Sustainable Cannabis Aquaponics Production in Uruguay

by

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Last but not least, I would like to thank my family for their unconditional support.

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Executive Summary

This document describes a research thesis project carried out as a requirement to achieve Deakin University's Master of Sustainability. The subject matter of this research thesis is the application of aquaponics in the industrial production of cannabis for pharmaceutical purposes, with a firm intention to achieve a fully sustainable production.

This aquaponics system allows the use of fish waste as nutrients for plants, which in this process purify the water to be pumped back again to the fish tanks. The main product of this process is pharmaceutical CBD isolate, and the fish species selected for the aquaponics system is barramundi.

First, the document provides a brief introduction to the main research topics, which are medicinal cannabis and aquaponics, followed by a brief background of the project, explaining how it was originally conceived, and a detailed section regarding the research methodology I followed during the whole process.

Chapter 2 offers the reader a thorough analysis of the current situation with cannabis, aquaculture and aquaponics, with special emphasis on the current international, regional and national situation with cannabis. The most important regulatory framework is then outlined.

Chapter 3 focuses on a more in-depth analysis on all of these topics, with decisions being made on this particular project. These decisions include establishing this project in a special trade zone in southern Uruguay called *Zona Franca Florida* and specific production issues.

Chapter 4 focuses on economic and financial issues, determining running costs and an initial investment of almost USD 10 million. The cash flow prepared for the project is based on all the data and information gathered during the research period, calculating extremely attractive profitability indexes and a very short repayment period.

Chapter 5 presents the main conclusions reached.

Glossary

- ANII (*Agencia Nacional de Investigación e Innovación*): Uruguayan National Research and Innovation Agency
- API: Active Pharmaceutical Ingredient
- AUDER (*Asociación Uruguaya de Energías Renovables*): Uruguayan National Association of Renewable Energies
- BCU (Banco Central del Uruguay): Central Bank of Uruguay
- BIPV: Building Integrated Photovoltaics
- BPS (*Banco de Previsión Social*): Uruguayan Social Security Administration
- CBD: cannabidiol, one of cannabis' most important compounds
- CCRF: Code of Conduct for Responsible Fisheries
- CECAM (*Cámara de Empresas de Cannabis Medicinal*): Chamber of Medical Cannabis Companies of Uruguay
- DFT: Deep Flow Technique (hydroponics)
- DGI (*Dirección General Impositiva*): Uruguayan General Revenue Service
- DGSA (*Dirección General de Servicios Agrícolas*): Uruguayan National Directorate of Agricultural Services, depending on the Ministry of Livestock, Agriculture and Fisheries (MGAP)
- DINARA (*Dirección Nacional de Recursos Acuáticos*): Uruguayan National Directorate of Water Resources, depending on the Ministry of Livestock, Agriculture and Fisheries (MGAP)
- DNA (*Dirección Nacional de Aduanas*): Uruguayan National Customs Directorate
- EAA: Ecosystem Approach to Aquaculture
- EXW: Ex Works; an international trade incoterm describing a price condition which indicates that the seller offers the goods available at its own premises, the buyer being responsible for export and import procedures, shipping, insurances, etc.
- FAO: The Food and Agriculture Organization of the United Nations.
- FCR: Feed Conversion Ratio; "*Kg fish produced per kg feed*" (Fore et al. 2017)
- FTZ: Free Trade Zone (Uruguayan "*zona franca*" regime)

- GAP: Good Agricultural Practice
- GMP: Good Manufacturing Practice; international guidelines for an organization, especially in the pharmaceutical and food processing industries, in order to manufacture standardized products
- HACCP: Hazard Analysis and Critical Control Points
- HR: Human Resources
- HPLC: High-Performance Liquid Chromatography
- IQF: "*Instant Quick Frozen*", a production technique in the food industry which requires the product to be directed through a freezing tunnel under extreme low temperatures, so it freezes in a very short time. Even though it has many advantages, mainly concerning the final product presentation and ease of use, it is a highly energy-demanding technique.
- INA: Instant Nutrients Analysis
- INASE (*Instituto Nacional de Semillas*): Uruguayan National Institute for Seeds
- INCB: International Narcotics Control Board "*is the independent and quasi-judicial monitoring body for the implementation of the United Nations international drug control conventions*" [1].
- INIA (*Instituto Nacional de Investigación Agropecuaria*): Uruguayan National Institute for the Research on Agriculture
- IRCCA (*Instituto de Regulación y Control del Cannabis*): Uruguayan Institute for the Regulation and Control of Cannabis
- IRR: Internal Rate of Return
- ISA: Instant salinity analysis
- ISO: International Organization for Standardization
- JND (*Junta Nacional de Drogas*): Uruguayan National Drug Council
- MEF (*Ministerio de Economía y Finanzas*): Uruguayan Ministry of Economy and Finance
- MGAP (*Ministerio de Ganadería, Agricultura y Pesca*): Uruguayan Ministry of Livestock, Agriculture and Fisheries

[1] http://www.incb.org/

- MSP (*Ministerio de Salud Pública*): Uruguayan Ministry of Public Health
- MTSS (*Ministerio de Trabajo y Seguridad Social*): Uruguayan Ministry of Labour and Social Security
- NFT: Nutrient Film Technique (hydroponics)
- NPV: Net Present Value
- OECD: Organisation for Economic Co-operation and Development
- OHSAS: Occupational Health and Safety Assessment Series
- OSE (*Obras Sanitarias del Estado*): State Sanitary Works Administration.
- PV: Photovoltaic
- RAS; Recirculating Aquaculture System: "*describe intensive fish production systems which use a series of water treatment steps to depurate the fish-rearing water and facilitate its reuse.*" (Espinal et al. 2019)
- RNC (*Registro Nacional de Comercio*): Uruguayan National Registry of Commerce
- ROI: Return on Investment
- RUO (*Registro Único de Operadores*): Centralized register for organizations and people working in the Uruguayan non-psychoactive cannabis industry
- SENACLAFT (*Secretaría Nacional para la Lucha contra el Lavado de Activos y el Financiamiento del Terrorismo*): Uruguayan National Secretariat for the Fight Against Money Laundering and the Financing of Terrorism
- SQFT: Square feet
- SQMT: Square metres
- THC: tetrahydrocannabinol, one of cannabis' most important compounds
- UCUDAL (*Universidad Católica del Uruguay – Dámaso Antonio Larrañaga*): Catholic University of Uruguay.
- USD: United States Dollars
- Uruguay XXI; Investment, Export and Country Brand Promotion Agency: "*the (Uruguayan) agency responsible for the promotion of exports, investments and country image*" (Uruguay XXI[2])

[2] https://www.uruguayxxi.gub.uy/en/

- UTE (*Administración Nacional de Usinas y Trasmisiones Eléctricas*): Uruguayan Electrical Power Utility
- UYU: Uruguayan Pesos
- VAT: Value Added Tax

Relevant Definitions and Concepts

- Aeroponics: a technology to grow vegetables and fruits, highly energy dependent, which uses no soil but a mist environment in order to transmit water and nutrients directly to the roots.
- Aquaculture: the activity of rearing aquatic animals, mainly fish.
- Aquaponics: the combination of aquaculture and hydroponics working together in a recirculating close-loop system aiming to achieve synergies.
- Cannabinoids: a group of many different compounds present in cannabis.
- Cannabis/Marihuana: A flowering plant of the *Cannabaceae* family.
- Cannabis growing methods: extensive agriculture (Outdoors), in greenhouses or inside buildings (Indoors)
- Fish farming: the activity of rearing fish, involving many different methods and techniques in an extensive, semi-intensive or intensive basis.
- Glazing: in the food processing industry, glazing is the application of a thin layer of ice to the product in order to protect it from the production process, storage and transport.
- Hemp: non-psychoactive cannabis. In Uruguay, cannabis is considered non-psychoactive with less than 1% THC, while in the United States and the European Union this ratio goes down to 0.3% and 0.2% respectively.
- Hydroponics: a technology used to grow plants without any soil, but only water and nutrients. It can include the use of substrates such as sand, coconut fibres or others.
- Transfer pricing: accounting methods to determine the right price for goods and services sold between two or more companies controlled by the same entity.
- *Zona franca / Uruguayan Free Trade Zone regimen*: A special economic zone in Uruguay, where companies can work with special tax benefits under certain circumstances.

1. Introduction

This first chapter serves the reader as an introduction to the most important topics of this research thesis, and explains the main concepts related to this project, id est., non-psychoactive cannabis and aquaponics.

A brief introduction to cannabis and aquaponics is at first presented, followed by a comprehensive literature review on both topics. This literature review, based chiefly on scholarly research papers, covers different aspects related to cannabis, such as regulatory, commercial and technical issues. It focuses later on aquaponics, explaining the perspective of different researchers on this technology and describing different experiences, research results and experts' opinions.

The whole background of this project, which started in Australia in 2018, is explained in section 1.4, followed by a complete explanation of the research methodology and the resources used during the development of this research undertaking.

