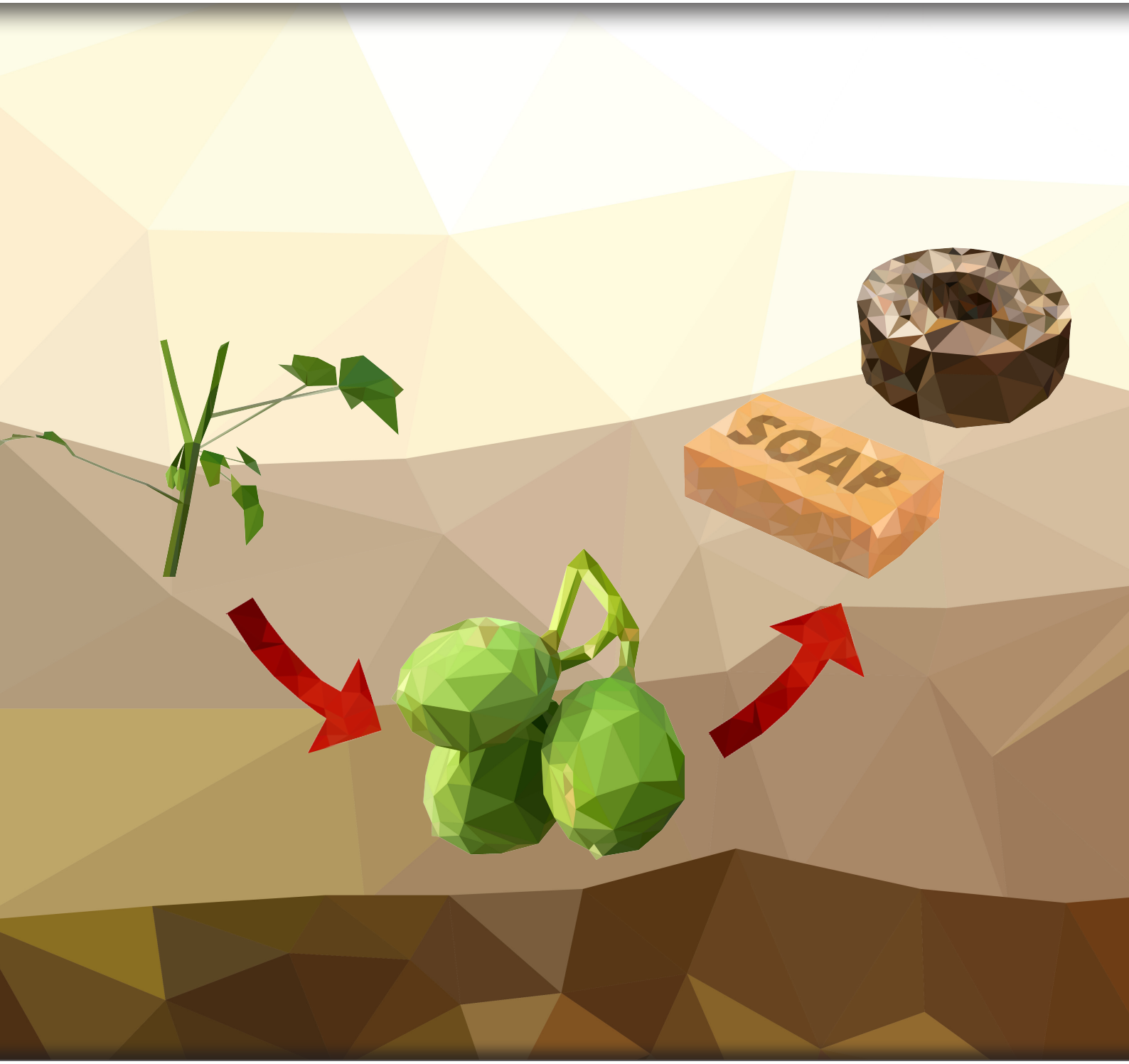
WALL-NUT

THE SOLUTION IN A NUTSHELL



A research report written by
Nikki Louwerse, Yza de Ridder, Katja Schmahl,
and Stef Siekman,
for the Imagine School Competition.

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SCIENCE FOR YOUR FUTURE

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WALL-NUT

THE SOLUTION IN A NUTSHELL

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February 1st 2016

IMAGINE...
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PREFACE

Before you lies the research project -The solution in a nutshell- about Jatropha, written by Nikki Louwerse, Yza de Ridder, Katja Schmahl and Stef Siekman. We're 4 students in year 5 vwo. We came across Imagine last year. We heard a lot of positive stories about it from the 2014 participants and we found the subjects they mentioned interesting. Furthermore, all of us liked the idea of thinking to come up with a solution for an actual problem. The idea of doing something which could really change people's lives seemed beautiful to us and inspired us to sign up. Each of us has different strengths and we have known each other for quite a long time, which enabled us to criticise and help each other in a positive way.

However, without the help from our supervisor, drs. Ilsemarie Samson, and our specialist, prof. dr. Marc van der Maarel, we would never have been able to complete this project the way we have. They were always available and willing to answer our every question. They helped with getting to the point as well; they helped us figure out what's really important.

We also want to thank Mr Jonkman, our teacher Management and Organisation, who gave us insight into the financial side of our project and Mr Karsmakers, our English teacher, who checked the quality of the English in our report.

Furthermore, we would like to thank all the respondents, without whose cooperation we never could have gotten all the required information, and Enyini for the very useful workshop they gave about all the aspects of a sustainable business. We learned a lot from them and gained some brand new insights during the brainstorming session. The day they organised turned out to be very refreshing for us.

And last but absolutely not least, we want to thank the Imagine Foundation, in particular Frank Sekeris. They gave us the opportunity to take part in this project and we are very grateful for all the experiences we got from our participation.

