Growing plants with high protein content in the Netherlands

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Preface and Acknowledgements

I am Jan Jetze de Vries, a student in double degree program International Food Business. In front of you, you can find the thesis ``Growing plants with high protein content in the Netherlands´´. I wrote this thesis because during my studies I learned about the challenges of the 21th century and about possibilities how to reduce the global warming. I learned that the food sector is a major contributor to global warming, but also has a major role in reducing the environmental pollution. I grew up at a farm which is at the starting point of the food sector. Throughout my time at the university I also learned about the importance of the farmers in the food chain. With this research I want to show that it is possible to reduce the environmental impact while producing food. Therefore this research is for all farmers who are looking for opportunities to reduce the environmental impact of the food they produce for local and global markets.

I would like to thank my coach Sintija Kuipers, for the help during the process of writing my thesis. I also want to thank the entrepreneurs who made time available to help me collect the data in form of an interview, and I want to thank Feitze de Vries and Rama Hordijk for their help during the process of writing this thesis.

Table of Contents

Summary

The primary purpose of this thesis is to show entrepreneurs in the Netherlands that the companies in the country import protein, mostly in the form of soy and use them to grow animals. These animals where eaten for their protein content, this is not a efficient way and is causing an unnecessary exhaust of carbon-dioxide. Meanwhile the people in the Netherlands are looking for products with less impact on the environment. One way is to eat less meat or to take meat out of their diet. To still get a healthy diet with sufficient proteins, alternative protein sources are found. One of these sources are plant based proteins. Therefore the researcher has researched the question : Which plant is financially most beneficial to be grown in the Netherlands for the production of protein for human consumption? This research is to show entrepreneurs that it is not only good for the environment but also financial interesting, to grow plants with a high protein content. To give the entrepreneurs an idea of these financial benefits. In-depth interviews are done with entrepreneurs who currently grow plants with a high protein content. To give the research some limitations, only four plants and their financial benefits are researched. These four plants are lupine, hemp, duckweed and seaweed. After doing interviews the researcher has gathered all the cost and the benefits and has used a benefit cost ratio to show the plant which is most interesting to grow. This resulted in the plant hemp, is expected to be the most financially beneficially to grow. However the difference with duckweed is not a lot. The researcher has learned that these two plants require a whole different approach. The entrepreneurs who are interested in growing plants with a high protein content should do research about which crop suits the best with their own situation.

1. Introduction

One of the biggest challenges in the 21th century is climate change. The average temperature on earth is rising because of an increase in man-made carbon dioxide emissions since the beginning of the 20th century. This results in melting ice on the North and South poles. The seasons on earth change and become more extreme, for example: extreme droughts and floods and an increase of the number of tornados and lightning storms. The main causes of carbon emissions are food, transportation and housing. If humanity does not start dealing with this issue today, the problem will only get bigger and harder to solve (Hartmann et al., 2013, p. 3).

To solve the problem, we need to look at what can be changed. One of the biggest contributors to the environmental pollution is the food sector. That is due to the choices people make about what they eat and what they are willing to pay for. Meat has been in the basic diet for many years in many parts of the world. Humans need protein and meat is high in protein. Researchers have discovered that if humans would replace meat in their diet with plants with high protein, then that would only result in positive changes to the health, but also in a major decrease in carbon-dioxide emissions (Lacour et al., 2018).

The reason why meat is causing significantly more carbon-dioxide emissions is because animals use a lot of water and are eating plant based proteins to grow. Because the proteins from the meat are in a longer process before they end up on a plate, compared to eating plant based protein directly. The plants that are grown for the animals are mostly soy plants and they only grow in certain areas, e.g. Brazil. The areas are scarce, to sustain the demand of soy and therefore rainforests are being cut to grow soy (WWF, 2014, p. 5). The soy is then transported to countries all over the world to feed animals. By growing plants with high protein in the country where they will be used, the carbon-dioxide emissions can be reduced.

Another alternative to supply proteins needed for humans could be bringing insects into our diet (Van Huis, 2013, p. 59). However, when introducing these insects in Europe, the people did not embrace the insects with open arms. The feedback on introducing insects was, that it was awful and people refused to eat it (Van Huis, 2013, p. 563-583).

In a small country like the Netherlands, which is known for its large agricultural sector, only around 38% of their own protein demand is produced in the country itself. The EU is also subsidizing growing crops with high protein content (Denanot, 2017, p. 9). Additionally the trend in the Netherlands is that more and more people gain awareness of the importance of reducing their carbon-dioxide emissions (CBS, 2015, p. 26). This is resulting in an increased number of people living on plant based diets.

However, the transition from meat protein to plant based protein is a long process. As mentioned earlier there is an increasing number of people who want to live more sustainable and choose a plant based diet (Schyns, 2016, p. 70). This increase results in a growing demand for crops that have high protein content. The Netherlands is also a country that has a large share of the total food production of the world for its size (Eurostat, 2012). This is a result of the knowledge gained by the entrepreneurs in the primary food production. These entrepreneurs realize that the demand of plant based protein is increasing and that when there is demand, the supply has to be kept high.

There are many plants which contain protein, For the purposes of this research, only four plants are chosen. These plants are chosen because of their high protein content and other characteristics that can be beneficial for the entrepreneurs. The four plants are; Lupine, Hemp, Duckweed and Seaweed. In the following table their protein content is shown, followed by an introduction of each plant.

