genetic improvement and improvement in the productive process (mechanization) among others, resulting in a guarantee of production and profit. This cannot be confirmed with bamboo yet, since the industry is in the embryonic stages and the processes of mechanization of the productive chain are punctual.

According to Mr Céspedes the greatest benefits of harvesting bamboo in terms of ecology is that bamboo protects soil better than woody species. He adds that certain bamboo has the great capacity to adapt to adverse soil and climate conditions and that it allows the production of biomass for different purposes which is positive for the local economy. Mr Céspedes thinks the most important factor/improvement to increase the demand of bamboo is the need for new products based on bamboo that meet the markets demand and the investors who invests in bamboo cultivation.

Since Beema bamboo is a clone from the strand of Bambusa Balcooa Mr Céspedes sees a risk with planting clones. He claims that it is scientifically proven that in case there is emergence of a disease or the pest for which the clone is susceptible, all planting will be lost. He also thinks there is a risk for farmers to convert their crops to bamboo if they don’t have a settled contract with a guaranteed factory or buyer.

Mr Céspedes ends the interview by informing that in Brazil they have planted bamboo to protect river banks to prevent erosion and in mining areas. In Maranhão they have bamboo plantations that are flooded for more than 30 days and the bamboo survives. As a curiosity he quotes:

*After the atomic bombing in Japan, the first plant that sprouted was the bamboo.*
5.3 Interview with Arjan van der Vegte, Moso International

Arjan van der Vegte is the research and development manager at Moso International BV. Moso International BV works with the bamboo species Phyllostachys edulis, which is also known as ‘Moso’ and ‘Maozhu’. His company source their bamboo from China but are always looking for new alternative suppliers and countries to source from. According to Mr. Van der Vegte, they are the largest trader of Bamboo. They do bamboo flooring, decking, beams, panels and more. When asked about bamboo availability, he says that there is enough bamboo in China today to meet their demands.

As the majority we have spoken to, Mr. Van der Vegte also believes the demand for bamboo will increase. He believes it will increase because hardwood is getting less available and prices are going up. The demand for more environmental sources is also increasing, in which bamboo is a great material.

Mr. Van der Vegte also believes that bamboo is a great crop for countries prone to natural disasters because it will survive most. Bamboo has great hardwood like characteristics. It is very hard and durable. According to him, bamboo is an ‘endless’ resource. It is the world’s fastest growing plant, allowing for harvest every year. He also claims that Phyllostachys edulis “Moso Bamboo” absorbs more CO2 then what is released during production. This means that their production is CO2 neutral over the complete lifecycle.

5.4 Interview with Susanne Lucas, WBO

Susanne Lucas is the Executive Director of World Bamboo Organization (WBO) and a Horticultural Consultant that aims to create jungle oasis in residential suburbia with specialty emphasis on ornamental bamboo. Mrs Lucas believes Beema bamboo is a "marketing name" of Bambusa Balcooa named by Dr Barathi of Growmore Biotech. Mrs Lucas think there are not enough bamboo plantations to provide alternative fiber, timber or fuel for growing demand, and nowhere near enough plantations growing on degraded lands to mitigate climate change. She also believes the demand for bamboo will increase to mitigate climate change and for alternative fiber, timber & fuel, but how much is still unknown.

Mrs Lucas brings up that the benefits of bamboo are many, providing environmental remedies beyond human needs & products. Restoring degraded lands, watershed management, erosion control, wildlife habitat, carbon storage, as well as poverty alleviation.

The most important factors (change and improvements) to increase the demand of bamboo according to Mrs Lucas is government & public acceptance of this sustainable resource, innovations for modern applications and investment in Forest Stewardship Council (FSC) plantation development.