We hope you enjoy reading our research project,

Nikki Louwerse, Yza de Ridder, Katja Schmahl and Stef Siekman

Gouda, January 2016

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EXECUTIVE SUMMARY

Ethiopia is one of the poorest countries in the world. Most people depend upon agriculture as their source of income, but this is not always reliable and can differ enormously throughout the year. Furthermore, the country is dealing with deforestation, soil erosion in the highlands and food insecurity. These problems are partly solvable using the plant Jatropha Curcas.

Jatropha is a plant that grows in abundance in Ethiopia, but is not yet used in a effective and profitable manner. It is a plant with many possible applications, such as: countering soil erosion and rehabilitating gullies using the plant's roots, making biodiesel, lamp oil and soap using the oil pressed from its nuts or making briquettes, fertilizer and mushroom cultivator using the seed cake.

Lots of these applications have not yet been researched sufficiently, but we still managed to figure out a profitable and self-sufficient platform that allows Ethiopian farmers to use the applications Jatropha offers. We evaluated all of its possible applications and it turned out producing soap used the fewest resources and was therefore most suitable in Ethiopia. The use of Jatropha oil as biodiesel competes with food production which will only increase food insecurity. Using it as lamp oil wasn't efficient and in our trial installation the lamp oil didn't even burn at all. Cultivating mushrooms was unpredictable and solved fewer problems than using it as briquettes. Also, using it to make briquettes doesn't have to eliminate the use as fertilizer, since the ash remaining when the briquettes are burned still contains the same nutritional value.

Our proposition for a project with Jatropha therefore consists of three phases. First, cuttings will be placed in gullies. Next, there will be five years of only basic upkeep of the Jatropha plants. After these five years the maximum yield is reached. The nuts will then be harvested and used to produce soap and briquettes. These items can then be sold on local markets for profits, or be used by the farmers themselves.

INTRODUCTION

In 2000, Ethiopia had one of the highest poverty rates in the world. Since then there has been a remarkable increase in well-being: Ethiopia has seen a 33% reduction in the share of the population living in poverty.[1] This is caused by, among other things, agricultural growth and increased government spending on basic services and effective rural safety nets.

However, the progress wasn't without challenges and poverty remains widespread. The poorest households have even become poorer since 2005. Despite the major improvements, Ethiopia still has relatively low rates of educational enrollment and access to sanitation and struggles with investment in health, safety and education.

The majority of Ethiopian households still work in agriculture and are living in rural areas. The agricultural productivity remains low and the country faces frequent droughts. Analytics showed a vicious cycle in which various factors interact to worsen the health of people and of their ecosystem. Action is necessary to ensure a more stable income for the local farmers.

In Ethiopia grows Jatropha: a plant that is not yet being used in an effective and profitable way yet, but Jatropha has many potential applications. Jatropha could be a solution to the poor living conditions of farmers in the highlands of Ethiopia. This is why our main question reads:

How can we improve the low and inconsistent income of farmers in Ethiopia with the help of Jatropha?

Our report comprises three stages. First, we took a look at the socio-economical situation, we examined the agriculture, and we studied the problems with erosion in Ethiopia. We wanted to know what problems we could possibly solve.

Next, we looked at the applications Jatropha offers. We researched these applications to find out which one was the most profitable. Moreover, we researched if Jatropha is applicable in developing countries, specifically in Ethiopia, and if its application would be useful.

Lastly, we designed our project. We asked ourselves: 'how can the applications of Jatropha be used to solve income problems?' ' how can the project be integrated in the local communities?' 'what will the different phases of the project consist of?' and 'where does the money come from and how quickly will the project be profitable?'.

1 The World Bank (2014)

ETHIOPIA

Ethiopia is a country in East Africa: it is Africa's oldest independent country and with over 100 million inhabitants it is second largest in terms of population. It is bordered by Eritrea, Djibouti, Somalia, Kenya, South Sudan and Sudan. The capital of Ethiopia is centrally situated Addis Ababa.

Ethiopia is one of the world's poorest countries. The country's per capita income of $550 is substantially lower than the regional average. According to the Development Program of the United Nations, 44.2% of the population in Ethiopia lives below the poverty line (in 2014).

Figure 1

Ethiopia consists mainly of the vast Ethiopian Highland, crossed from north to south by the Great Rift Valley. The highest mountain in Ethiopia, the Ras Dashan, is 4550m high. Lake Tana in the Ethiopian Highland is the source of the Blue Nile, which constitute together with the White Nile and the Tekeze river the Nile. Other major rivers that originate in the highlands are the Awash, Baro, Omo and Wabi Shebelli. The great diversity of terrain determines wide variations in climate, soils, natural vegetation and settlement patterns.

ECONOMY

Ethiopia was one of the fastest growing economies in the world, registering over 10% economic growth from 2004 till 2009, according to the IMF.[4] It was the fastest growing non-oil dependent African economy in the years 2007 and 2008. The economy of Ethiopia is largely based on agriculture, which accounts for 46% of gross domestic product (GDP), 60% of exports, and 80% of total employment (labour force).

Until 2013, the major agricultural export crop was coffee, providing about 26% of Ethiopia's foreign exchange earnings. Coffee is critical to the Ethiopian economy. 25% of the population derive their livelihood from the coffee sector.

Other exports include live animals, leather and leather products, chemicals, gold, legumes, oilseeds, flowers, fruits and vegetables and khat (a leafy shrub which has psychotropic qualities when chewed).[5]

Despite rapid growth in recent years, GDP per capita is still one of the lowest in the world and the economy still comprises a bunch of serious structural problems. The productivity of the agricultural sector remains low and the country faces frequent droughts.