Table 1.1 Protein content in different plants (Hove, 1974, Galasso, 2016,Nour, 2014,Angell, 2015)

Plant	Protein content (%)
Lupine	28,6-36,2
Hemp	20-25
Duckweed	43
Seaweed	33

From the table above it can be seen that the plant with the highest protein content is duckweed, and hemp has the lowest protein when compared to duckweed, seaweed and lupine.

Lupine (Lupinus)

Lupine is currently grown for food and feed purposes. This plant is chosen because it can adapt to marginal soils, it can be grown in the Netherlands and has a high protein content. The beans are used mostly in the baking industry, for example eggs in a cake can be replaced by lupine beans. The lupin flour also improves water binding, texture, shelf life and aroma (Kohajdova, Karovičova & Schmidt,2011).There are over 400 different kinds of lupin. The white (Lupinus albus) and yellow lupin (Lupinus luteus) are also called the European lupines. However, Europe produces a small amount of the world lupin production (Kohajdova, Karovičova & Schmidt,2011). One entrepreneur who anticipated on the lupin demand is Andre Jurrius who is growing lupines for De Vegetarische Slager (The Vegetarian Butcher) who is using the lupines for creating meat alternatives with a comparative nutritional value. This cooperation between them started in 2008 and has gained more and more popularity (Jurrius,2018). This is one of the examples of how to add value to the protein created.

Hemp (Cannabis sativa)

Hemp originated in the Yunnan Province of China and is currently grown all around the globe. The first hemp was already grown 8000 years BCE, and in Europe 300 BCE by the Romans. The variety used for this research has a very low THC (Tetrahydrocannabinol) value which is the working compound for the psychoactive constituent of Cannabis. This plant has such a low level that is useless for that purpose. This however had a great impact on the history of the plant, because in the year 1937 the plants which contain even a bit of THC were banned. The plants could only be grown in some areas and in 1992 the EU allowed the plants to be grown again. This resulted in popularity of the plant for its other purposes. These are paper, plastics, medicines, food, construction, feed and chemicals (Bouloc, 2013). For most of these products the substitute products have a higher carbon footprint than hemp and therefore hemp is a good alternative. The part of the plant with the highest protein content are the seeds and can therefore be used for human consumption.

Duckweed (Lemna)

The duckweed has a relatively short history that goes back to in 1981. Before that time the plant already existed, but there is no data available whether/how it was used or grown. The plant is one of the smallest ones that exists, having a size somewhere between 0,3mm and 20mm. The biggest advantage is that it multiplies its mass in 16 to 48 hours. This gives the opportunity to harvest every 48 hours and keep the same farm size (Leng, Stambolie, Bell, 1995). For sales this can be convenient to sell a fresh product without having to process it for conservation. Since people are using and learning about this crop, the demand for it is growing and more purposes for the end product are found. One of the most important ones is to use as food. In Europe this is still a problem because it was not seen as a food before 1997, and therefore the EU has labelled Duckweed as novel food. This means that it can be served as food in the home environment but not sold in commercial enterprises, such as restaurants and grocery stores. Novel foods are being instantiated as food to become an official food and then it can be sold under certain requirements. These are for example, it is safe to sell it as food and it is healthy to use as food. This can mean that it has to be tested, for example for bacteria such as E.coli before it is sold. However, the process from novel food to food can take a long time and it is uncertain how long it would take. This could happen at any point in time. When this happens the demand most likely will increase, since it will be possible to sell to a bigger market.

Seaweed (Laminaria)

Seaweed has been used as food in the world for a long time. There are over 1800 known seaweed species. In 2002 the EU has listed some of those as novel food and in 2014 some of those species were listed as food and a list of these species can be found in the appendix A. Seaweed is mostly served fresh like spinach or in salads. The seaweed is also used as a medicine and there are some projects by the Dutch government which focus on research on feeding seaweed to dairy cows. The project is already tested on one farm and resulted in an increase of the milk production and a substantial cut in the methane output of the cows (Groot Antink, 2017). This methane output is one of the biggest reasons why meat has a high impact on the environment. If this could be reduced for the meat that humans eat, it would also reduce the environmental impact of meat production. This can be a reason for the entrepreneur to choose for this crop, however the research focusses on the plants with applications primary for human consumption.

When showing entrepreneur the demand of plant based proteins is growing, the entrepreneur can meet the demand by investing in those crops and that will result in more plant based proteins being available. This will stimulate the transition to a more environmentally friendlier eating pattern, not only on a national level but also internationally. Therefore, this research is written for the entrepreneurs in the Netherlands who want to be part of the transition of producing environmentally friendlier proteins, while making financial progress. An important income for the entrepreneur can be subsidies from the EU. The new strategy for 2030 is available. The focus is on reducing the carbon footprint. Although the EU did not yet release the amount of support farmers will get for reducing the carbon footprint, it is at the top of the agenda, this indicates that more funds will be available (European Commission, 2017). During the research this will kept in mind and if new data is available it will be used in the research.

The reason why the researcher has chosen to only look at the financial part of the plants is, because the farmers are entrepreneurs and the basis of the entrepreneurs is that they want a return on their investments. By giving an indication of the required investment and the possible return on investment the entrepreneurs are shown an opportunity. It is up to the entrepreneurs to make the decision to invest in these plants, but by showing this opportunity the chance that they will invest in one of these plants will increase and therefore there is a change that the carbon footprint of food from the Netherlands is decreasing.

To conclude, this has resulted in the main research question is; **Which plant is financially most beneficial to be grown in the Netherlands for the production of protein for human consumption?**

To answer the main research question, the following sub questions have been formulated:

SQ1 : What are the estimated costs when growing these four plants ?

SQ2 : What are the estimated incomes of selling these four plants ?