1.1 Cannabis

The use of cannabis for medical purposes has a long history, with written records of medicinal cannabis dating back over 5,000 years to ancient China and Greece (Washer 2017). This crop was largely used in this way for most of the 20th century, until being internationally banned in the early 1970s (Chandra 2017).

In the recent years, the world has seen legalization processes in many countries, mainly for growing and production of medicinal cannabis, but also for fibres and with recreational purposes. "*Uruguay is the only country where regulations currently permit the cultivation of CBD-rich hemp on a commercial scale, allowing licensed producers to grow hemp with THC concentrations of up to 1%, providing a significant yield advantage over global competitors*." (Aurora / ICC Labs 2018)[3].

"Uruguay in December 2013 became the first country in the world to legalize a national cannabis market from growing to purchase for personal use, and the government later legalized the export of medical marijuana products to countries where it is legal, a move that has brought a wave of investment. Colombia, which has decriminalized pot use, legalized medical marijuana products." (The Associated Press 2019)[4].

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[3] https://www.marketwatch.com/story/cannabis-stocks-boosted-by-auroras-acquisition-of-uruguay-based-icc-labs-2018-09-10

[4] https://federalnewsnetwork.com/government-news/2019/04/2-firms-first-to-export-latam-medicinal-marijuana-to-europe/

Uruguay’s first and foremost intention when legalizing cannabis was to fight the growing illegal drug trade, so the initial focus was on recreational cannabis (this study will not look into this topic). It soon started to be clear that medicinal cannabis could be a new and attractive market, with great potential to create large numbers of job positions and a new income flow to the country.

I believe the focus of the new legislation turned to medicinal cannabis mainly in response to this growing interest and large national and foreign investments.

This project intends to seize this Uruguayan competitive advantage, growing cannabis with medicinal purposes and adding the innovation and sustainability of aquaponics. Being the cannabis growing industry such an environmentally unfriendly sector, largely due to excessive energy requirements (Ruby 2018), I expect that the addition of aquaponics and renewable energies will make it a sustainable and profitable undertaking.

1.2 Aquaponics

As previously stated, aquaponics combines hydroponics and aquaculture. Crops are grown in a hydroponic system and share the same water environment with fish growing. In this process, water is carefully recirculated in order to achieve the best balance so that plants can purify the fish waste coming from the fish tanks while being fertilized by the same waste.

Albeit a very old technique used for many centuries, industrial aquaponics is completely different from “traditional aquaponics”. The following drawing depicts what could be a “regular” aquaponics system:

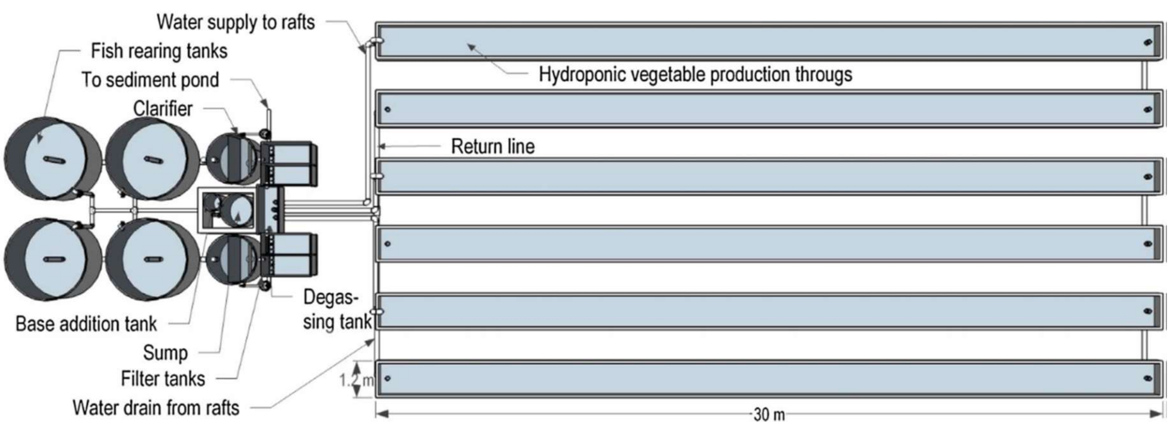

Figure 1.1 Basic Aquaponics System

Source: Bailey et al. 2017.

According to Bailey et al. (2017), this aquaponics layout consists "*…of three main components: fish rearing tanks, solids removal for water treatment (clarifier, filter tanks, degassing tank), and hydroponic vegetable production troughs. Water returns to a sump where base is added into the base addition tank*". According to other reviewed authors, these are indeed the main three components in an average aquaponics system.

The most important issue in an aquaponics system is choosing the best combination of plants and fish, while maintaining a permanent balance of the entire system in order to achieve maximum yields both for plants and fish (Petrea et al. 2016). Any unbalanced issue should be immediately adjusted in an aquaponics system, if it is to achieve interesting profitability indexes (Engle 2010).

Figure 1.2 Pure Ponics' Aquaponics System

Source: Pure Ponics 2017.

The picture above is from Pure Ponics, a company based in Geelong which started working with this aquaponics system in 2017 as a research project with Deakin University. According to Steve Gleeson (2018, *Personal communication*), the company's Director, the results were extremely positive, although Deakin University never had the chance to validate any results before the first trials ended by the end of 2017.

One of the main issues concerning this project was the determination of the most appropriate fish species for the aquaponics system. Pursuing perfect balances means establishing ways to balance the system in the event negative outcomes arise during its operation.

1.3 Literature Review

This literature review covers different topics related to cannabis growing in Uruguay using a specific technology: aquaponics. The complexity of this review lies in the fact that the success of such a project depends on many different issues, complex on their own, such as fish growing, cannabis growing, aquaponics, international commerce issues, etc.

I have reviewed the available literature on two main topics: cannabis and aquaponics, hydroponics and aquaculture. The first topic includes available literature on cannabis legalization status, markets and the growing industry in general. The second topic, while mainly covering aquaponics, also takes into account important issues related to hydroponics and aquaculture. These topics cover most of the necessary information and data that I needed in order to properly work on my research project.

Conclusions are finally reached, including in sections 6.1 and 6.3 a detailed list of references with the papers, articles and different news I have reviewed.

1.3.1 Cannabis

The first part of this literature review focuses mainly on the commercial and industrial sides of the medicinal cannabis industry. Other topics such as particular applications of cannabis byproducts or cannabis health benefits and other uses will not be addressed. Recreational cannabis is not considered either, mainly in view of the difficulty to obtain the required certifications and authorizations in Uruguay to grow cannabis for this purpose.

Legislation in different markets will be addressed only if somehow having an impact on this project.

"*The oldest known written record of medicinal cannabis use comes from the Chinese Emperor Shen Nung in 2727 BC, and the ancient Greeks and Romans were also familiar with the use of cannabis as a medicine*" (Washer, 2017). According to Chandra (2017), cannabis growing can be for recreational, medicinal or fibre purposes. Recreational cannabis is normally associated with high concentrations of THC (up to 20% w/w of the floral tissue), and medicinal cannabis is associated with CBD production (Chandra 2017). "*Thanks to human influence, as well as natural diversity, plants within the species differ widely in structure and appearance. Varieties grown for fiber are typically tall, unbranched, and grown to produce a high ratio of fibrous stem-to-floral material. Plants grown for fiber and seed are commonly referred to as hemp. Recreational users, however, desire female floral material, so "drug plants" have been selected and bred to produce a higher proportion of flowers.*" (Chandra 2017). According to the same author, natural resins in natural cannabis plants contain both THC and CBD in balanced proportions. However, as a result of human intervention certain species may have high concentrations of either of them.

Cannabis may be grown indoors or outdoors. Indoor agriculture can be highly intensive or not so intensive. It could be stated that in the case of cannabis for recreational or medicinal purposes, indoors growing would be preferred. On the other hand, cannabis growing for fibre purposes would be more convenient outdoors. After the harvest and in the case of medicinal cannabis, the plants are dried, milled and heated to obtain CBD (Chandra 2017).

"*In the United States, cannabis was common in patent medicines in the late 1800s and was listed in the US Pharmacopeia from the 1850s up until 1942, prescribed for various pain conditions and nausea. In 1899, cannabis was listed in the first edition of Merck's Manual and recommended for the management of several conditions including epilepsy. It also had some history of use as an intoxicant, but, in 1937, the Marihuana Tax Act made it illegal except for medical use, which was taxed. Those who produced, prescribed, or dispensed marijuana were required to buy a stamp and pay the tax. This requirement greatly restricted legal use of marijuana, and, gradually, in the mid-20th century, when the use of most crude botanical drugs in US medicine declined, cannabis medical use plummeted as well. Of course, illicit use continued, but no "dealers" for this purpose would buy the stamp and pay the tax, because doing so would incriminate themselves. This practice was a major basis on which the Marihuana Tax Act was ruled unconstitutional in 1969. In 1970, congress passed legislation that included marijuana on the "Schedule I" list with many other controlled substances, and it remains so to this date*."[5] (Chandra, 2017). "*In the UK in the late 19th and early 20th century, the use of cannabis as a medicine saw a similar rise and fall to that seen in the United States. Its use declined, however, and ceased when declared a Schedule I substance in 1971.*" (Chandra, 2017). Cannabis was also classified as a Schedule 1 drug by the International Narcotics Control Board in 1961, for being regarded as a drug with low medical value but high potential for abuse (Hakkarainen, 2015).