In addition to that, almost 50% of Ethiopia's population is under the age of 18.[6] The education enrollment at primary and tertiary level has increased significantly but job creation is still developing too slow compared to the expansion of general education. Ethiopia must create hundreds of thousands of jobs every year just to keep up with the population growth.[7]

CLIMATE

The dominant climate type is tropical monsoon, but the climate changes in different divisions. The Ethiopian Highlands cover most of the country and have a climate which is considerably cooler than other regions at similar distance to the Equator.

In the highlands the average temperature is between 15 to 25 °C but there is a variation in climate dependent on elevation. The year could be divided into three seasons. Winter lasts from October to February. It is followed by a dry hot period, which gives way to the rainy season around the middle of June. The rain is heaviest in the Tekezé basin in July and August.

Because the prosperity is dependent upon the rainfall, the rainy season is very important to the population of Ethiopia.

1 United States Census Bureau (2011)
2 Worldbank (2015)
3 United Nations Development Programme (2014)
4 IMF (2012)
5 Ethiopia Export Institute
6 CIA World Factbook (2015)
7 The Economist (2007)

ETHIOPIA'S DEMOGRAPHICS

Ethiopia's population is highly diverse: it contains more than 80 different ethnic groups.[8] Most people speak Afro-Asiatic languages, mainly of the Semitic or Cushitic branches. The latter include the Oromo, Amhara, Tigray and Somali, which together make up three-quarters of the spoken languages.

The country is multi-religious too. Most of the Christians live in the highlands, while the Muslims mainly occupy the lowlands. Adherents of traditional faiths are chiefly concentrated in the southern regions.

INFRASTRUCTURE

Ethiopia is a country with largely non-navigable rivers and no railway systems. Due to this, road transport plays a critical role for the implementation of the Ethiopian economy.

Over the period 1997-2010, an investment program (known as the Road Sector Development Program) was carried out in Ethiopia. Data reported by Ethiopian Road Authorities indicate that, between 1997 and 2011, the road network expanded from 26,550 km to 53,997 km, while the fraction of roads in good and serviceable conditions increased from 22% to 57%.[9] The improvements in the road infrastructure have had an advantageous influence on the size and structure of the manufacturing sector in Ethiopia.

AGRICULTURAL

Agriculture accounts for 46.3% of the GDP, 83.9% of exports, and 80% of the labour force.[10] Ethiopia's agriculture is plagued by periodic drought, soil degradation caused by overgrazing, deforestation, high population density, high levels of taxation and poor infrastructure. Yet agriculture is the country's most promising resource. Many other economic activities depend on agriculture, including marketing, processing, and export of agricultural products. Production is overwhelmingly of a subsistence nature, and a large part of commodity exports are provided by the small agricultural cash-crop sector.

In 2008 only 65% of rural households in Ethiopia consumed the World Health Organization's minimum standard of food per day (2,200 kilocalories), with 42% of children under 5 years old being underweight.[11]

Analyses showed a vicious cycle in which various factors interact to worsen the health of people and their ecosystem.

Land holdings are often so small that farmers cannot afford to let the ground lie fallow, reducing soil fertility. The land has become so degraded that it doesn't produce adequate cattle-feed which results in low milk production. The community usually burns livestock manure as fuel instead of plowing its nutrients back into the land. This causes further reduction of crop production. The low productivity of agriculture leads to inadequate income for farmers, hunger, malnutrition and disease. The poor farmers are in turn unable to spend money to increase their land's productivity. The disease and malnutrition also makes it physically difficult for the farmers to work their land, causing productivity to drop further. It's also a problem for families relying on agriculture that their labour and income is not equally spread throughout the year.

EROSION AND DEFORESTATION

Soil erosion has been one of the country's main problems. Over the centuries, deforestation, overgrazing, and practices such as cultivation of slopes not suited to agriculture have eroded the soil. Besides, the rugged landscape of the highlands and the brief but extremely heavy rainfalls that characterize many areas have accelerated soil erosion in much of Ethiopia's highland areas. Land degradation is expressed in terms of soil erosion and loss of soil fertility. Deforestation is one of the major factors contributing to land degradation because it exposes the soil to erosion. Ethiopia has experienced this: from a baseline of perhaps 40% forest cover in the 16th century, the country is down to 4.6%, a result of 0.8% deforestation a year.[12] A significant reason for deforestation is locals clearing forests for personal needs: such as fuel, hunting and agriculture.

Ethiopia is highly susceptible to soil erosion, especially in the highlands.

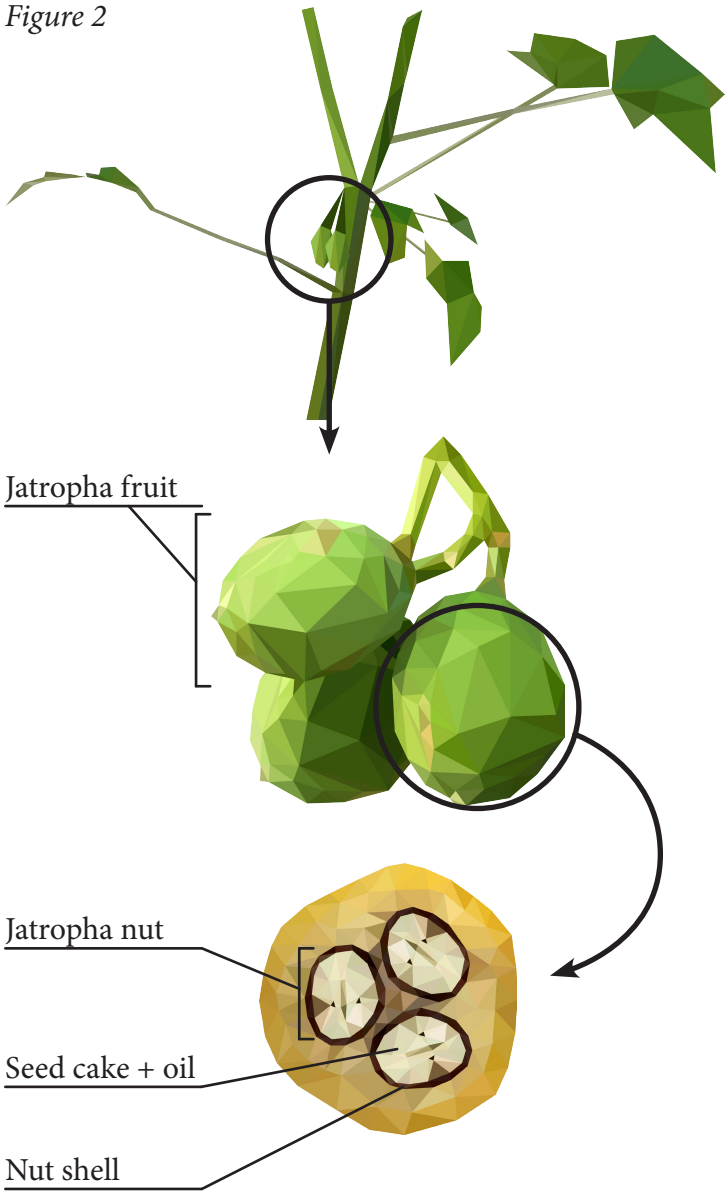
8 Ethnologue
9 ERA (2014)
10 Netherlands Space Office (2014)
11 Crawley, Mike – IDCR (2003 (retrieved 2008)),
12 The Guardian (2013)