SQ3 : Which of the four plants has the highest benefit cost ratio ?

From here on MQ will refer to the main question and SQ 1 till 3 to the sub question with that number.

Objectives

The outcome of this research will give an insight into the costs and benefits of the four different plants namely lupine, hemp, duckweed and seaweed. This can mean that when an entrepreneur reads this research and has his/her own ideas to create more value to the product than the interviewed entrepreneur, the benefit to cost ratio might change. The author of this research expects that hemp has the highest financial benefit for the entrepreneur. The reason for this is, that even though only the seed is used for the protein, the rest of the hemp plant can be used for a lot of purposes which can be financially beneficial.

2. Materials and methods

This chapter describes the materials and methods used to answers the sub questions. After the materials and methods the role of each sub question is described.

To give an answer to the sub questions an in-dept interviews are conducted. The reason why the researcher has chosen for an in-depth qualitative interview is, because the information about the costs and benefits are different for each entrepreneur and therefore are not gained when conducting data with a questionnaire, also with a questionnaire you would not be able to gather information which is not known beforehand. Another reason is that there are currently not a large number of entrepreneurs who are growing one of the four crops. Although most of the information is numeric which indicates a quantitative research according to Baarda (2014) in the book: "Research, this is it!", the researcher has chosen for a qualitative research, because there is only a limited amount of knowledge on the subject and more was needed to develop a good closed question survey. Only a few people who have the information relevant for this interview and therefore an in-depth interview was the most appropriate. For this interview entrepreneurs were asked which benefits and which costs they have during the process of growing the crop. A brief outline of the questions can be found in appendix B. Before the interview an indication per sub question were made of which costs and benefits could be expected.

The interviewed people are all entrepreneurs who are currently growing one of the four plants. The interviewed entrepreneurs are listed below with the crop the they grow and the company names:

Table 2.1 Interviewed people

Person	Crop	Company
Koen van Zwam	Seaweed	Noordzee boerderij
Andre Jurrius	Lupine	De Lingehof
Kees kroes	Duckweed	Ecofarm
Eelkje oldenburger	Hemp	Hempflax

SQ1 : What are the estimated costs when growing these four plants ?

The expected cost when growing the plants are made beforehand to make sure none of the costs were forgotten during the interview. The expected costs are indicated per plant, because not all plants require the same setup to grow. This is shown in table 2.2. As can be seen in table 2.2 there six categories of costs and additionally ``Other´´ are included to make sure that all relevant costs were represented.

Table 2.2 Expected costs

Costs for							
Lupine	Soil	Seeds	Plant feed	Labor	Machines	Equipment	other
Hemp	Soil	Seeds	Plant feed	Labor	Machines	Equipment	other
Duckweed	Water/Soil	Seeds	Plant feed	Labor	Machines	Equipment	other
Seaweed	Water	Seeds	Plant feed	Labor	Machines	Equipment	other

SQ2 : What are the estimated incomes of selling these four plants ?

The expected income streams when growing the plants are made beforehand, to make sure none of the costs were forgotten during the interview. The expected benefits were indicated per plant, because not all plants have the same end product. This is shown in the table 2.3. As can be seen in table 2.3 there are three categories of income and additionally the category ``other´´ are included to make sure that all relevant income is represented.

Table 2.3 Expected benefits

Benefits for				
Lupine	Government funds	Seeds	Plant or seeds	Other
Hemp	Government funds	Seeds	Plant or seeds	Other
Duckweed	Government funds		Plant or seeds	Other
Seaweed	Government funds		Plant or seeds	Other

SQ3 : Which of the four plants has the highest benefit cost ratio ?

The data from the interviews is used to create a benefit to cost ratio analysis, According to the presentation of Professor Shuzhong (2014), this ratio will indicate which of the plants will give the highest benefit if it is applied the same as the interviewed entrepreneur.

To make this ratio, excel is used. In the excel file the benefits are added up, this is divided by all the costs. This gives the benefit to cost ratio. The ratio´s which are higher than one, make a return on the investment, the higher the ratio the better the return on the investment. If the outcome is one the investment has financially no loss and no benefit. When the ratio is below one the investments costs money.

The interviews are in-dept interviews, this means that there is a brief outline of what is asked, but during the interview the researcher asked more questions to gain relevant knowledge of what has to be done to grow one of the four plants. The interview is written down during the interview and added as an appendix in the thesis.

Collection of data

The most relevant data gained during the interviews is the financial data. During the interview more useful data was collected. The interviewers reoffered to information sources, these sources do not only contain financial information but also information about how to grow these plants. This information can be used by the entrepreneurs who are interested in growing these plants.

3. Results

Here, the outcome of the interviews are displayed. All entrepreneurs showed an average year with no giant influences like droughts or diseases in the plants. The used information is not from a harvest of more than 3 years ago, to have the most reliable information. Each plant is shown with answers to the first two sub questions, after all plants SQ3 is answered and the benefit cost ratio is shown. The interviews can be found in the appendixes. The interviewed people referred to recent documents where they partly got their information. Kees kroes did a documented research during a season of growing duckweed this is partly used to find some of the cost and benefits. The document which is used is: De ecoferm kringloopboerderij in de praktijk(Kroes et al., 2016, p. 82). During the interview with Koen van Zwam the document: The economic feasibility of seaweed production in the north sea (Burg, van den,et al., 2016) is used for financial data. The interviews can be found in appendix C till appendix F

SQ1 : What are the estimated costs when growing these four plants ?