Many countries, as well as many US states, have experienced general legalization processes in the past few years. According to Ruby (2018), 29 US states have legalized cannabis for medical use and other 5 are undergoing this process, while 6 others are considering legalization of recreational cannabis (Sanders, 2018). California was the first state to do so in 1996. It is believed that legalization could go federal in the United States in 10 years time (Welch 2018). According to Abrams (2017), legalization at a federal level is almost inevitable.

There are further signs indicating that this process to complete cannabis legalization in the United States is on its way. The U.S. Food and Drug Administration (FDA) approved in June 2018 the first drug derived from marijuana, to treat severe forms of epilepsy[6]. Apart from that, industrial hemp (cannabis with up to 0.3% THC) has been legalized at a federal level

[5] This changed on 20 December 2018 after the "Farm Bill" removed cannabis from "Schedule 1" classification, no longer being a "Controlled substance": https://www.ams.usda.gov/sites/default/files/HempExecSumandLegalOpinion.pdf

[6] https://www.fda.gov/news-events/press-announcements/fda-approves-first-drug-comprised-active-ingredient-derived-marijuana-treat-rare-severe-forms

after the 2018 Farm Bill (USDA 2019[7]). Moreover, more states have legalized cannabis during 2019, so this tendency has been widely confirmed.

The regulated cannabis market has experienced continuous growth during the past few years, estimated to have reached USD 6.9 billion in 2016 and projected to climb to USD 21.6 billion by 2021 (Mihelich 2017). Both public and private investors in the United States have put USD 1 billion in this industry only from 2014 to 2017 (Mihelich 2017). Estimations indicate that if prohibitions came to an end, the market could grow up to USD 100 - 200 billion in the United States alone (Welch 2018). "*The production and consumption of cannabis for the treatment of medical conditions is of increasing importance internationally; however, research on different aspects of the phenomenon is still scarce*." (Hakkarainen 2015). According to Hakkarainen (2015), the interest in medicinal cannabis has increased immensely since the early 1990s. According to Washer (2017), 65% of patients use cannabis for chronic pain.

The cannabis growing industry requires high levels of light in order to achieve optimum yields (Chandra 2017). Therefore, cannabis growing is a highly energy demanding activity. According to Andrle (2017) and to Mills (2012), 1% of the electricity used in the United States is consumed by the cannabis industry. The production of 1 kilogram of final product implies 4,600 kilograms of carbon dioxide emissions, and comparing on a square-feet basis, a cannabis growing facility requires 4 times more energy than a hospital (Mills 2012). "*Along with high energy consumption, the cultivation of cannabis raises concerns about water consumption, pests and pesticide use, odor control, and waste generation*" (Ruby 2018).

However, the cannabis plant has incredible conditions to be grown in a sustainable way, mostly due to its highly root biomass (Amaducci 2008). According to Stickland (1995), cannabis is an ideal crop for organic agriculture. Renewable energies should be used in order to achieve energy self-sufficient facilities and move towards sustainable growing.

Mainly due to important international prohibitions, "*access to banking remains one of the biggest challenges many cannabis businesses face*" (McCarthy 2016). Many cannabis businesses in the United States suffer important disadvantages in terms of federal tax deductions, and "*It is relatively well known that many cannabis business owners end up paying their taxes in cash, literally carrying bags filled with currency to the office locations of municipal agencies because they are unable to open a bank account*" (McCarthy 2016). Being Uruguay such a small country, with an open economy and strong international financial connections, cannabis businesses in this country have been facing similar problems, which tend to be solved some way or another. There are currently no problems to operate such a business. This issue would be completely solved probably only upon global legalization of cannabis.

[7] https://www.ams.usda.gov/sites/default/files/HempExecSumandLegalOpinion.pdf

1.3.2 Aquaponics = Aquaculture + Hydroponics

Aquaponics is the combination of aquaculture and hydroponics working together in a recirculating close-loop system aiming to achieve synergies. The main input of an aquaponics system is the feeding of the fish, as the nutrients the plants need to grow come from the metabolism of food by the fish (Filep et al. 2016). Plants consume some of these nutrients, and in this process they filter the water in the system (Love et al. 2015). "*A mutual benefit is created*" (König et al. 2018). The main objective of aquaponics is the minimization of both the inputs and the pollution created by the system, while maximizing efficiency, revenues and profitability.

The Food and Agriculture Organization of the United Nations (FAO) classifies aquaponics as "*Climate-smart agriculture*", mainly due to the fact that it promotes sustainability and productivity, mitigating the impact of climate change. "*Climate-smart agriculture (CSA) – which includes aquaculture and aquaponics – is starting to be used to help develop the technical, policy and investment conditions needed to achieve sustainable agricultural development for food security under climate change (FAO, 2017r, 2017s). CSA entails simultaneous attention to increasing productivity, mitigating climate change and adapting to it. It is thus starting to serve as an alternative and innovative approach for increasing aquaculture production while avoiding adverse impact on sustainability. The challenge is to implement climate-smart aquaculture in accordance with CCRF*[8] *and EAA*[9] *in order to address the three interlinked economic, environmental and social dimensions of sustainability.*" (FAO 2018)

"*The technology is still in its infancy, with many challenges*" (König et al. 2018). The first peer reviewed paper on aquaponics was published in 1981 (Rakocy et al., 1981), and the development of research on aquaponics in Europe started in the 2000s. Figure 1.3 shows the number of research papers published on aquaponics from 1980 to date compared to the number of papers published on RAS[10] and on hydroponics. It is clear that aquaponics does not attract much attention from the scientific field.

According to a survey carried out by Villarroel et al. (2016), most of the current aquaponics European entities are research centres, 74.5% of the facilities were developed after 2010, and aquaponics was not the main source of income for 80.4% of the surveyed. Together with the fact that most organizations behind aquaponics are universities, Villarroel et al. concluded that this technology is in an early stage of development in Europe.

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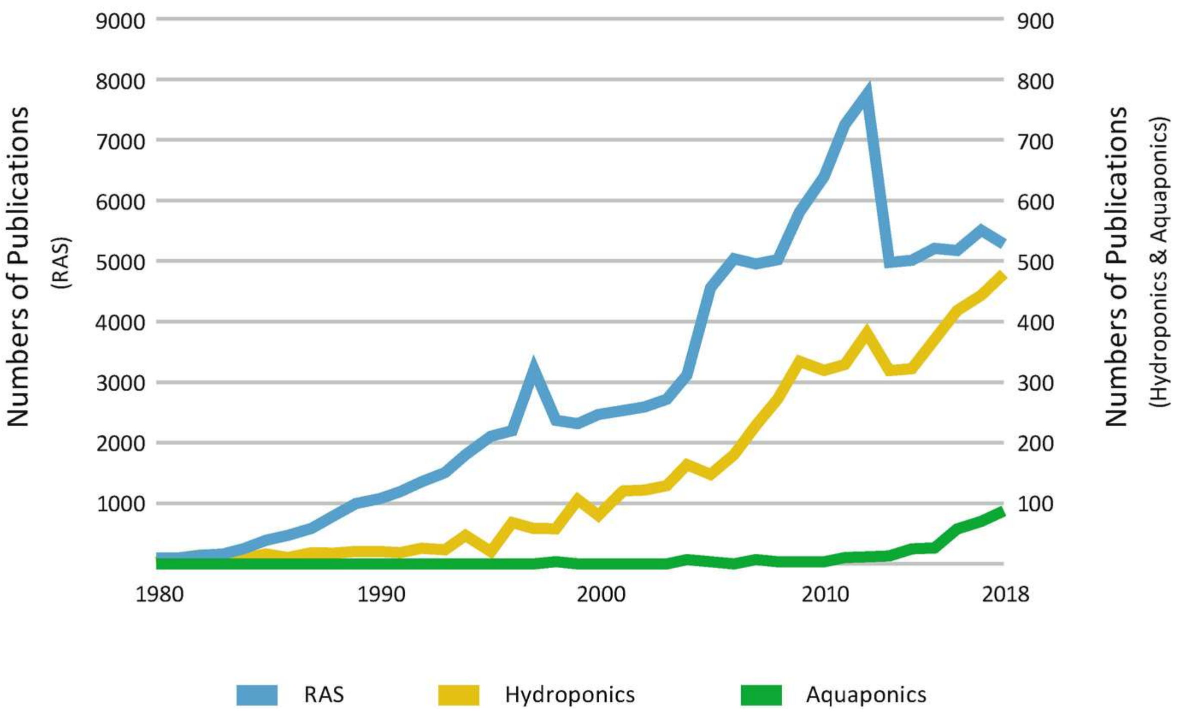
[8] Code of Conduct for Responsible Fisheries (FAO 2018).
[9] Ecosystem Approach to Aquaculture (FAO 2018).
[10] RAS stands for Recirculating aquaculture systems.