JATROPHA AND ITS APPLICATIONS

Jatropha curcas L. is a drought-resistant shrub, originally from Latin America. Jatropha grows relatively quickly; within two to five years, it can start to produce fruits. These fruits are highly toxic, so they can not be directly consumed by humans or used as food for animals. The Jatropha plant has strong roots, which can keep loose soil together. One 'Jatropha nut' contains three Jatropha seeds. About 40% of the Jatropha seed is oil. This percentage can fluctuate with different growing conditions. Some pictures of the Jatropha plant and its nuts are attached in appendix 1.

With the press we used to calculate our costs, we can get an efficiency of 77%. This means we can get 0.31 liters of oil out of every kilogram seeds (see appendix 2) . The press is made by a Dutch company called Piteba. What remains of the seed after the pressing can also be used in several ways. We will call the matter resulting from the pressing 'seed cake' from this point onwards.

Figure 2



WHERE TO GROW JATROPHA

In the past, Jatropha has been considered a renewable source of biodiesel. Jatropha has been planted heavily in areas that weren't thriving because of their low sourced soil.

But were these lands actually unused? To make Jatropha more profitable as a source of biodiesel, better soil was needed. The large production of biodiesel led to less space available for food production. Thus, food insecurity was increased by creating these big Jatropha plantations.

The solution for the competition between food and Jatropha uses the principles of intercropping: two or more crops on one piece of land. This way, Jatropha can stimulate other crops to grow, even during the first years, when the Jatropha shrub doesn't have fruits yet. Intercropping is also a great way to prevent pests.[1]

Erosion due to heavy rainfall is a big problem in Ethiopia. This erosion forms gullies. Gullies are especially easily formed when there is little or no vegetation on the slopes. Because farmers don't want gullies on their lands, they build stone wall barriers to control the runoff of water and to reduce the angle of the slope. These walls increase water storage and trap sediment. This makes the soil more fertile.

However, building a wall of stone takes a lot of time, effort, and it is very expensive for smallholders.

Jatropha is very appropriate as a replacement for these stone walls. The root-structure of Jatropha can play a vital role in preventing the soil from

1 NL Agency Ministry of Economic Affairs (2013)

erosion. It is very easy to plant Jatropha walls and they're cheaper than the stone alternatives. Furthermore, these Jatropha hedges come with other useful functions, such as the possibility to produce oil and seed cake.

There are a few drawbacks to using Jatropha as a natural wall. First, Jatropha is not able to withhold soil above a height of one meter. This is because beyond this height, the stems tend to be too thin. Stone walls can obviously withhold soil to a much higher level.

Secondly, when you want to use Jatropha in an effective way on steep hillsides, you have to plant them very close together. The space in between is reduced enormously, so the loss of arable land is big. This loss of land increases food competition with other crops. In these areas, using stone walls is still the better alternative.[2]

FUEL AND FERTILIZER

The Jatropha seed cake can be used in many different ways, for example as a fertilizer, as animal food, for biogas and ethanol production or as fuel when pressed into briquettes.[3]

There is need for fuel, for cooking, heating and lighting purposes. There is need for fertilizer as well, as this will enrich the soil. This means crops will grow better and the nutritional value of food will be higher. Fortunately, it's possible to combine theses two.

The most lucrative use of the seed cake is when you first use it for energy purposes, by pressing it into briquettes. Jatropha has a high calorific value, which has a positive effect on the combustion of the briquettes. Along with the high calorific value, Jatropha has a high nutritional value as well. The briquettes can be burned on a fire like other briquettes. Afterwards, the majority of the nutritional content remains: in the ashes. These ashes will thus still be applicable as fertilizer. This way both the nutritional value and the calorific value are used.

It's not hard to make a briquette press yourself. The wooden do-it-yourself briquette press, made by Lee Hite and his team is already very successful in rural areas all over the world. (see appendix 3) With this easy method, you can press many briquettes in a very short period of time.[4]

2 Ehrensperger, A. (2015)
3 Hidayat, H. (2014)
4 Engineers Without Borders (2013)

After pressing the Jatropha seed cake, the briquettes have to dry in the sun. Drying the briquettes takes approximately a day or a day and a half. Normal briquettes have to be stored in a moisture-free area. The Jatropha seed cake briquettes still contain a little oil, this makes them a sort of 'waterproof'. This doesn't mean that the briquettes can be outside when it's raining, but creating a totally moisture-free area has no priority.