In table 3.1 the costs of growing lupine are shown of the organic farm of Andre Jurrius. The costs in Table 3.1 are of the year 2016. This was a normal year for growing lupine. Fertilizers are not used in organic farming and therefore plant health cost are higher than it would be for conventional lupines. This means that farming conventional lupine would mean more fertilizer cost and less plant health costs, so at the end about the same costs for the crop. Andre Jurrius does all the work himself with his own machines and has given this information based up on what it would costs if he hired a contractor to come with the machines and do the work he does during the process.

Table 3.1 Costs of growing lupine

Variables	Costs
Fertilizer costs (€/ha)	€ -
Seed costs (€/ha)	€ 190.00
Plant health costs (€/ha)	€ 200.00
Other costs and variable charges (€/ha)	€ 261.00
Total of all variables for the crop (€/ha)	**€ 651.00**
Cost of harvesting (€/ha)	€ 142.00
Cost of cultivating(€/ha)	€ 49.00
transport costs (€/ha)	€ 29.00
Total of all variables for harvesting (€/ha)	**€ 220.00**
Total costs (€/ha)	**€ 871,00**

Table 3.2 shows the costs of growing hemp by Hempflax. Hempflax used information of their whole operation of 800 hectares and divided the costs by 800, so the outcome of the costs showed below can differ a little since they could be less efficient when working with a smaller areal. Because the flower is used separate the cost of mowing and sheafing are calculated in table 3.2.

Table 3.2 Costs of growing hemp

Variables	Costs
Fertilizer costs (€/ha)	€ 137.33
Seed cost (€/ha)	€ 111.30
Plant health costs (€/ha)	€ 2.00
other costs and variable charges (€/ha)	€ 32.00
Total of all variables for the crop (€/ha)	**€ 282,63**

Cost of harvesting (€/ha)	€ 113.00
Cost of mowing and sheafing (€/ha)	€ 36.30
Cost of baling (€/ha)	€ 214.00
transport costs (€/ha)	€ 90.76
Total of all variables for harvesting (€/ha)	**€ 454.06**
Fixed mechanical cost (€/ha)	€ 124.75
Variable labour costs (€/ha)	€ 99.00
Total costs (€/ha)	**€ 960,44**

In table 3.3 the costs involving of growing duckweed on the Ecoferm are shown. The seeds or plants to grow are found in nature and can multiply in 48 hours there are no costs related to seeds are plants bought. The plants grow on manure of the animals on the Ecoferm and no other plants health costs are needed during the growing of outside duckweed. The duckweed can be harvested daily by a conveyer belt.

Table 3.3 Costs of growing duckweed

Variables	Costs
Fertilizer costs (€/ha)	€ 150.00
Seed cost (€/ha)	€ -
Plant health costs (€/ha)	€ -
other costs and variable charges (€/ha)	€ 200.00
Total of all variables for the crop (€/ha)	**€ 350.00**
Cost of harvesting (€/ha)	€ 50.00
Fixed cost (€/ha)	€ -
Variable labour costs (€/ha)	€ 100.00
Total costs (€/ha)	**€ 500,00**

The costs involved in running a seaweed farm are shown in Table 3.4. The costs are from the given research mentioned before. This research was done based on small experiments and based on that an assumption is made of the costs to start a seaweed farm in the north sea. The highest costs are the fixed costs of man hours and material to keep it the seaweed on a somewhat controlled place in the sea. The fixed costs are of an investment of 138.000,- with a return of 6,25 and a lifetime of 10 years. As can be seen the total costs of production are not close to the costs of the other plants and it takes a whole different approach to start a farm in the north sea.

Table 3.4 Costs of growing seaweed

Variables	Costs
Fixed costs (€/ha)	€ 18.594,00
Labor costs (€/ha)	€ 418,00
Harvesting and transport costs (€/ha)	€ 2.860,00
Material costs (€/ha)	€ 13.800,00
Maintenance costs (€/ha)	€ 690,00
Insurance costs (€/ha)	€ 700,00

Total costs of production	**€ 37.062,00**

SQ2 : What are the estimated incomes of selling these four plants ?

Andre Jurrius is investing in new ways to add value to the beans but, currently has a neighbor who buys the product to cover the costs. One of the ways to add value is together with the vegetarian butcher who is using the beans in products which can substitute meat in daily nutritional needs for humans as mentioned in the introduction. The gross revenue of selling the lupine beans are showed in table 3.6.

Table 3.6 Gross revenue lupine

Variables	Income
Beans yield (t/ha dm)	3.4
Sale price of beans	€ 210.00
Revenue from beans	€ 714.00
Subsidy from EU (€/ha)	€ 375.00
Total revenue	**€ 1089,00**

The interviewed company, Hempflax also does its own research on using of the end product. The company does not only grow the plants but also makes building material and animal bedding of the straw. The seed with the high protein content is dried and sold as protein powder used by vegans and athletes. The gross revenue of growing hemp are shown in table 3.7. These prices are based on the value of the products straight of the field with no extra treatment to add value.

Table 3.7 Gross revenue hemp

Variables	Income
Straw yield (t/ha)	7
Seed yield (t/ha)	0.8
Sale price of straw	€ 122.00
sale price of seed	€ 313.33
Revenue from straw	€ 854.00
Revenue from seed	€ 250.66
Subsidy from EU	€ 375.00
Total revenue	**€ 1479,66**

The company Ecoferm is using the duckweed in their own farm and therefore the revenue is based on the worth of the protein content and the product which it replaces. The sale of duckweed for human consumption and its price is not set since small amounts can be found all around the Netherlands. The expected gross revenue is showed in in table 3.8.