"The number of papers published on 'hydroponics', 'RAS' and 'aquaponics' from 1980 to 2018 (data were collected from the Scopus database on 30 January 2019). Please note that the scale for 'RAS' is one order of magnitude higher than that for 'hydroponics' and 'aquaponics'" (Goddek et al. 2019)

Figure 1.3 Number of research papers published on "RAS", Hydroponics and Aquaponics (1980-2018)

Source: Goddek S., Joyce A., Kotzen B., Dos-Santos M. (2019) Aquaponics and Global Food Challenges. In: Goddek S., Joyce A., Kotzen B., Burnell G. (eds) Aquaponics Food Production Systems. Springer, Cham.

"*Aquaponics is a term that has been 'coined' in the 1970s, but in practice has ancient roots – although there are still discussions about its first occurrence. The Aztec cultivated agricultural islands known as chinampas (the earliest 1150–1350CE), in a system considered by some to be the first form of aquaponics for agricultural use (…). In such systems, plants were raised on stable, or sometime movable and floating islands placed in lake shallows wherein nutrient rich mud could be dredged from the chinampa canals and placed on the islands to support plant growth*" (Espinal et al. 2019, based on Crossley 2004). "*An even earlier example of aquaponics started on the other side of the world in south China and is believed to have spread within South East Asia where Chinese settlers from Yunnan settled around 5 CE. Farmers cultivated and farmed rice in paddy fields in combination with fish*" (Espinal et al. 2019, based on FAO 2001).

The reason behind my interest to apply aquaponics in this project is to minimize the system waste sustainably, and in the same process increase the output, diversifying products and markets. The downside of considering aquaponics is the additional complexity to be taken into account in all the steps of the project, from the plant layout to operational and commercial aspects. A permanent system balance is crucial in the system operation.

According to Petrea et al. (2016), several studies have demonstrated that integrating aquaponics into an existing aquaculture system is a good way to increase profitability, as long as cost and production efficiencies are permanently looked after and the system is managed properly. Furthermore, and according to the same research, certain plant species, culture densities and aquaponics techniques must be applied in order to allow aquaponics to add value to the project cash flow (Petrea et al. 20016). A successful business using aquaponics will need to be able to adjust any negative outcome that may occur to the system (Engle 2010).

Despite the apparent profitability boost that aquaculture could add to a simple cannabis growing system using hydroponics, research does not show such a clear convenience. Most of the reviewed papers analysing the economical convenience of aquaponics agree that this is far from being clear. "*More research and development are needed to determine if aquaponics will evolve into a profitable food production method*" (Love et al. 2014). More research is needed in order to reach unequivocal and general conclusions about the convenience of aquaponics (Maucieri et al. 2018).

According to Petrea et al. (2016), electricity costs represent more than half of the variable costs of an average aquaponics system, therefore "*…in order to improve the economic sustainability of the analyzed Aquaponics integrated systems, there is a strong demand for implementing renewable energy sources*" (Petrea et al. 2016). "*Aquaponics systems are energy and infrastructure intensive*" (Goddek et al. 2019). The economic convenience for companies to invest in renewable energy sources in Uruguay, mainly due to a special tax credit system that promotes renewables, implies that such a sustainable aquaponics project will necessarily include 100% energy self-sufficient facilities.

Figure 1.1 shows a basic plant layout of a regular aquaponics facility. According to most of the authors reviewed, this consists "*…of three main components: fish rearing tanks, solids removal for water treatment (clarifier, filter tanks, degassing tank), and hydroponic vegetable production troughs. Water returns to a sump where base is added into the base addition tank*" (Bailey et al. 2017).

The analysis and convenience of aquaponics require a thorough study of both **hydroponics** and **aquaculture,** and the appropriateness of specific combinations of fish and plants (Petrea et al. 2016). Therefore, this project will require the selection of the most appropriate fish species in order to achieve the best possible synergies, considering technical, biological and market issues.

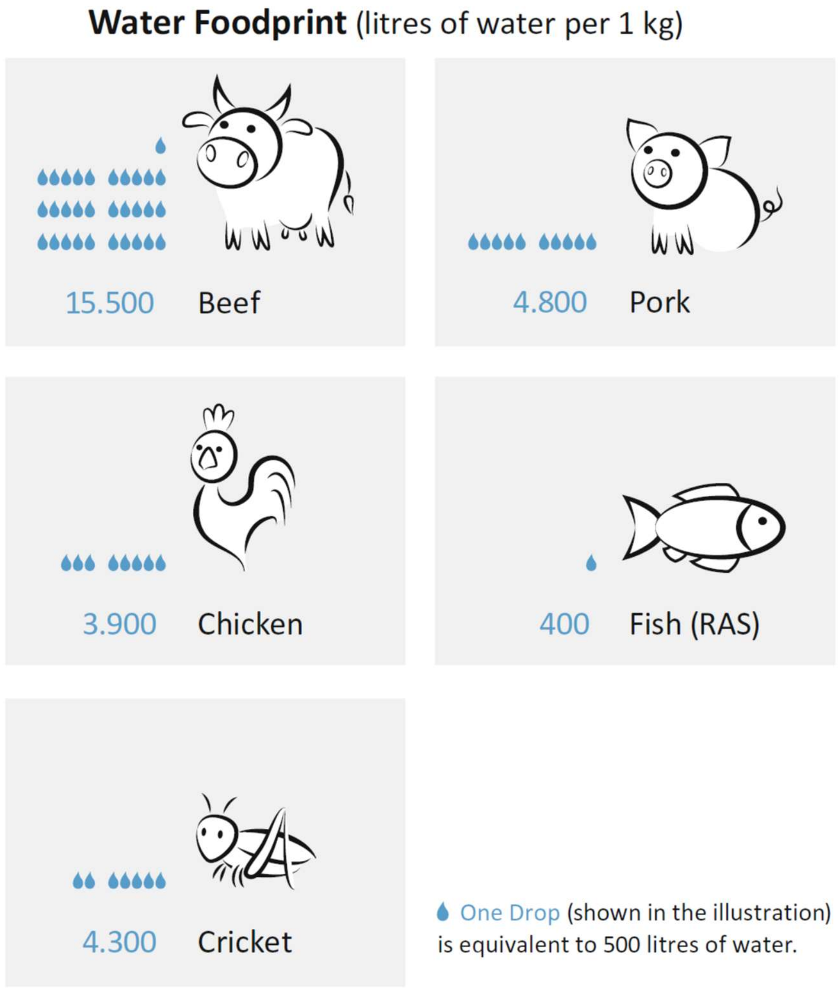
Another positive aspect of aquaponics regarding sustainability comes from the **aquaculture** side of this technology. The feed for the fish can be easily prepared in Uruguay in any of the factories in operation producing processed animal foods, and it could be even made from recycled sources. Furthermore, the feed conversion ratio[11] (FCR) in aquaculture is by far the highest compared to chicken, pork or cattle raising. This FCR varies depending on the fish species and the kind and quality of the feed, but according to the research developed by Love et al. (2014) on tilapia, this FCR was 1.29[12]. According to a research carried out by Martins et al. (2010), where different scenarios for trout growing where studied, the FCRs were 0.8 and 1.1. The same two figures are mentioned for trout growing in a research developed by Badiola et al. (2018), stating that these figures are "literature values". According to Besson et al. (2014) and to a research carried out by them with African catfish, FCRs fluctuate between 0.69 and 0.82[13]. Aquaculture is further analysed in section 3.3.

According to the Food and Agriculture Organization of the United Nations (FAO, 2015) and to the Global Aquaculture Alliance (2015), the average FCR for farm-raised fish is 1.2, while the same ratio for cattle climbs up to 6.8, for hogs is 2.9 and for chicken is 1.7. This is a clear positive side of aquaculture towards a more sustainable world, indicating that a well-balanced aquaponics system would even improve this issue.

As reported by Joyce et al. (2019), the efficiencies and use of resources for the production of fish in aquaculture using Recirculating Aquaculture Systems (RAS) is considerably better compared to the same ratios for the production of other food productions. Figure 1.4 and 1.5 show this reality based on water usage and production efficiencies for beef, pork, chicken, fish and cricket. The most amazing difference relates to the use of water, in which RAS needs by far the least amount of water to produce 1 kilo of fish. Figure 1.5 shows the average FCR for the same five products, as well as the ratio "kg feed / kg edible weight".

Fish farming using RAS is clearly much more efficient and sustainable than other competing meat production sectors.