When combusting the briquettes, it is important not to do this inside without a kind of chimney, since the emission of nitrogen monoxide and dioxide is high.[5]

FERTILIZER FOR EDIBLE MUSHROOMS

In our experiment, we tried to grow mushrooms on Jatropha seed cake. We tested if A. Niger could grow on blanco seed cake or if it needed some carbohydrate source. For all the results, see appendix 4.

We found out that with glucose added, our fungus was cultivated best. So when a good harvest is desired, glucose will have to be added. But with only these results, we cannot say if there's a big chance that enough edible mushrooms will grow for it to be profitable, since glucose is expensive. Besides, a lot of extra steps would have to be taken, which would add even more to the costs.

Our knowledge of cultivating mushrooms on Jatropha seed cake is small and we're not sure about the chance of its succes. So we decided not to hold on to this idea and to instead use the seed cake as fuel and fertilizer.

LAMP OIL

It has been reported that Jatropha oil can be used as a fuel for lamps.[6] Since we weren't able to find much specific information concerning this topic, we decided to test it ourselves. We only had 10 mL of Jatropha oil, with which we did the best we could. The details and results from our experiment can be found in appendix 5. We sadly came to the conclusion that Jatropha oil doesn't function as a light source, at least not with our setup. With more oil and a different setup the results might be different, however we were unable

5 Kavalek, M. (2013)
6 Henning, R. (2000)

to test this. Because it was hard to use Jatropha oil as a light source for us, we decided it would not be a great application to base our project upon.

SOAP

The oil that results from pressing Jatropha nuts can be used to make soap. Not just the oil is required to make soap though. Here is a quick summary of the necessary materials:

1. 8 cups of water
2. 8 cups of Jatropha oil
3. 1 cup of soda (NaOH), commonly known as caustic soda
4. Two bowls or buckets
5. Cardboard boxes (to function as molds)
6. Plastic canvas (to make the molds waterproof)

One of the bowls is used to make a solution of the soda and water. Since the NaOH will react with the water, the water's temperature will rise. Once the water has cooled down, it can be mixed with the Jatropha oil in the other bucket. At this point the blend has to be stirred for one and a half hours, at a continuous speed and in one direction only. The soap won't solidify if this stage is performed incorrectly, but won't lose its washing capabilities. The paste-like soap can still be used to wash clothing.

After this process, the (still semi-liquid) soap can be poured into moulds. To fully solidify the soap needs to be stored in a cool place. The temperatures have to be somewhere between 20 and 32 °C.[7] When the soap has hardened, it can be taken from the molds and cut to the correct size.[8]

7 Van der Horst, D. (2016)
8 Chibwe, T. (2012)

WHY ETHIOPIA NEEDS JATROPHA

Jatropha can be a solution for the erosion problem in the highlands of Ethiopia. The plants can be used to for a natural wall. Farmers may use the fertile pockets of soil behind the barriers to plant crops.

The oil of the jatropha nut can be processed to soap: this antibacterial soap can be sold to obtain revenue and create more employment and knowledge. Because of these profits, more money becomes available for food and investments. The cash can also be used to improve the quality of the soil and offers possibilities to combat the previously mentioned vicious cycle. It will also result in more equally spread and more reliable income.

In addition to that, the remaining products of pressing Jatropha fulfill another function: people in Ethiopia are in need of fuel (for cooking and lighting) and fertilizer. Jatropha can solve both these problems. Another important advantage is that it decreases deforestation, as people won't have to chop down as much trees for their fuelwood. This will in turn have a positive influence on the reduction of erosion.

In short, Jatropha offers plenty of possibilities for a self sufficient platform that can enable small communities in the highlands of Ethiopia to use the plant's nut sustainably and profitably.

For a detailed description of these application, please turn to the section 'Jatropha and its applications'.

THE PROJECT

We plan to solve the aforementioned problems in Ethiopia using some of the properties of Jatropha. Namely the strength of the twigs to counter erosion, the oil for soapmaking and the seed cake as fuel for cooking or warmth and fertilizer. The project can be divided up into several phases, which we will cover in this section of the report. Furthermore, we will cover the resources and requirements, costs, funding and revenues that we expect to come with this project.

In short, our project is planting Jatropha in gullies to rehabilitate them and create more arable ground. The nuts will be used to produce soap and briquettes. This will provide more jobs, and improve hygiene and fuel availability. This will help reduce deforestation. We plan on starting out small, but when the project becomes successful, we imagine other farmers will follow the precedent we set. The exact size of the project will depend on the location. For the cost calculation we used 5 kilometers of gully, this results in 780 meters wall.

PHASES

Phase 1: Planting (year 0)

Before anything can start, we first need to plant the Jatropha. For this we want to use cuttings, as this means that the plants will reach the required height sooner. Walls like these are build more, but they are most often stone ones. Since the walls solve a concrete problem, they are easily integrated.

Phase 2: Waiting (year 0-5)

After having planted the walls, farmers will have to wait. After 9 months, the Jatropha plants will start growing nuts. There won't be an optimal yield of 1 kg/m until after 5 years. These first years the only thing that needs to be done for our project is the yearly pruning of the Jatropha in the winter. It is unknown how long it will exactly take for the ground between the walls to be rehabilitated, but we estimate it will be about 2 years.

Phase 3: Processing the nuts (year 5 >)

After these 5 years the nuts have to be harvested weekly during the summer. Since the Jatropha nuts do not cope well with moisture, they need to be pressed right away. This means that all the nuts that were collected that week need to pressed. The resulting oil is stored for later use and the briquettes are also pressed immediately and placed in the sun to dry.

During the winter the farmers have less work, this is when all the oil is processed into soap. This happens in batches of 4 litres of soap. The soap gets cut and in the winter period the soap bars and briquettes are sold on local markets. This way the farmers also have income during the winter. This reduces their reliance on good yield. In the winter the Jatropha plants will also still be pruned yearly. The ashes are collected and used as fertilizer.