Mrs Lucas don’t see a risk with planting clones such as Beema bamboo. According to Mrs Lucas experience she is definitely sure that bamboo survives natural disasters such as earthquakes, typhoons and floods.
5.5 Interview with Dr Nambi Barathi, Growmore Biotech

Dr Barathi is the creator of Beema bamboo. He started to work with bamboo 2002 in order to increase the yield of bamboo. According to Dr Barathi the present national average yield of Bamboo in India is 1 Ton/Ha/Year, but with improved clones and appropriate agricultural practices the yield can increase to 10-20 tons/Ha/Year. Dr Barathi improved Bambusa Balcooa to give more biomass with thicker walls and a better adaptability to a wide range of climatic condition compared to the original Bambusa Balcooa. The planted area of Beema bamboo in India is around 7000-8000 Ha and the first plantation is 10 years old. The greatest benefits of Beema bamboo compared to other plants according to Dr Barathi are:

- Fast growing (100 Tons/Ha/Year)
- High Biomass Production (100 Tons/Ha/Year)
- High carbon Sequestration (200 Tonnes of Carbon dioxide/Ha/Year)
- High oxygen generation (150 Tonnes of Oxygen/Ha/Year)
- Suitable for high density plantation and quick harvest from the time of planting (in 2 ½ years’ time)
- Short rotation harvest (harvest once in a year)
- Low ash content of 1-2%
- Fastest growing plant (1 ½ feet per day)
- Has multiple end uses starting from furniture, construction, fuel, shoots serve as food.
- Higher profit from cultivated bamboo than food crop like rice, wheat, cotton, sugarcane etc

The main application of the Beema bamboo that has been harvested in India are furniture, construction, raw material for electricity, bio-CNG and activated Carbon. When asked what industrial application Dr Barathi thinks would give farmers the highest income the answer was furniture, but he thinks the market is not big enough to absorb all the production; So, considering market volume, he believes selling the bamboo as raw material for energy would provide better salary to the farmer than many other agri-horticulture crop.

When asked what ecological improvements that has been noted where Beema bamboo is growing Dr Barathis answer was:

- The Carbon dioxide concentration is reduced
- Reduction in Temperature
- Reduction in soil erosion
- Increase in water holding capacity
- Rise in ground water table (observed with other Bamboo, not yet studied in Beema bamboo).

He also claims that Beema bamboo is as similar to other bamboo in absorbing toxic material. He mentioned there are a lot of references available for Bamboo on absorption of heavy metals, absorption of sewage water, absorption of carbon dioxide, reduction of particulate matter of PM2.5 & PM10.
According to Dr Barathi the inputs to estimate the cost of planting Beema bamboo are:

- Cost of land preparation
- Cost of agricultural inputs
- Cost of labor
- Cost of fertilizers
- Cost of manure
- Cost of irrigation
- Cost of fuel etc.

According to Dr Barathi the demand for Beema bamboo from industrial companies is high, he is currently working with a cement industry to replace coal with bamboo and that company is entering into contract farming with farmers. Dr Barathi claims there are many such examples of projects upcoming; within power industry and other industrial products.
6. Field trip to Tablas Island, Romblon

Together with Dr Merian Mani and Dr Senoro a field study to Tablas Island was conducted. In Tablas two different Beema bamboo plantations was visited. The first plantation of 20 Ha is located high up on a mountain with conditions similar to desert, in municipality San Andres. The plantation was owned by Cleanergen company who financed the plantation by letting foreigners donate money. The idea was to let foreigners ‘adopt’ a bamboo plant. The plantation is three years old but hasn’t been taken care of properly and is now abandoned. Dr Mani was surprised to see the plantation in such a bad shape. The color of the bamboo greyish and not as green as it supposed to be. The Beema bamboo is not supposed to have thorns but this plantation was full of thorns and the thickness of the bamboo wasn’t either as it was supposed to be. Each rhizome that stemmed from one seedling had 3-5 bamboo shoots. Dr Mani said she would send pictures to Dr Barathi Nambi and investigate further. She thinks the reason is simply that it hasn’t been taken care of and not enough water during the first year.

The second plantation that was visited, located in municipality Canduyong, was also initiated by Cleanergen company together with Romblon state university. The plantation is divided in different parts, some of the bamboo are 4 years old and some are 5 years old. The plantation is spread over 30 Ha in a small village where there was no vegetation earlier. The second plantation was very healthy even though it had been abandoned, this because it was well taken care of and watered during the first critical year. Each rhizome had 20-35 new shoots and was more than 20 feet tall.
The locals in the area had been told not to remove any leaves. The leaves go back in the earth as fertilizer when they fall. If you remove the leaves new shoots won’t come out. According to Dr Mani the shoots would have been even thicker if they had been harvested so new bigger shoots comes out. This plantation had banana and coconut trees among the bamboo. Evidence of bamboo being able to be intercropped. Dr Mani stated that the soil would hold a lot more water now since the field is full of bamboo shoots.