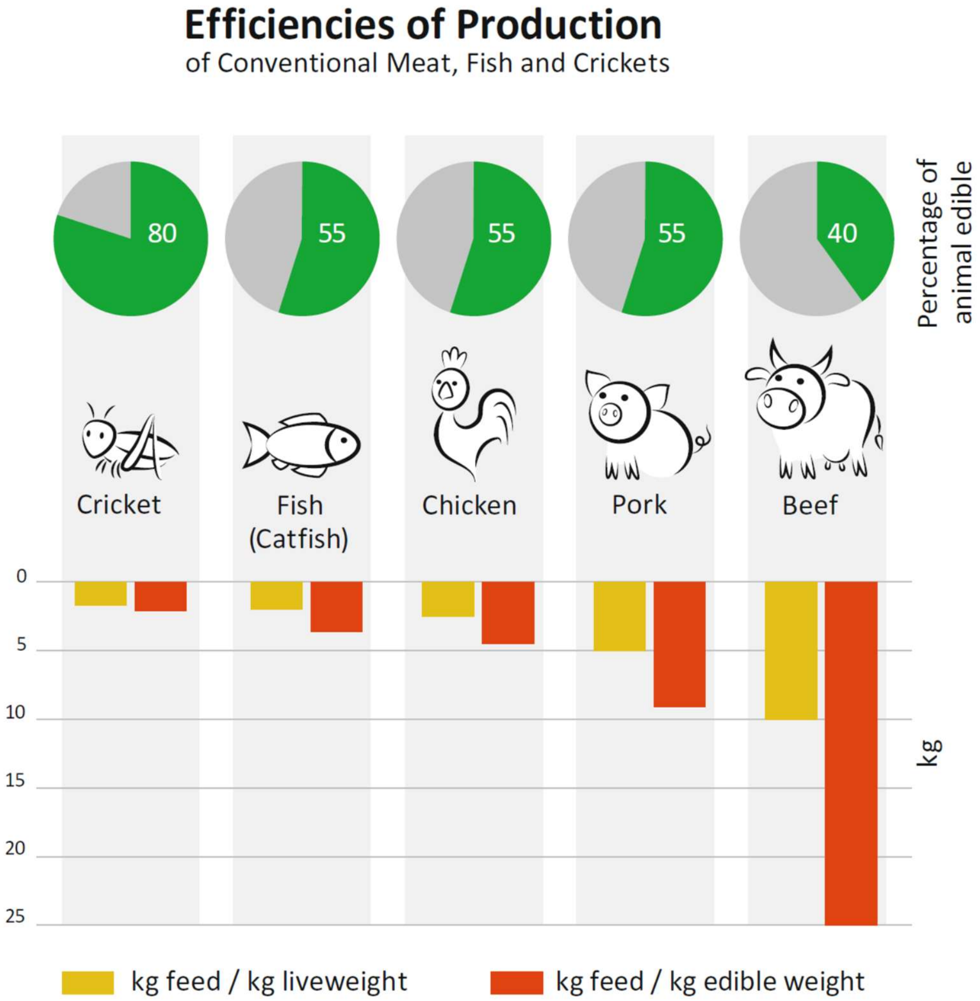
[11] "Kg fish produced per kg feed" (Fore et al. 2017)
[12] Total kg feed over kg of fish produced.
[13] Kg fish over kg food.



"Water footprint (L per kg). Fish in RAS systems use the least water of any food production system"
(Joyce et al., 2019)

Figure 1.4 Water Consumption in Different Food Production Systems

Source: Joyce A., Goddek S., Kotzen B., Wuertz S. (2019) Aquaponics: Closing the Cycle on Limited Water, Land and Nutrient Resources. In: Goddek S., Joyce A., Kotzen B., Burnell G. (eds) Aquaponics Food Production Systems. Springer, Cham.



Feed conversion ratios (FCRs) based as kg of feed per live weight and kg of feed for edible portion. Only insects, which are eaten whole in some parts of the world, have a better FCR than fish" (Joyce et al., 2019)

Figure 1.5 FCRs in Different Food Production Systems

Source: Joyce A., Goddek S., Kotzen B., Wuertz S. (2019) Aquaponics: Closing the Cycle on Limited Water, Land and Nutrient Resources. In: Goddek S., Joyce A., Kotzen B., Burnell G. (eds) Aquaponics Food Production Systems. Springer, Cham.

The Food and Agriculture Organization of the United Nations (FAO) recognizes the great contribution of both aquaponics and aquaculture to sustainability and food safety. "*The challenge of meeting consumer needs with a sustainable supply of aquatic foods persists, and fisheries management and environmental protection are important in this regard. In the future, aquaculture and aquaponics may play a greater role in coping with the increased demand of a growing world population.*" (FAO 2018). Aquaponics is further analysed in section 3.4.

Hydroponics techniques may be classified into two main categories: those without substrate, and those using a medium based system (Cooper, 1979). In the first category, we can find floating raft systems and the Nutrient Film Technique (NFT), while there are different systems that use medium based techniques. The second category could be also classified depending on the kind of substrate used, i.e., organic, inorganic or synthetic (Enzo et al. 2001). According to Maucieri et al. (2018), 43% of the current systems in use are medium-based, followed by Floating systems (33%) and NFT (15%). The kind of hydroponics to be used depends on the kind of plant to grow, with each one carrying advantages and disadvantages (Maucieri et al. 2018). It has been found that the type of hydroponics does not affect much the yields or the quality of the final products, with comparative studies being rare since researchers normally use growth beds, while commercial facilities tend to use NFT (Maucieri et al. 2018). Hydroponics is further analysed in section 3.1.

According to Eck et al. (2019), nutrients for hydroponics can be classified in Macronutrients and Micronutrients. This researcher includes Carbon (C), Nitrogen (N), Phosphorus (P), Potassium (K), Magnesium (Mg), Calcium (Ca) and Sulphur (S) as Macronutrients, and Iron (Fe), Manganese (Mn), Zinc (Zn), Boron (B) and Copper (Cu) as Micronutrients.

Upon completion of my research and regardless of the many premixed nutrient solutions available in the market, I believe that precise mixtures are like "*grandma's secret recipe*", similar to the special bullet made by a famous hunter or a unique fly made for special fishing events; they are kept with zeal. When interviewing Sebastián Figuerón (2019), the person in charge of the entire hydroponics system in Fotmer, he mentioned that he could help me by answering simple questions about the implementation of such project but he, for example, "*would never ever reveal the precise mixture of nutrients they use*".

1.3.3 Conclusions

The reviewed literature shows that most of the topics analysed need further research undertakings and development.

Cannabis is clearly a newly legalized crop in many countries and states, still with most countries banning its growing and commercialization. Research has been clearly limited for too long. There is a lack of data and information in literature about commercial and business aspects, as well as more detailed information about industrial processes.

Aquaponics is an even newer technology. Despite the fact that the "aquaponics idea" has been used for centuries, industrial aquaponics is a whole new story. Most of the literature reviewed focuses either on aquaculture or hydroponics and not so much on specific issues of aquaponics, which was disappointing considering my expectations on some papers.

If this project is to be developed, I believe it will allow the possibility for further R&D both on cannabis and aquaponics.

1.4 Background

This research project was conceived during my first year of this Master's degree, being the result of a long process of exchanging ideas with many professors, entrepreneurs and especially with Esteban Melgarejo, who was at the time working at the Embassy of Uruguay in Australia.

He first introduced me to the concept of aeroponics[14], which actually fascinated me, and I immediately started working on this idea for application on horticultural products. Being too ambitious, especially for someone with no agricultural background whatsoever, I started to look into hydroponics and right after I began considering medicinal cannabis as a promising and innovative crop to work on.

The concept of aquaponics was introduced to me by Robert Faggian, one of my professors at Deakin University. He referred me to Steve Gleeson and his company, Pure Ponics, which was being developed as a research project with Deakin in Geelong Campus. I had the opportunity to visit the company and interview Steve, and the idea of aquaponics looked very promising. Being such a little developed and researched technology, and so closely related to hydroponics at the same time, I began to look into hydroponics in order to continue working on this research.

Therefore, I started the process of contacting companies working with hydroponics and soon had the opportunity to visit fully automated hydroponics facilities in Tasmania. Right after that and as a result of these visits, I got in touch with experts working with hydroponics and currently advising hydroponics facilities. I actually fell in love with this technology and immediately realized the profound impacts that the right development of this technology could have, especially if done sustainably. And the rest is history…

Research Aim

The main concern behind this research idea was first summarized in the following research question:

Which are the characteristics of the optimum aquaponics system in Uruguay for the industrial medicinal cannabis growing production in order to achieve the best sustainability, efficiency and profitability indexes?

[14] "*Aeroponics could be defined as a technology to grow vegetables and fruits, highly energy dependent, which uses no soil but a mist environment in order to transmit water and nutrients directly to the roots*" (Definition elaborated by the author of this research in 2018 for SLE761).

Specific Objectives

Going through different steps was necessary for this question to be answered, so I then listed a series of specific objectives I needed to achieve on this research in order to reach appropriate conclusions:

1- Determine the main technical and market issues regarding the **cannabis industry**. Since that the output from cannabis will be the main source of income for this project, achieving appropriate and reliable market information and data will be crucial.