COSTS

The building of the walls costs practically nothing. The cuttings are readily available (*Gully rehabilitation and hill stabilization with Jatropha hedges. - Simon Bach*) since Jatropha is pruned yearly or every two years and they cost next to nothing. The litter or stones can be collected from a nearby landfill and thus also cost nothing in material

Table 1

walls	Cuttings Litter	
pressing	Piteba press, economic lifetime of 5 years	25,05
soap making	0,0625 kg NaOH per kg soap ->32 kg in total, 0,075 euro per kg Carton boxes Plastic foil	2,40 100
briquettes	Wood and bolts for briquette press, economic lifetime of 5 years	10
Total costs / year		**137,45**

costs. Both of these resources will however need to be collected and sorted and thus do require some labour. This is accounted for in the hours it takes to build a meter of wall. The costs for the labour it takes to build and prune the walls will be spread over the first 5 year of income on soap.

The press will have to be imported. A press costs 125.25 euro, including shipping and a maintenance kit. The economic lifetime is 5 years, this leads to a yearly write-off of 25.05 euros. The NaOH costs 1.20 per kg. We don't know the exact price for cardboard and plastic foil in Ethiopia, so we calculated 100 euros per year on mold and bucket costs.

Worktime

The labour time is shown in table 2 in hours per year. A monthly salary of 2,000 birr is considered high in Ethiopia for this kind of labour.[1] This is 86.66 euros, and is based on a fulltime job of 32 hours per week, so 128 hours per month. This concludes to a salary of 0.68 euros per hour.

The labour costs per year will thus be €1136.47 per year.

This means that the total costs will be €1306.42 per year.

REVENUES

We make soap bars of 125 grams a piece. On a yearly basis we harvest 780 kilograms, which yields 241.8 litres of oil. We can produce 513.8 kilograms of soap with this. Theoretically, this means we could produce 4110 soaps per year. In practice, materials will be lost during the process, so we estimate it will be realistic to say 3500 soaps will be produced on a yearly basis that are suitable for selling.

We will be left with 538.2 kg seed cake. The price of wood in Ethiopia is €1.25 $/GJ.[2] Jatropha seed cake has an energy value of 18.2 MJ/kg.[3] We thus have a yearly energetic value of 9.795 GJ.To be able to compete with the price of wood we will thus have to sell our briquettes for less than €12.25, which is very little.

We will be able to turn 65% of the mass of Jatropha nuts into baguettes.[4] This is 349.83 kilograms of briquettes. Our price will be €0.035 per kg briquette. This is not the most profitable part of our project, it will however result in less deforestation and better access to fuel. Furthermore, the briquettes can be used by the participating farmers themselves.

To let the complete project be profitable, we have to cover the costs of 1261.92 with the sales of 3500 soaps. With a price per soap bar of €0.40, we will have a revenue on soap of €1400. If €0.40 per soap is too expensive for sales in Ethiopia, the soap could also be exported.

The yearly profit is 105.58, the total project will make a profit of €527.90 over the course of five years. This money can be used for unexpected expenses and the expansion of the project.

FUNDING

In the beginning the project will need a certain amount of funding to start up our project. The funding will be needed at the end of phase 2.This is however a very small amount like shown in the table below.

We plan to fund this using one of the many existing platforms that lend money to these type of projects without interest, for example the 1%club or Kiva. This is easily possible since it's a small amount. This money will be paid back with the money earned with the soap and briquettes. After that, NaOH can be paid with the money that is earned.

1 Wageindicator (2014)

Table 2

Planting the walls	74.88
Pruning the walls	375
Harvesting the nuts	257.4
Pressing the nuts	390
Washing the nuts	50
Producing the soap	224
Pressing the briquettes	300
Total	**1671.28**

2 Asfaw, A. (2012)
3 Jingura, R. (2010)
4 Kumar, S. (2013)

Table 3

Piteba press	125.25
Material for briquette press	50
32 kg NaOH	34.91
Material for molds	100
Total	**277.65**

CONCLUSION

We started with asking ourselves how we could improve the low and inconsistent income of farmers in Ethiopia with the help of Jatropha. Unfortunately we could not use every single application of Jatropha towards this end, but there were still some applications that fit the problems of Ethiopia quite well. We were able to tackle not only the income inconsistency of the Ethiopian farmers, we found a solution that simultaneously combats erosion and deforestation in the area.

We came up with a single project in which we combined several applications: walls to counter erosion, soap for extra profit and hygiene, and seed cake for briquettes and fertilizer. The soap can be sold in intermediary periods were little money is made from the farmers' own harvests. This way, the income of farmers is spread throughout the year more equally. In our opinion, this project is the best way to lay hands on as many problems as possible at once.

However good our plan might be at utilising a great number of possible applications though, there were also many we were not able to implement in a single project. The use of seed cake as a substrate for mushroom cultivation showed much promise in theory, so this mustn't be ruled out as a viable application. However, more testing ought to be done to ensure its eligibility.

Before the execution of our project, several local farmers will need to be contacted to ask them about their current work and lifestyle. We feel like we have a project that fits into the life of an Ethiopian farming community, however, since we were not able to verify this with local farmers, we can not ensure this and this would have to be confirmed before possible implementation of the project.

POSTFACE

We worked on this project from September to January: five months of research and development. We learned a lot in this period.

We started reading about this plant and we discovered that there have been a lot of projects with Jatropha, most of them in the past, a few ongoing. We were surprised by the enormous amounts of Jatropha plantations, just for oil. We saw that these plantations were rarely successful, but we had plenty of other ideas. And actually, having so many ideas was our first "mistake" .

It caused a lack of focus: we wanted to use every single part of the plant, all of the countless possibilities. So the first important lesson we learned was: start making decisions at an early stage. It is always preferable to focus on one concept, so we had to make choices to provide us with said focus.