Table 3.8 Gross revenue duckweed

Variables	Income
Duckweed yield (t/ha)	9
sale price of duckweed	€ 250.00
Total revenue	**€ 2250,00**

The gross revenue of Seaweed is showed in table 3.9. The income is based on using half of the output for human consumption, which is sold for 950,- euro per ton. The other half is calculated to be used in animal feed at a price of 555,- euro per ton. Which gets an average price of 555,- euro per ton.

Table 3.9 Gross revenue seaweed

Variables	Income
Yield (t/ha)	20
Price (€/ha)	€ 555.00
Gross revenue	**€ 11.100,00**

SQ3 : Which of the four plants has the highest benefit cost ratio ?

The information of SQ1 and SQ2 is used to give an answer to SQ3. The answers of percentage of benefits compared to the costs are calculated as explained in the introduction. Table 3.10 shows which information is used and the out come of the benefit costs ratio.

Table 3.10

Variables	Lupine	Hemp	Duckweed	Seaweed
Costs (€/ha)	€ 871.00	€ 960.44	€ 1,479.66	€ 37,062.00
Benefits (€/ha)	€ 1,089.00	€ 1,479.66	€ 2,250.00	€ 11,100.00
Gross benefits	€ 218.00	€ 519.22	€ 770.34	€ -25,962.00
Benefits cost ratio	**1.25**	**1.54**	**1.52**	**0.30**

As can be seen in Table 3.10, the highest benefit cost ratio is Hemp with a ratio of 1.54. The second one is Duckweed with a difference is 0.02.

4. Discussion of results

In this chapter the results of the gathered financial data from the interviews is discussed. With this data an entrepreneur can gain knowledge about the financial aspect of growing one of the chosen plants. The plants that are chosen all have a high protein contents as can be found in the introduction. The purpose of having a plant with a high protein contents is because of the increase awareness of impact of the imported soy to the Netherlands. The supporting literature review can be found in chapter 1. All of the financial data which is gathered are estimates, since these are all four plants who grow are influenced by natural factors. An example of a factor, can be influence of the weather, if a long period of drought occurs extra cost can occur to spray water on the crops. These factors should be considered by the entrepreneurs when looking at the results.

Lupine

The interviewed farmer for the lupines is farming organic and not conventional. For the research the ideal situation would be to look at a conventional way of growing lupines. The conventional farms can only use a small amount of pesticides until the lupines grows out of the ground. When the plant is visible the conventional farmers cannot use pesticides anymore. This difference will result in a possible higher yield than the interviewed farmer. The farmer uses bumblebees to stimulate the pollination to gain yield. The costs of the bumblebees are considered in the financial data and the farmer indicated that this the use of the bumblebees increased the yield by 10%. The lupines are grown on heavy clay ground and leave a surplus of nitrogen in the ground after harvesting. This can also be a benefit when considering of growing this plant, but cannot be put in numbers. The crop is grown for research purposes and not a crop which is expected to gain the best income possible. This results in a benefits cost ratio of 1.25.

Hemp

The company Hempflax has years of experience and has 2500 hectares of hemp in use. Of the 2500 hectares 700 are in the Netherlands those are considered in the financial data. The company has developed a special harvester to harvest the flower and the stem with one machine. This machine is now for sale in cooperation John Deere but not everyone who starts with hemp has access to either a new machine or to hire a contractor who has a harvester which can harvest both. No pesticides are used for growing the hemp. Only fertilizer is used before planting the hemp seeds. This hemp harvest has resulted in a benefit cost ratio of 1.54.

Duckweed

The ecoferm farm, which is growing the duckweed has two location of growing duckweed. One was on top of a calf breeding barn for 1200 calves. The farm wants to make a closed circular system on its farm by feeding the duckweed to the calves and used the manure of the calves to feed the duckweed. The other location was in an outside pool. Because the first location is an unique setup and it is not likely that other entrepreneurs are considering growing duckweed in this way, the second location is used for the financial data for this research. The farmers is likely to know more about duckweed that the average entrepreneur who just has an outside pool this could result in a lower yield than showed in this research. The benefit cost ratio for growing duckweed is 1.52.

Seaweed

The project which Koen van Zwam referred to is a government project to research the feasibility of growing seaweed in the north sea. The project was partly financed by companies who researched possible markets for seaweed. The benefit cost ratio for growing seaweed in the north sea is 0.30.

Methodology

The chosen methodology is experienced as narrow because a lot of factor are not considered when using only financial data. When looking back the methodology should be more elaborate to give the reader a better an idea of growing a plant high in protein. This was not added in this research to avoid a research which would require more a horticulture study instead of a food business study. This is why this research only contains financial data and no information about the study of how to grow the plant in the most efficient way.

5. Conclusions and recommendations

In this chapter, the conclusion and the recommendations are given. First the conclusion per sub question are given followed by the main question. Followed by a recommendation