2- Determine the characteristics of the **cannabis breed to grow**, not only in order to establish the plant layout, but also to determine its particular needs for nutrients.

3- Analyse different **fish species** and their particular requirements, so as to determine their suitability for the cannabis aquaponics system.

4- Choose the most appropriate fish species and complete all the system technical details and plant layout. Technical aspects regarding fish production will be more important than market issues, since the fish growing side of the system is mainly intended to add sustainability to the system, not so much profitability. The main profitability advantages will come from cannabis growing.

5- Decide if it would be appropriate to start working on the development of an automated and centralized device **prototype** to control and manage the whole aquaponics system.

6- Considering all the data and information gathered, together with the conclusions arrived regarding technical details and market information, analyse **financial and economic aspects**.

7- Conclusions: Economic convenience, degree of sustainability achieved, potential to apply knowledge to other national and regional sectors, etc.

Later on, I realized that a few of these tasks were way too ambitious for this research, so I had to make a few assumptions. All of them were made mainly based on opinions of highly qualified experts and professionals, so I am quite confident that I have been working on solid ground.

I will expand on these specific aspects of the research on upcoming chapters of this document.

These research specific objectives have been addressed in different sections of this document, as follows:

Table 1.1 Research Specific Objectives

Specific Objectives	Chapter 1	Chapter 2	Chapter 3	Chapter 4	Chapter 5
1	X	X	X	X	X
2			X		
3		X	X		
4			X	X	
5			X		
6				X	X
7					X

Source: Self-made 2019.

Specific objective 5 shows my initial intention to work on the development of a device prototype to automatically manage an aquaponics system. Although I decided not to work on this issue mainly because of time constraints, I did come up with the idea to suggest the development of an Instant Nutrients Analysis (INA) as a recommendation for further research on aquaponics.

This topic is addressed in chapter 3 and shown in figure 3.19.

The entire research process is shown in figure 1.6, right from the first initial idea to the conclusions reached, final recommendations and further research possibilities.

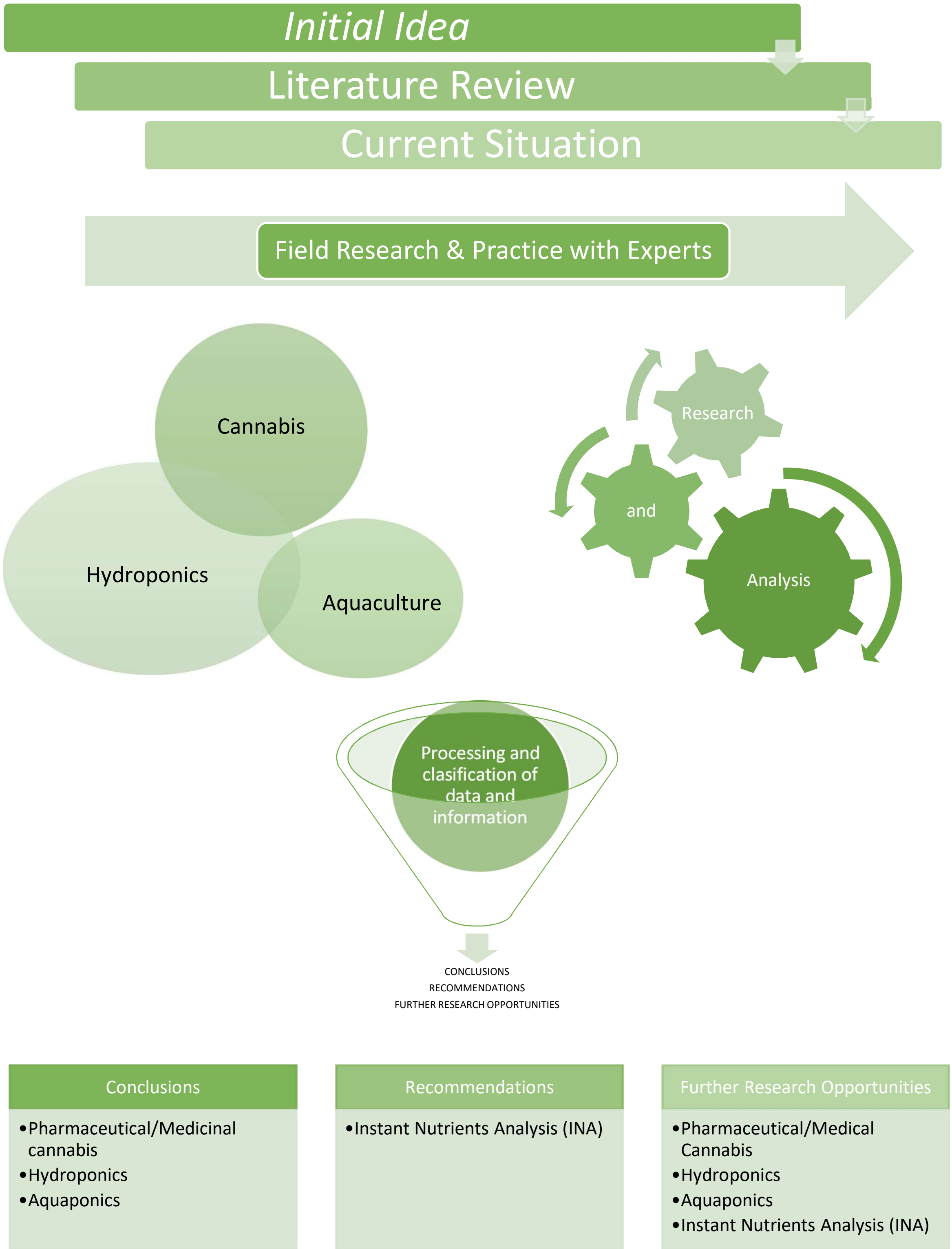


Figure 1.6 Research Process

Source: Self-made 2019.

The best possible scenario of this research was defined in 2018 as finding an aquaponics system to grow cannabis, adequate enough to be used in Uruguay and complying with the following requirements:

- Maximum repayment period of 5 years.
- Completely sustainable production, depending only on rainwater. If not possible, water should be otherwise purchased only in a few specific times of the year or upon severe drought events.
- With a positive SWOT analysis, especially with low risks and low dependence on foreign specialized technology. In case high technology dependence is found, the possibility to develop sufficient national knowledge and capabilities will be important.

The initial research proposal included the possibility of developing an automated and centralized device prototype to monitor and manage the aquaponics system. It could have been potentially a further source of income of the projected cash flow, but it finally proved too ambitious for this research.

To the extent that water is the main production resource, the main focus of this research would be on the use of water. **Future climate scenarios** are to be taken into account to analyse the possibility of using rainwater exclusively. Should this be a possible scenario, determination is to be made about the technical requirements necessary to collect and store rainwater for self-sufficiency purposes (Analysed in section 3.5.8).

Cannabis soil growing was never an option for this research due to high weather dependence, fluctuating production quality and quantity, high labour costs, high and increasing land market prices and, most of all, due to the lack of innovation that such a research project would imply.

The main clients based on the results of this research would be potential investors, but also the Uruguayan Ministry of Livestock, Agriculture and Fisheries (MGAP). Aquaponics could be applied not only to cannabis production, but also to other crops. It could represent a real disruptive technique, allowing the whole country to achieve competitive advantages on a global scale, if applied properly.

While the main international markets for pharmaceutical cannabis are Europe and the United States (Melgarejo 2018, *Personal communication*), international companies carrying out activities in Uruguay could be first customers (Taullard 2018, *Personal communication*).

Choosing the right fish species for the system was first appreciated as crucial. Therefore, an important aspect of the research was thought to be focused on this. Unfortunately, I soon needed to admit that I had greatly underestimated the complexity of this issue.