Both plantations were supposed to be used as feedstock for energy production but have now served the purpose of rehabilitating the soil and clean the air. The second plantation was supposed to fuel a 1 MW generator. It’s still unclear if the plantations ever will be harvested due to the company’s bankruptcy and the abandoning. The locals in the second plantation are free to do whatever they want with the bamboo but have left it untouched.
7. Discussion

The discussion section will draw connections between the presented theory and the presented result. These connections will be analyzed with the authors own knowledge, thoughts and impressions gained during the field study in The Philippines.

7.1 Analysis of study

The aim of the study changed slightly during the field study, the first intention was to examine how Beema bamboo could help towards natural disasters and add financial income to farmers. It later turned out the current Beema bamboo plantations in the Philippines are owned and planted by institutes or companies and not private farmers. Therefore, no calculation of profit for individual farmers could be made. The plantation in Marinduque is still very young and can’t be harvested yet and the two plantations in Romblon are abandoned and have also not been harvested, this led to no information about buyers and profit.

Seeing the first plantations in Tablas island weak and unhealthy led to uncertainty about the claim that Beema bamboo survives on its own without assistance. The damaged plantation needs to be investigated further before planning another plantation on a dry mountain.

There are not any published case studies similar to this one which makes it hard to compare the research with others. The only published case study about Beema bamboo is by Dr. Barathi Nambi titled “A case study of usage of Beema bamboo as a sustainable energy source” where the conclusion is “This study clearly suggests that bamboo as a fuel plantation would be a good fuel with potential fixing higher amount of carbon due to better yield as a hard fuel species” [Dasappa and Barathi, 2016]. Beema bamboo has proven great quality at the second plantation in Tablas, one part was cut off to be examined at Mapúa university; it was extremely dense and hard as a hammer. There is no doubt Beema bamboo is an extraordinary material that regrow itself and has good characteristics. However, there is still not a industry ready to buy tons of Beema bamboo. The paradox is that no farmer/company wants to plant hundreds of hectares of Beema bamboo if there is not a contracted buyer, and no buyer/company wants to write a contract in advance for a plantation that doesn’t exist yet. According to [Pacifico L. 2019] farmers in small islands with low income live on a day to day payment to survive and can’t plant for three years ahead. He also mentioned a recent incident where several farmers were promised money for planting Abacá trees but instead didn’t receive any payment for one year of effort due to contract disputes. This is a risk that occurs when farmers change their traditional crops to bamboo. Both Dr Mani and Mr Céspedes mentioned it’s important that farmers have guaranteed agreements with buyers before they change their crops to bamboo.

An area that was not explored in this thesis is the application of bamboo. When we asked our respondents during interviews what they thought would be the most important factor to increase the demand for bamboo they all replied the same: Innovation. During our trip in the Philippines we saw bamboo being applied in many different ways. Pump-boats use bamboo to keep their boat balanced, we saw many houses built of bamboo, crooked trees were hold up by bamboo, due to plastic-straw ban some cafés offered bamboo straws. By 2021 a wide-
range of single-use plastic items such as straws, cotton buds and cutlery will be banned in Europe. This creates a big possibility for the bamboo industry to grow and replace products usually made by plastic.

7.2 Recommendations future work

As mentioned, there are several areas that will need further research. Beema bamboo is a potential source for a profit-driven industry in the Philippines but first calculations must be done.

Our idea is that Beema bamboo should first be sold as feedstock for green energy companies and sold to already existing companies that can make products out of the bamboo before any investments are made for industries in the Philippines. Since Beema bamboo plantations in the Philippines are still in early stage more research of growing conditions needs to be done, especially on the weak plantation that was visited on a mountain in Tablas. If this thesis were to be followed up on the recommendation is to separate economic benefits and ecological benefits. Focusing on the potential bamboo industry and economic growth is one project in itself and soil rehabilitation on degraded land is another project.

Beema bamboo is not the only plant that absorbs heavy metals from the soil, a lot of other plants does too. Whether Beema bamboo is a good soil rehabilitator is still unknown today, and more importantly if it is better than other bamboo species for this purpose? This is an area that can be researched. Chemical engineers can do further laboratory work on how much heavy metals Beema bamboo can uptake and the effect of these metal ions. Perhaps the heavy metal can have consequences if the bamboo is used as food and furniture. If so, what will happen to the affected bamboo?