Some of us found it challenging to write a report in English and thought that it would be harder. It was at times, as you are not able to make the same sentences as you would have done if you were allowed to write them in Dutch. Also, it takes longer. However, executing this kind of project in English had a lot of benefits. We became accustomed to reading and writing in English, which could be important and will definitely be useful when we go to university. Furthermore, when we looked for sources in English, we found more information than we would have in Dutch, especially on very specific subjects, like Jatropha.

The four of us also found it very valuable that we could contact our professor when we had questions. Doing the practicum in Groningen at the RUG was very educational. We got some Jatropha products as well so that we could do some experiments at home, in Gouda. The results gave us a lot of information about what was possible and what wasn't.

Imagine, science for your future, is about creating a better world. Some of us seriously consider studying something about development aid or sustainable business when we finish high school in 2017. The essence of this project is to try to improve someone's life. We think that that's an important message, and that it's an important message to carry out.

Participating in Imagine is the first real step for us towards doing something with sustainable business, and will surely not be our last!

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Sandar Swaran Singh National Institute of Renewable Energy, Kapurthala, India

APPENDICES

APPENDIX A
PICTURES OF JATROPHA

APPENDIX B
PITEBA PRESS

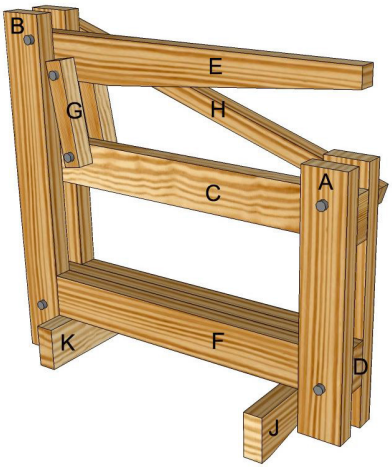
Purchase, shipping and maintenance set:
€125.25

Economic lifetime:
5 years

	Oil content % of kg seed	**Oil extraction** liter per kg	**Efficiency** %	**Oil** liter per hour	**Seed** kg per hour
Jatropha	42	0.31	77	0.58	1.6

APPENDIX C
BRIQUETTE PRESS

This is what our briquette press will look like



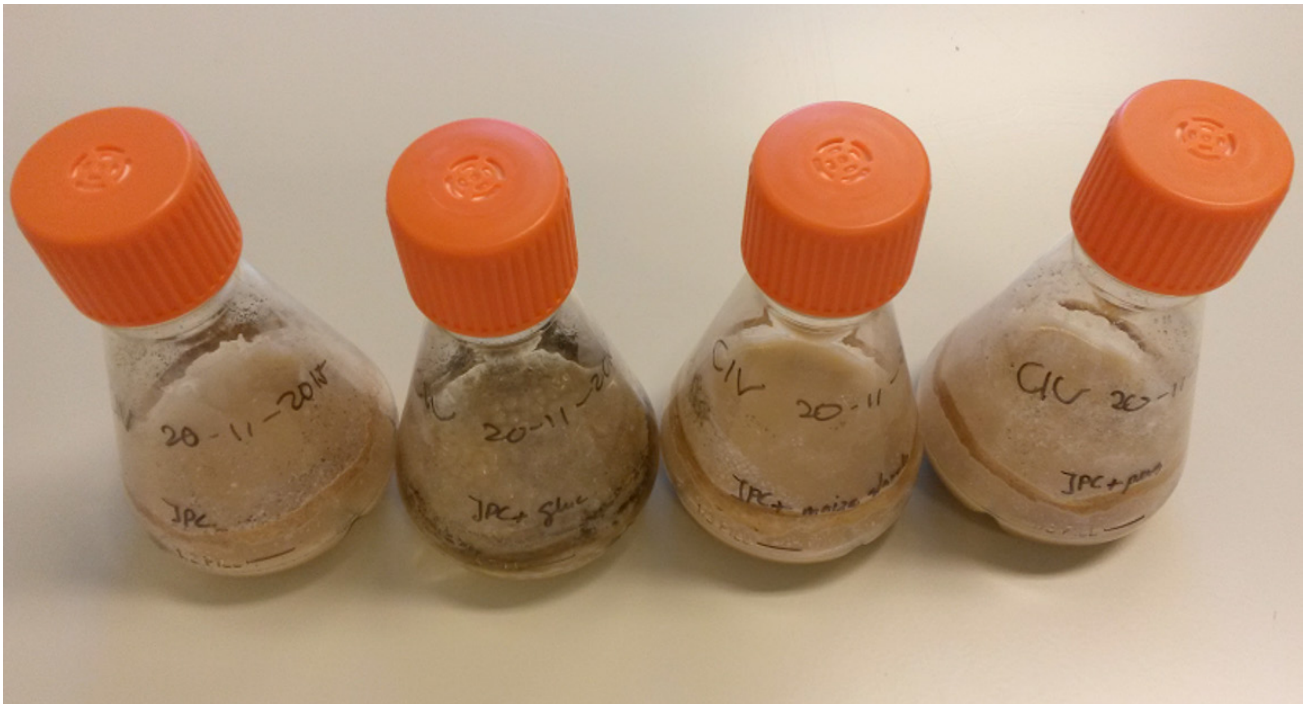
There is an excellent building plan for this press, so it is very easy to build a press yourself.

APPENDIX D
MUSHROOM CULTIVATION

Practicum Glucosamine in Jatropha Seed Cake Substrate

We added a carbohydrate source to sample 2-4 to test if this would affect the amount of glucosamine.

Sample	Total grams of glucosamine
1 Jatropha Seed Cake Blanco	0.36 gram
2 Jatropha Seed Cake + Glucose	4.54 gram
3 Jatropha Seed Cake + Cornstarch	0.40 gram
4 Jatropha Seed Cake + Peas (crushed)	0.24 gram



APPENDIX E
LAMP OIL EXPERIMENT

STATEMENT OF THE PROBLEM

How well does Jatropha oil function as lamp oil?