Conclusion

The aim of this research was to find a crop which is financially interesting for entrepreneurs and high in protein content. The long term goal is to reduce the import of the Dutch import of soy because of its high protein content. This research has focused on four plants which can be grown in the Netherlands and have a high protein content. To show the crop is interesting to grow in the Netherlands the benefit cost ratio is shown. This ratio gives the reader an idea on the financial benefit of the crop. To come to the ratio, first the costs are being researched. This was done by sub question 1 and resulted in the costs for growing lupine are 871,- euro and for hemp 960,44 euro and for duckweed 1479,66 euro and for as last Seaweed 37.062,- euro. This shows that the investment for growing seaweed requires a lot of financial input at forehand. These costs are from the buying the seed till harvesting the crops. The second part to answer the benefit costs ratio are the benefits of each crop. This is done by sub question 2 and resulted in the benefits for lupines at 1089,- euro and for hemp at 1479,66 euro and for duckweed at 2250,- euro and as last for seaweed at 11.100,- euro. These benefits consist of income of selling of the yield together with the EU subsidy on the fields. This brings it to the main question which is, Which of the four plants has the highest benefit cost ration ? This ratio is showing how much of the investment is coming back to the entrepreneur when growing this crop. The crop which has the highest benefit cost ratio is the crop hemp. This crop has a ratio of 1.54, which indicates that each euro put into the costs is coming back times 1,54. So this would mean 54% profit. The crop with the second benefit costs ratio is the duckweed with a ratio of 1,52. The third crop is the lupine with a ratio of 1,25. The last and not profitable crop is Seaweed with a ratio of 0,30. From this last one we can conclude that growing this crop costs more money than it would make in the end. The research used for this information also indicates that till there is a way to add value to seaweed as an end product the growing of it would make no sense.

Recommendation

It is recommended that the entrepreneurs who are looking for new ways to grow proteins in the Netherlands to look at Hemp and Duckweed. The entrepreneur should considered that there is a lot of difference in growing each crop. The entrepreneur should do research in this difference and can look at its own situation and should look which suits the best to them to grow. Another factor can be the end product which are both high in protein but are different in composition. Like mentioned before hemp is mostly sold as dried protein powder while duckweed is used in salads. This would require a different approach of the entrepreneur when looking for buyers.

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Appendix A

Monday 8 December 2014

EDIBLE SEAWEEDS – REGULATORY (as of II/2014)

1. THE FOLLOWING EDIBLE SEAWEEDS AND MICROALGAE ARE LISTED AS NOT NOVEL IN THE EU NOVEL FOODS CATALOGUE

- *Ascophyllum nodosum* (also listed as *Fucus nodosus* and *A. laevigata*) - European
- *Eisenia bicyclis* - SE Asian
- *Fucus vesiculosus* - European
- *Hizikia fusiforme* - SE Asian
- *Laminaria digitata* - European
- *Laminaria longicruris*- European
- *Palmaria palmata* (listed as *Rhodymenia palmata*) – supplement use only
- Porphyra *tenera* – SE Asian
- *Saccharina japonica* (formerly *Laminaria japonica*) – SE Asian
- *Saccharina latissima* (formerly *Laminaria saccharina)* - European
- *Undaria pinnatifida*- European & SE Asian
- Microalga *Chlorella pyrenoidosa* (also listed as *C. luteovirids, C. vulgaris*)

Further details are given below page 3

2. THE FOLLOWING SEAWEEDS AND MICROALGAE ARE LISTED AS SAFE FOR CONSUMPTION UNDER THE FRENCH GUIDELINES

See appended documents – réglementation algues MAJ 2014.pdf / seaweed & regulation 2014 (English version)

1. SEAWEEDS LISTED AS NOT NOVEL IN EU NOVEL FOODS CATALOGUE

http://ec.europa.eu/food/food/biotechnology/novelfood/nfnetweb/mod_search/index.cfm?action=mod_search.details&seqfce=560

Macroalgae

***Ascophyllum nodosum* (also listed as *Fucus nodosus* and *A. laevigata*) -**

European

***Eisenia bicyclis* - SE Asian**

***Fucus vesiculosus* - European**

***Hizikia fusiforme* - SE Asian**

***Laminaria digitata* - European**

***Laminaria longicruris*- European**

***Palmaria palmata* (listed as *Rhodymenia palmata*)**

Porphyra *tenera* – SE Asian

***Saccharina japonica* (formerly *Laminaria japonica*) – SE Asian**

***Saccharina latissima* (formerly *Laminaria saccharina)* - European**

***Undaria pinnatifida*- European & SE Asian**

Microalgae

***Chlorella pyrenoidosa* (also listed as *C. luteovirids, C. vulgaris*)**

Marine plants

***Salicornia europea* - Samphire**

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Appendix B

The brief outline of the interview questions can be found below.

What was the reason to grow this crop ?

What is the area(ha) you use to grow this crop ?

Which possibilities did you consider?

How long ago was the decision made that this crop is going to be grown ?

Has the crop been a financial success so far ?, if not, what difficulties did you face ?

Is anything done to add extra value to the crop or end product ? Such as labeling as superfood or organic ?

For SQ1 the questions are:

Which costs do you have when growing the crop ?

Dependent on the answer and the crop Table 2.2 will be used to see if the listed expected costs are already given, or they are asked separately.

For SQ2 the questions are:

What are the financial benefits of growing this crop ?

Dependent on the answer and the crop Table 2.3 will be used to see if the listed expected benefits are already given, or they are asked separately.

Appendix C

Interview met kees kroes over de telefoon (29 augustus 2018)

Begin gesprek:

Jan : goedendag mijn naam is Jan Jetze de Vries. Ik ben student aan de Aeres hogeschool in Dronten en doe een onderzoek naar de kosten en opbrengsten van eendenkroos en ik wou vragen of u me daarbij kan helpen.

Kees : goedendag Kees Kroes van Ecoferm. Ja ik heb een tweejarig project gedraaid op mijn bedrijf over eendenkroos en dit onderzoek mag je wel gebruiken. Het onderzoek is gesloten in maart 2016 en de cijfers daarna deel ik liever niet. Als je een mail adres hebt mail ik heb naar je toe en als er nog vragen zijn kun je me nog altijd op bellen maar eigenlijk staat hierin wel alles wat je nodig hebt.