The four respondents who has been interviewed all believe the demand for bamboo will increase, Arjan van der Vegte mentioned hardwood is getting less available and more expensive and that companies are demanding more material with less environmental impact. If this can be statistically proven perhaps it will be easier for institutes and politicians in the Philippines to receive funding and government aid for planting more bamboo.

No scientific comparison of different bamboo species was found, to be assured Beema bamboo is the best choice for the growing conditions in the Philippines this needs to be examined further. Our sources claimed that bamboo is a carbon sinker, though there are still mixed opinions among the scientific community in whether bamboo is a carbon sinker or not. This is an area where more research is needed.

7.3 Plausibility

The majority of the results in this thesis is based on interviews made with people who has a vested interest in bamboo. This will in turn affect the answers they have given us during the interviews. Answers will most likely be subjective. Interviewees will be reluctant to leave information that might damage their sales or ability to receive funds from agencies. The positive attributes of bamboo might be highlighted whilst negative attributes might de-emphasized.
8. Conclusions

What we have been able to conclude from our field study and interviews is that a more developed bamboo industry, Beema bamboo in particular, has great potential to create economic growth and stability for farmers in the Philippines. This is partly because it is very resistant to natural disasters and weather conditions. To be successful, the plantations need to be planted and managed correctly. Farmers would need training and education on how to properly farm Beema bamboo. This could be achieved through local workshops and seminars.

Farmers would also need to use less manual work than the more traditional crops. This is because:

1. The plant does not need irrigation after the first year.
2. Beema bamboo does not require replanting for 50 years.

This would open up time for the farmers to farm other crops or produce products out of the bamboo. The fact that Beema bamboo is not invasive and could be intercropped open ups possibilities to harvest other crops between bamboo harvest cycles.

According to Dr Mani, farmers would need to process the raw material into products to achieve net profit. This in turn would create the need for more education, training and equipment. Farmers does not possess the means or willingness to invest in such equipment. Farmers should create collectives in order to share knowhow and processing equipment.

The major investments needed to establish farmers and conduct further research will most likely come from government agencies and educational institutions. We believe state efforts such as the bills introduced by Senator Villar will only increase and help establish a bamboo industry in the Philippines.

The field trip to Tablas island proved Beema bamboo could survive and thrive in harsh environments without any irrigation if managed properly in the early critical stages. This characteristic of bamboo, to be able to grow on degraded soil is very suitable for the Philippines which has 7.1 million hectares of unproductive, degraded and denuded forestland.

As mentioned in “Recommendations for future work” we cannot draw any conclusions on whether Beema bamboo is a viable, applicable or working solution for soil rehabilitation in mined out areas and areas where mining disasters/spills have occurred. What we know is that the plant can survive and thrive in harsh conditions and the idea of using Beema bamboo as a soil rehabilitator is worth pursuing.

What must be thought of in the scenario of Beema bamboo being a viable working treatment for heavy metal contaminations is what happens with the harvested bamboo which contains heavy metals. Since Beema bamboo can uptake heavy metals this can lower the quality of the bamboo. Therefor Beema bamboo can be planted in the Philippines for two different purposes, either in destroyed land as a soil rehabilitator or in better land conditions to later be processed and sold. Another reason why Beema bamboo benefits the Philippines is the fact it will survive natural disasters, which all our sources have confirmed.
With the results gathered from the interviews and literature we can draw the conclusion that Beema bamboo is a good option as feedstock for energy production. It is a environmentally good choice and it is resource efficient as presented in the chapter result.

In summary Beema bamboo is a great biodegradable material that can grow in the Philippines. An investment in Beema bamboo and bamboo production in general is a good idea for the Philippines. The production chain of bamboo is not yet advanced and resource-efficient compared to timber. When technology within the area advances for new applications bamboo will be more competitive on the market. Further research on Beema bamboo is required and here Dr Mani has a critical role being the head of Beema bamboo trial plantations in the Philippines. Beema bamboo can be used as a source to mitigate climate change and can rehabilitate soil. The world is demanding more environmentally friendly sources which is a great advantage for the future of bamboo.
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