We have seen Jatropha mentioned as lamp oil several times in literature. We could however not find how well this would work in practice. Since this was something that we could test relatively easily, we conducted this experiment.

PROCEDURE

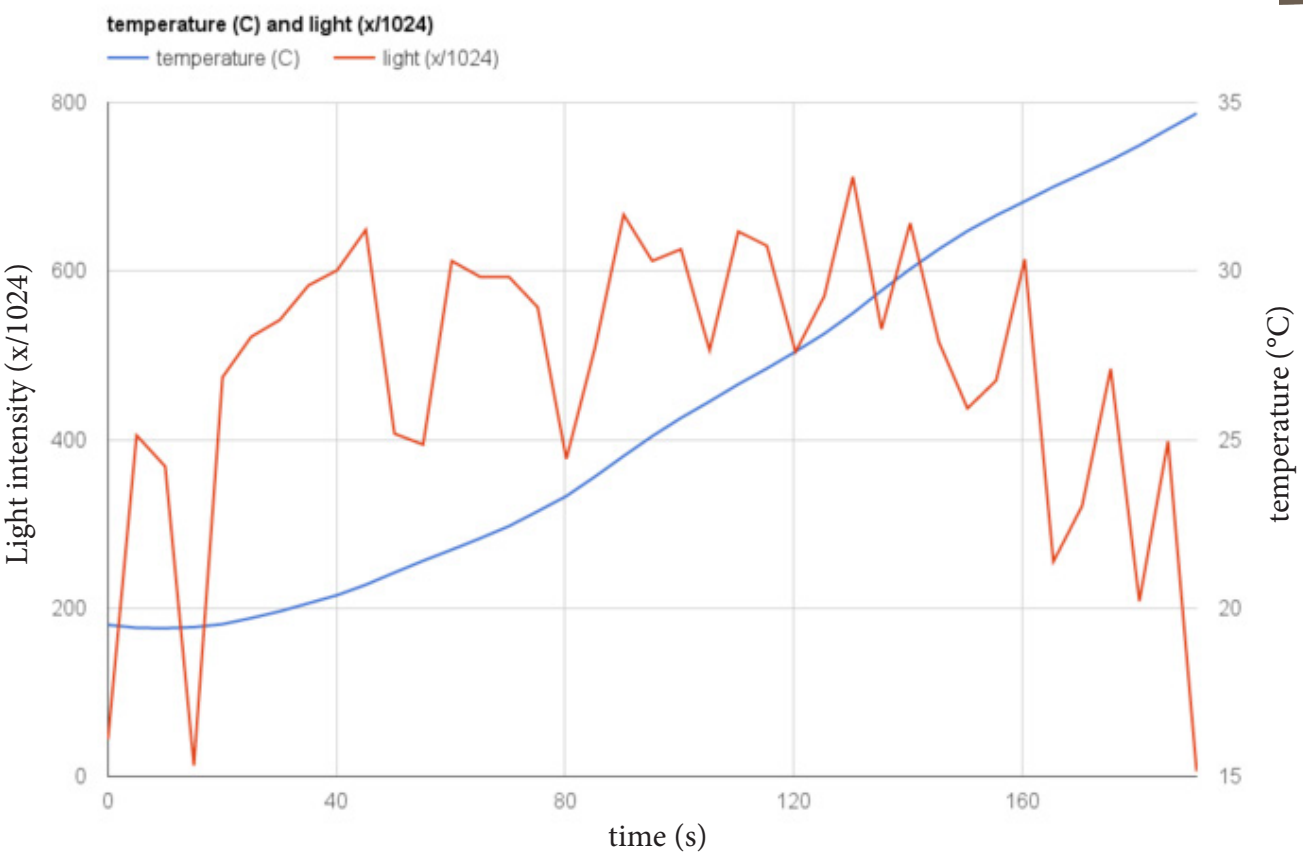
1. Remove the candle-grease and fuse from the tea lights.
2. Separate the fuse from the candle-grease so you have only the fuse with a metal stand remaining.
3. Clean the cup and fuse of as much residual candle-grease as possible, so that this interferes with the results as little as possible.
4. Put the fuse with its stand back in an empty, clean tea candle cup. You will end up with something looking like what's shown in figure 1.
5. Fill three cups with 3 mL of Jatropha oil and three cups with 3 mL of regular lamp oil.
6. Take one of the cups and put it in an environment that is as dark as possible. Place the light intensity meter ~10 cm away from it facing towards the light source. Put the glass cup with 25 g water 5 to 10 cm above the light. Our setup can be seen in figure 2.
7. Start the meter (it will log the brightness of the light and temperature of the water every 5 seconds).
8. Light the fuse.
9. Stop the meter as soon as the flame has faded away. Store all of the data.
10. Repeat step 6 through 9 until you have completed these steps for all of the six lights.

Figure 1

Figure 2a

Figure 2b

RESULTS



Observation: The first 2 to 3 minutes, the candle lint burt is a similar manner a seen in the tests with regular lamp oil. After these couple of minutes, the Jatropha oil did however not catch fire. Only a negligibly small flame was visible, as seen in figure 3. Because the oil did not catch fire, we did not complete all of the three tests and it was also not needed to complete the test with regular lamp oil after having seen that lamp oil did catch on fire.

CONCLUSION

Based upon our results, we have to reject our hypothesis, as the Jatropha oil didn't catch fire and the regular lamp oil did.
In a future experiment it would be good to do the same test with more Jatropha oil and lamps that are made for lamp oil. As we only had 10 mL of Jatropha oil at our disposal, this was not possible for us to do.

WALL-NUT

THE SOLUTION IN A NUTSHELL