Jan : Ok bedankt , mijn mail adres is janjetze@gmail.com. Zijn er in tussen veel dingen veranderd anders dan wat erin staat.

Kees: ja de we doen nog continue aanpassingen maar momenteel is de zomer te warm dus het eendenkroos is wat lastig om op temperatuur te krijgen dit jaar.

Jan : ok nogmaals bedankt ik zal het inkijken en als ik vragen heb hoort u het wel.

Kees : houdoe.

Jan: tot ziens

Appendix D

Interview Hempflax met Eelkje Oldenburger

Begin interview

Jan : welke producten maken jullie zoal van de hempvezel ?

Eelkje: wij gebruiken de hele plant voor diverse doeleinden. De bloem worden verkocht voor de CBD olie. De stengel drogen we zelf en word gebruikt als isolatie materiaal en als vervanger voor stro en katoen. De wortel word momenteel nog in het veld gelaten voor verbetering van de bodem kwaliteit. We hebben sterke aanwijzingen dat de wortel gebruikt kan worden in de farmaceutische industrie maar dat onderzoek loopt nog.

Jan: Hoe oogsten jullie de bloem apart van de plant ?

Eelkje: Hempflax heeft in samenwerking met John Deere een oogstmachine ontwikkeld waar twee rooiers op zitten. Deze oogsten op verschillende hoogtes waardoor de top (wat de bloem is) en de stengel apart van elkaar gehouden worden. Daarvan hebben we nu twee, één rijd in Nederland en Duitsland en één op onze locatie in Roemenië.

Jan: hoeveel hectare hempvezel heeft Hempflax momenteel ?

Eelkje: In totaal hadden we in het seizoen van 2017 ongeveer 2500 hectare hemp staan.

Jan: Wat zijn de kosten voor het groeien van hemp? en dan is het denk ik het makkelijkst om alleen te kijken naar wat er in Nederland verbouwt word.

Eelkje: Ik heb me een beetje voorbereid op de vraag dus ik heb een kort overzicht gemaakt van de kosten die we hebben per hectare hemp in Nederland en deze heb ik in een tabel gezet. (gegevens liggen op een papier op tafel en zijn in het interview ingevoegd)

		Totaal
kunstmest kosten (€/ha)	€ 137.33	
kosten voor zaden (€/ha)	€ 111.30	
overige plant (€/ha)	€ 2.00	
variable kosten (€/ha)	€ 32.00	
totaal plant kosten (€/ha)	€ 282.63	
oogst kosten(€/ha)	€ 113.00	
Bloem scheiden van blaadjes (€/ha)	€ 36.30	
Stengel in balen (€/ha)	€ 214.00	
transport kosten (€/ha)	€ 90.76	
totale oogst kosten (€/ha)	€ 454.06	
vaste machine kosten (€/ha)	€ 124.75	
Man uur (€/ha)	€ 99.00	
totale kosten (€/ha)		€ 960.44

Jan: Ik zie dat je de opbrengst en het totaal er ook in hebt gezet.

Eelkje: ja klopt de inkomen zijn deze:

inkomen		Totaal
opbrengst stengel (t/ha)	7	
bloem opbrengst (t/ha)	0.8	

verkoop prijs de stengel	€ 122.00	
verkoop prijs van de bloem	€ 313.33	
brutto winst stengel	€ 854.00	
brutto winst van de bloem	€ 250.66	
Totale brutto winst		€ 1,104.66

En de brutto netto zijn :

netto/brutto		Totaal
totale brutto winst	€ 1,104.66	
EU steun	€ 375.00	
totale kosten (€/ha)	€ 960.44	
netto winst		€ 519.22

Dit is allemaal een ruige schatting van afgelopen jaar de precieze kosten en opbrengsten kan ik niet met je delen.

Jan: Dat is prima hier kan ik prima mee werken. Wat verwachten jullie dat de EU steun gaat doen vanaf 2020 ?

Eelkje: er komt een kleine daaling van 8 tot 10% maar dit is niet heel erg en ze veranderen de regels vaak dus we verwachten dramatische gevolgen.

Jan: ok nou bedankt voor het interview.

Eelkje: graag gedaan.

Einde interview

Appendix E

Interview lupine met Andre Jurrius van eco boerderij de Lingehof (31 augustus 2018)

Begin interview

Jan : Welke soorten lupines heb je momenteel staan ?

Andre : Ik teel tot nu toe de blauwe en de gele lupines deze passen het beste bij het Nederlandse klimaat.

Jan : Heb je problemen met ziektes doordat je biologisch bent met en niet mag bestrijden net als conventionele bedrijven.

Andre : Nee, door te eggen kan ik de het onkruid en de ziekte groei beperken tot minimaal. Uiteraard hou zijn de planten wel heel vatbaar voor ziektes maar door goed bodemleven te creeren kan de plant op natuurlijke wijze weerstand opbouwen.

Jan :Ik las dat je twaalf gewassen hebt is de lupine een gewas wat je voor de winst verbouwd of voor andere redenen.

Andre : De lupines zij puur voor de afwisseling en vernieuwing maar het heeft wel voordelen bij de gewas rotering omdat het stikstof achterlaat in de bodem wat ik voor het volgende gewas weer kan gebruiken.

Jan : Kunnen we eens kijken naar de kosten en baten van de teelt voor het financiele gedeelte van het onderzoek ?