This selection was thought to be made based on the following criteria:

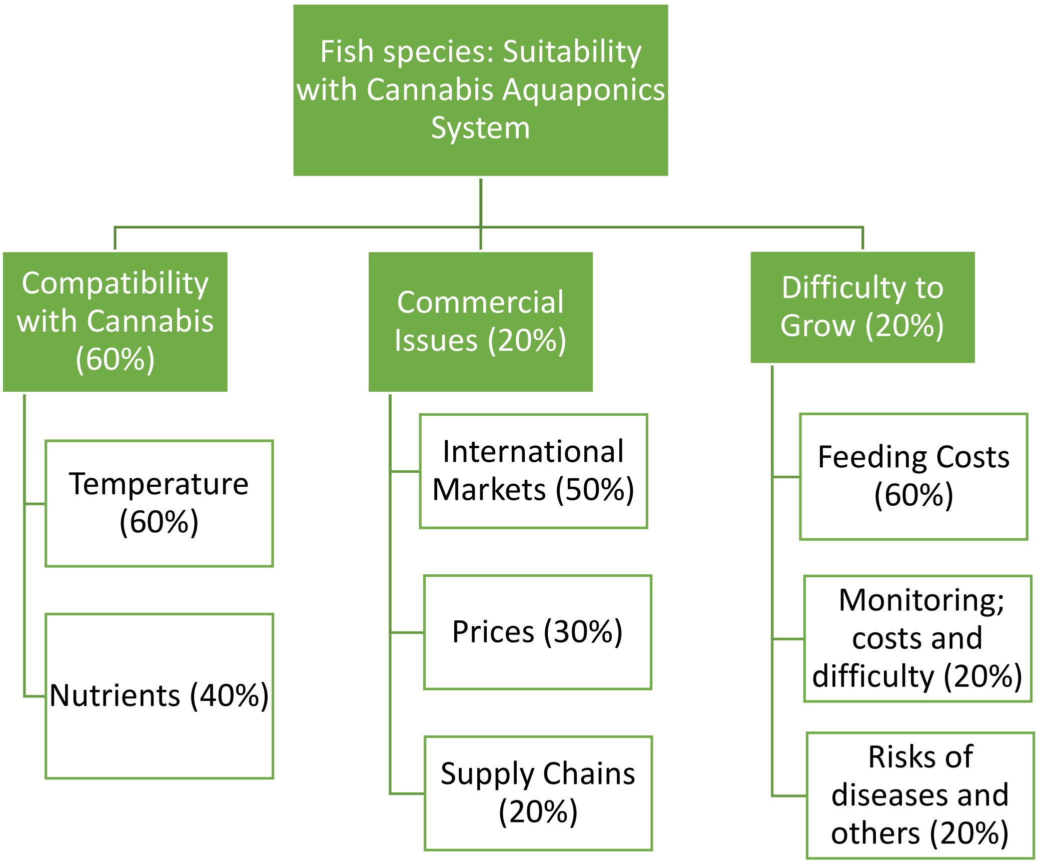


Figure 1.7 Original Decision Tree for the Selection of the Most Appropriate Fish Species (2018)

Source: Self-made, 2018.

Technical issues on fish-cannabis compatibility would have weighted much more than market issues as a result of the fish component adding sustainability to the project, but not so much profitability.

According to qualified informants at the moment, potential good combinations for a cannabis aquaponics system could be Murray cod (*Maccullochella peelii peelii*), rainbow trout (*Oncorhynchus mykiss*) or barramundi (*Lates calcarifer*). The last one would be *a priori* the best candidate (Francis 2018, *Personal communication*). Although domestic fish species could be better options, they were discarded as they have little or no commercial value.

The appropriate analysis of this compatibility between cannabis production and fish growing requirements on aquaponics would have required a thorough investigation on:

- Precise data on the characteristics of the waste of the different fish species being researched, with its variation on the different growing stages, water density and feeding characteristics and techniques;
- Precise data on the nutrient requirements of cannabis during the different growing stages;
- Technical solutions in order to combine, at a large scale and in real time, the fish waste with the nutrient requirements of cannabis, which are necessary to instantly counteract any system unbalances.

All of the heretofore issues proved to be too ambitious for this research. Even too ambitious for most of the researchers working on aquaponics nowadays, as I understand it after months of working on this technology.

The final fish species selection was made on simpler facts and based mainly on market issues and experts' opinions. This will be explained in detail in section 3.3.

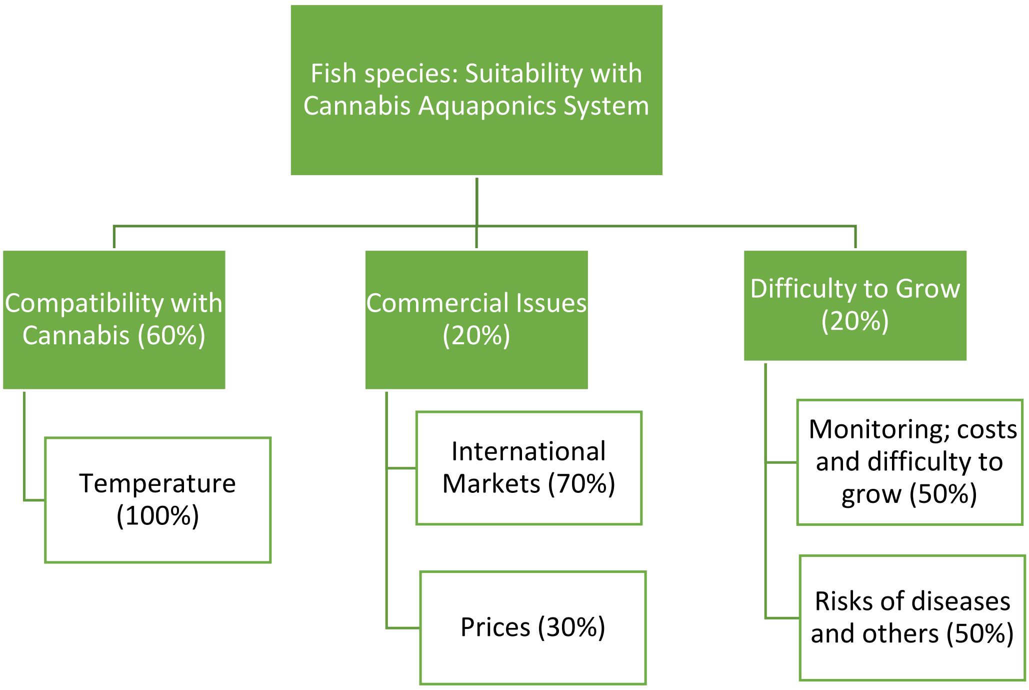


Figure 1.8 Decision Tree for the Selection of the Most Appropriate Fish Species (2019)

Source: Self-made, 2019.

1.5 Research Methodology

As I have expressed and explained throughout this document, the initial research proposal turned out to be much more complex than I could ever expect. Not only did I choose to work on two brand new and controversial topics, but I chose to combine them and even had the initial intention of reaching unequivocal conclusions. Moreover, the field research, which was at first my best alternative to obtain relevant information, was particularly difficult.

I will explain below the different methodologies I followed, as well as the methods and techniques used in order to carry out this research.

1.5.1 Field Research and Practice

The new growing field of cannabis in Uruguay turned out to be extremely closed, zealous and even secretive at times. In a country like Uruguay, where I could always get to meet the person I needed to, where there is always "*a friend of a friend*" willing to introduce me and where the famous idea of the "*six degrees of separation*" is probably much stronger than in many other countries, it was actually harsh to meet some key persons.

A few of the key people I intended to interview never replied to my messages. A couple of meetings I held are not even listed in section 6.2, as nothing was obtained from them and turned out to be just a waste of time. A few others started in a really awkward way with clear discomfort and suspicion, up to the point where I felt like saying "*Thank you for your time but please don't worry, you don't need to say anything and I will just show myself out…* ". And I heard stories that do not seem to come from my country but rather from the *"Far West"*. The above notwithstanding, I believe I managed to obtain enough information in order to have a reasonable idea of the current situation of this new Uruguayan business.

Before and right after legalization, most of the stakeholders involved in this business were bohemian and "dark characters"; however, in the last few years more professionals and experienced entrepreneurs have been engaging in this business (Figuerón 2019, *Personal communication*). I had the impression that a few start-ups are run by people who claim to be world-class open minded business people willing to share their experiences and give advice, while in reality this is merely an illusion and they are just in a new business working under very old-fashioned and conservative business practices.

I had the pleasure to interview people like Kevin Nafte or Sebastián Figuerón, young entrepreneurs who bring fresh ideas and experiences to this business. I was particularly amazed with Kevin Nafte and his approach to business and life, saying things like; "*we should support each other in order to strengthen our regulations and share our good and* *bad experiences… there is no point in thinking that we (Uruguayan companies) could ever compete with each other in such a huge world market*". He even contacted me with his suppliers and revealed the cannabis breeds he had been dealing with, and his results. I have to admit I am not used to that, but coming from the *start up milieu* in Israel and with vast international experience, it is not so strange after all.

In some cases, an official governmental source would claim something opposite to what had been said by other interviewed sources, for example regarding "*unspoken decisions*", certain key topics or bureaucratic issues. This came as no surprise to me, especially in such a new field. I decided to take the "unofficial" versions as reliable and true only after having heard the same from different persons.

All interviews carried out were completely unstructured, used as a method to reveal the current state of the art and business situation. The way I approached the interviewees and directed each interview was initially agreed with Dr. Ignacio Bartesaghi and approved by UCUDAL. Without any guidelines and in an unstructured way, I guided each interview as a simple fact-finding method with the purpose of finding as much information as possible about each research topic.

1.5.2 Scientific Research Papers

I looked into several scientific research papers, most of them focused on aquaponics. It was actually harsh to find relevant research papers on cannabis. Most of the research papers were retrieved during the first year of the Master's degree while studying in Australia, as well as most of the literature review. The field research was mainly carried out during the second and last year while in Uruguay.

Nothing definite was identified in any of the research undertakings I could read on aquaponics, but they provided me with an excellent background in order to understand this technique and be able to reach some conclusions and recommendations.