Andre : Ja, prima om te beginnen koop ik zaden welke van de beste kwaliteit zijn en de minste zaden zijn eruit gehaald dat kost 190 euro per hectare. Ploegen is 110 en het zaden zelf is 76 dan het eggen nog voor 75 euro. Tijdens het groei seizoen ben ik nog ongeveer 200 euro per hectare kwijt aan hommels en andere dingen om de plant weerstand te geven.

Jan : Wat doen die hommels ?

Andre : Hommels zijn iets zwaarden dan de honingbijen. De hommels gaan op de bloem zitten om hem open te krijgen en dan komt het stuifmeel op hun lijf en zo doen zij de bestuiving van plant op plant. Dit is zeer belangrijk anders komt de lupine boon niet aan de plant. ik heb hier samen met een leerling van Wageningen onderzoek naar gedaan en dit vergroot de opbrengst.

Jan : Hoeveel komt er van een hectare en hoeveel verschil zit er dan in sinds je de hommels gebruikt?

Andre : Ik haal nu ongeveer 3,4 ton van een hectare en dit was ongeveer 3.

Jan : Deze gaan nog niet allemaal naar de vegetarische slager neem ik aan ?

Andre : Nee, een klein gedeelte word daarin gebruikt en momenteel word er nog wat gebruikt voor ontwikkeling van nieuwe producten. Maar de grootste afnemer van mijn lupines is mijn buurman welke ze voert aan de koeien voor vervanging van de soja.

Jan : Hoeveel krijg je gemiddeld per ton ?

Andre : Dat verschilt wel per afnemer maar gemiddeld 210 euro de ton

Jan : En wat kost het oogsten ?

Andre : Dat kost 142 euro per hectare plus nog 29 euro voor transport.

Jan : Zijn dat alle kosten die erbij komen kijken ?

Andre : Nee, ik moet nog een keer met de cultivator over het land na de tijd dat kost 49 euro per hectare.

Jan : Ontvang je als biologische boer ook meer subsidie per hectare of is dat gewoon 375 euro per hectare ?

Andre : Nee, wij krijgen idd 375 euro per hectare.

Jan : Ok, nou volgens heb ik dan alles wat ik nodig heb voor het onderzoek, bedankt!

Andre : Geen dank, succes ermee.

Appendix F

Interview Koen van Zwam, initiatiefnemer Zeewierboerderij

Interviewer: Jan Jetze de Vries

Begin interview:

Jan : Wat was jou motivatie om aan dit project te werken ?

Koen : Na mij studie in Noorwegen over de carbon footprint kwam ik erachter dat zeewier een product is met een enorme potentie. We hebben meer eten nodig in de toekomst en tot nu toe halen we het meeste uit de grond terwijl het grootste deel van de aarde uit water bestaat.

Jan : Hoe is het project begonnen ?

Koen : Ik ben in 2014 met een crowdfunding begonnen voor een start kapitaal van 10.000 euro. Vanuit daar zijn we gestart en langzaam maar zeker groter geworden.

Jan : Was die 10.000 genoeg om het financieel rond te krijgen?

Koen : Nee, de eerste paar jaar begonnen we klein en tot nu toe zitten we op 25 hectare zeewier en dit kan nog niet uit omdat het nog wel echt een onderzoek project is.

Jan : Wat is het uiteindelijke idee om op te zetten ?

Koen : We hebben een plan geschreven om een zeewier boerderij op te zetten van 25.000 hectare met windmolens erin

Jan : Dat is omdat het met zo´n massa uit kan of gewoon om efficiency te verhogen ?

Koen : Dit is inderdaad om efficiency te verhogen maar, zoals de vraag en de prijs nu is kan het dan nog steeds niet uit. Eigenlijk moeten de prijzen nog 6x hoger van het zeewier, omdat de vraag nu ook nog klein is is de prijs ook niet wat we in gedachten hebben. Dit willen we vergroten door de bedrijven waar we mee samen werken. Zij werken aan onderzoeken om eindproducten waarde te geven. Hierbij kun je denken aan een veevoerbedrijf die de zeewier droogt en in een brok levert aan melkveehouders. Door de hoge eiwitten en andere nutritionele voordelen voor koeien kan deze brok meer waard zijn dan een product voor menselijke voeding. Maar ook kruiden fabrieken werken aan ideeën om zeewier meer waarde te geven.

Jan : Zouden we naar het plan kunnen kijken ik ben wel benieuwd naar de cijfers die jullie hebben gebruikt ?

Koen : Ja, we kunnen even een kijkje nemen het plan heet : The economic feasability of seaweed production in the northsea. Het is geschreven op basis van de gegevens die we tot nu toe hebben en dit kan ik met je delen. De cijfers tot nu toe kan ik niet met je delen in verband met geheimhoudingsplicht naar de investeerders.

Jan : Ok dan gebruiken we deze cijfers dan kunnen we de potentie in ieder geval in kaart brengen voor de ondernemers

Koen : Alle input en output staat al in tabel 2. Dus dan kun je die in principe op splitsen.

Jan : Hier staat inderdaad dat de opbrengsten veel lager zijn dan de opbrengsten is dat niet een heel groot probleem voor de haalbaarheid.

Koen : Ja klopt maar het project gaat ook pas in uitvoering als de opbrengsten enigszins in de buurt komen van de opbrengsten. Tot die tijd proberen wij de opbrengst te verhogen en de samenwerkende bedrijven om een markt te vinden waar het product meer waarde geeft.

Jan : Ok nou bedankt voor de samenwerking ik denk dat deze cijfers voldoende zijn en dat ik hiermee wel een beeld heb gekregen van de zeewier teelt.

Koen : Geen dank, als er vragen zijn kun je me nog altijd mailen.

Einde interview.