1.5.3 Specialized Newspapers, Daily News and Other Sources

There were other sources of information such as Hemp Industry Daily[15] or Marijuana Business Daily International[16] with different news, magazines and regular publications, which I decided to take as a serious source after having checked much of the news and information that had been published.

Other national and international newspapers such as the New York Times, *El Observador* and *El País* were taken as reliable sources of data and information as well. I should also mention different publications from international organizations, such as the Food and Agriculture Organization (FAO) of the United Nations and the World Bank, and national private and public sources such as DINARA, INIA, MGAP, MSP, INASE, CECAM and others.

1.5.4 Quantitative Analysis; Economic and Financial tools

After completing the research and taking into account all the information and data gathered, I have used different evaluation techniques in order to determine the project convenience, as well as its positive and negative aspects.

I have used a traditional economic and financial tool as the main analysis technique, which is a basic cash flow based on the information I had previously gathered. I calculated the repayment period, the IRR and the NPV.

Qualitative analysis was also carried out using SWOT analysis.

[15] https://hempindustrydaily.com/
[16] https://mjbizdaily.com/intl/

2. Current Situation

2.1 Current National, Regional and International Situation with Cannabis

In this section I will analyse the current situation with cannabis at a national, regional and international level. More emphasis has been laid on a national level, and not so much on the analysis of the current regional and international situation.

2.1.1 Current National Situation

With cannabis production being recently regulated in Uruguay, an increasing number of international companies have started activities in this newly created Uruguayan market. Even though at first they had to face incompatibilities with other international, regional and even national regulations, especially with the banking system, most of these problems are being solved one way or another.

Incipient export operations started in 2019 with a first exportation of medicinal flowers to Germany made by Fotmer Life Sciences (New York Times, 2019), which was considered as a "*first trial*". A second export operation took place on 25 September 2019, and it was carried out by the same company. It was considered by the entire cannabis industry and the press as the first "*real export*" of medicinal cannabis from Uruguay, and the first one from Latin America as well. The buyer was an Australian company, Burleigh Heads Cannabis, and it was for a whole container of high content THC cannabis flowers (*El País Negocios*, 2019[17]).

Most of the growing of medicinal cannabis is made in greenhouses in order to better control production and to avoid dependence on weather conditions, which pose the potential risk of not only lowering yield indexes, but also of losing the whole production under extreme weather events. Most of cannabis grown outdoors is used for its fibres, with a minimum amount used for medicinal purposes (Saldías 2019, *Personal communication*).

Every major undertaking in Uruguay addressing the medicinal/pharmaceutical sector is developed inside Free Trade Zones (Saldías 2019, *Personal communication*), for fiscal and security reasons. This fact will be further analysed and explained in section 3.6.

According to Kevin Nafte (2019, *Personal communication*), most of the companies on this international, regional and national market are acting towards a "*forced vertical integration*" strategy. The lack of specialization and suppliers with previous experience has forced most of these companies to grow vertically in order to internally attend their growth

[17] https://negocios.elpais.com.uy/empresa-uruguaya-realizo-primera-exportacion-cannabis-medicinal.html

needs. Nafte (2019, *Personal communication*) believes that this strategy will change in the near future towards a much clearer specialization, with different companies located in different places of the cannabis value chain.

The total investment made by companies already running in Uruguay and by those waiting for authorizations rises to USD 100 million (Losa, 2019). Fotmer Life Sciences alone, the first company to be authorized by IRCCA to produce high content THC cannabis, is estimated to have invested around USD 50 million so far (Nafte 2019, *Personal communication*). According to Jordan Lewis, Fotmer's CEO, this company will invest USD 100 million in the next few years, with "*projected profits of hundreds of millions of US Dollars*" (De León, 2019). He believes that the international market for medicinal cannabis will reach USD 100 billion in the next decade, and that Uruguay could seize an important portion of this market (De León, 2019). According to Lewis (2019), Uruguay could be exporting USD 1 billion in medicinal cannabis products in 5 to 7 years (De León, 2019), a figure that will put this sector among the most important in our country.

Fotmer Life Sciences is probably the most important company in our market according to many market stakeholders interviewed. Fotmer has reached a special agreement involving two Free Trade Zones (FTZ) in Uruguay: *Parque de las Ciencias* and *Colonia Suiza*, whereby they are allowed to grow cannabis in very automated and modern greenhouses in *Colonia Suiza* and to have their laboratories in *Parque de las Ciencias*, being able to transport goods between them without paying any national taxes.

Plants are grown in *Parque de las Ciencias (PC)*, completely indoors, and then transported to *Colonia Suiza* where they are grown in special greenhouses. The final product is processed in *Colonia Suiza* and then sent back again to *PC* for final elaboration and analysis. Logistics between FTZs must be escorted by the police because of the high THC content in the product and due to fiscal reasons. A general belief in the market indicates that PC would not accept any user building greenhouses, for aesthetical reasons, although Wehe (2019, *Personal communication*) indicated that they have no issue with having greenhouses in their premises. The only problem, according to him, might be the high costs to work in PC and that it may not be worth to pay for such an expensive area to set greenhouses.

This market has been moving extremely rapid in the past few months. Kevin Nafte (2019, *Personal communication*) shared an anecdote with me about this from the time when he requested a meeting with Uruguay XXI[18] in 2018. His aim was to introduce himself and enquire about the intentions of such Agency regarding this business. At that moment they had no plans whatsoever, and they were not even considering doing anything to promote

[18] Uruguay XXI is *"the (Uruguayan) agency responsible for the promotion of exports, investments and country image"*; https://www.uruguayxxi.gub.uy/en/

this sector. Less than 3 months later he met again with Uruguay XXI officials in an event, and he found that they were putting lots of effort to promote medicinal cannabis, already organizing international trips and participation in international fairs and exhibitions. This is a good example of an extreme paradigm shift in a very short period of time.

I refer further to this issue in section 3.6 as well.

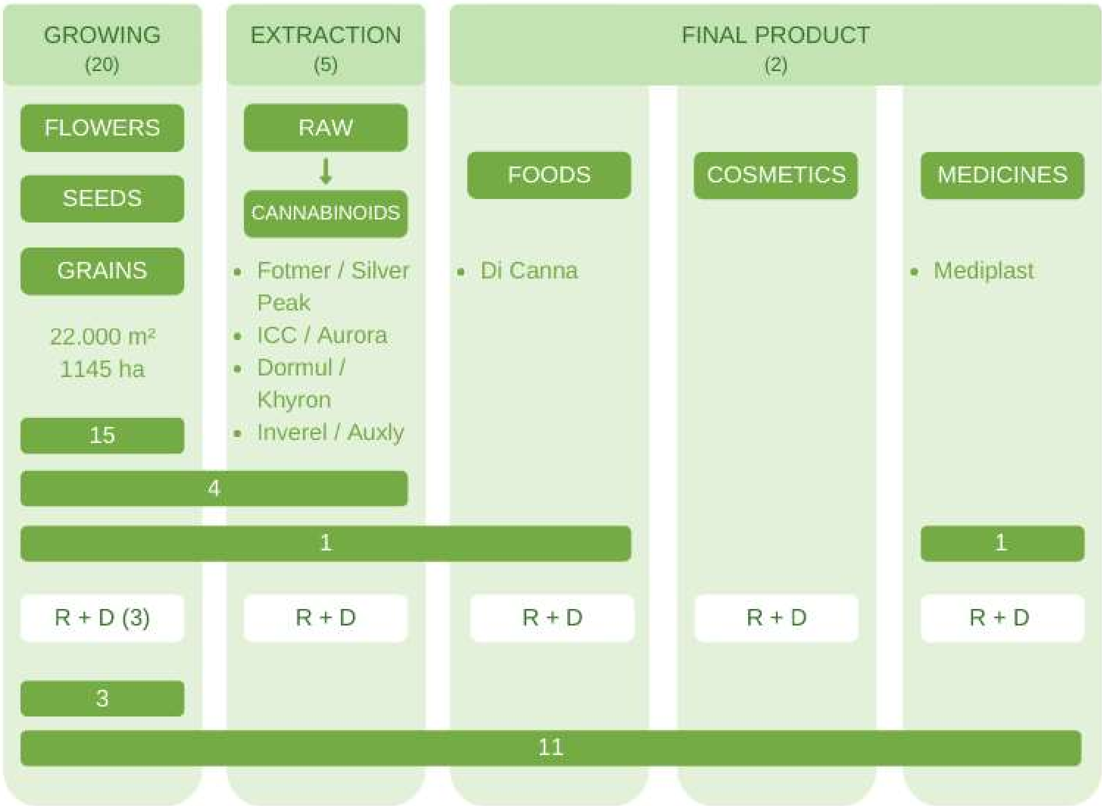


Figure 2.1 Uruguayan Non-recreational Cannabis Value Chain (2019)

Source: Uruguay XXI, 2019. Based on a private consultant. Preliminary version. (Adapted and translated).

Figure 2.1 shows the current Uruguayan non-recreational cannabis value chain, from a total of 23 companies identified by a private consultant doing a research for Uruguay XXI.

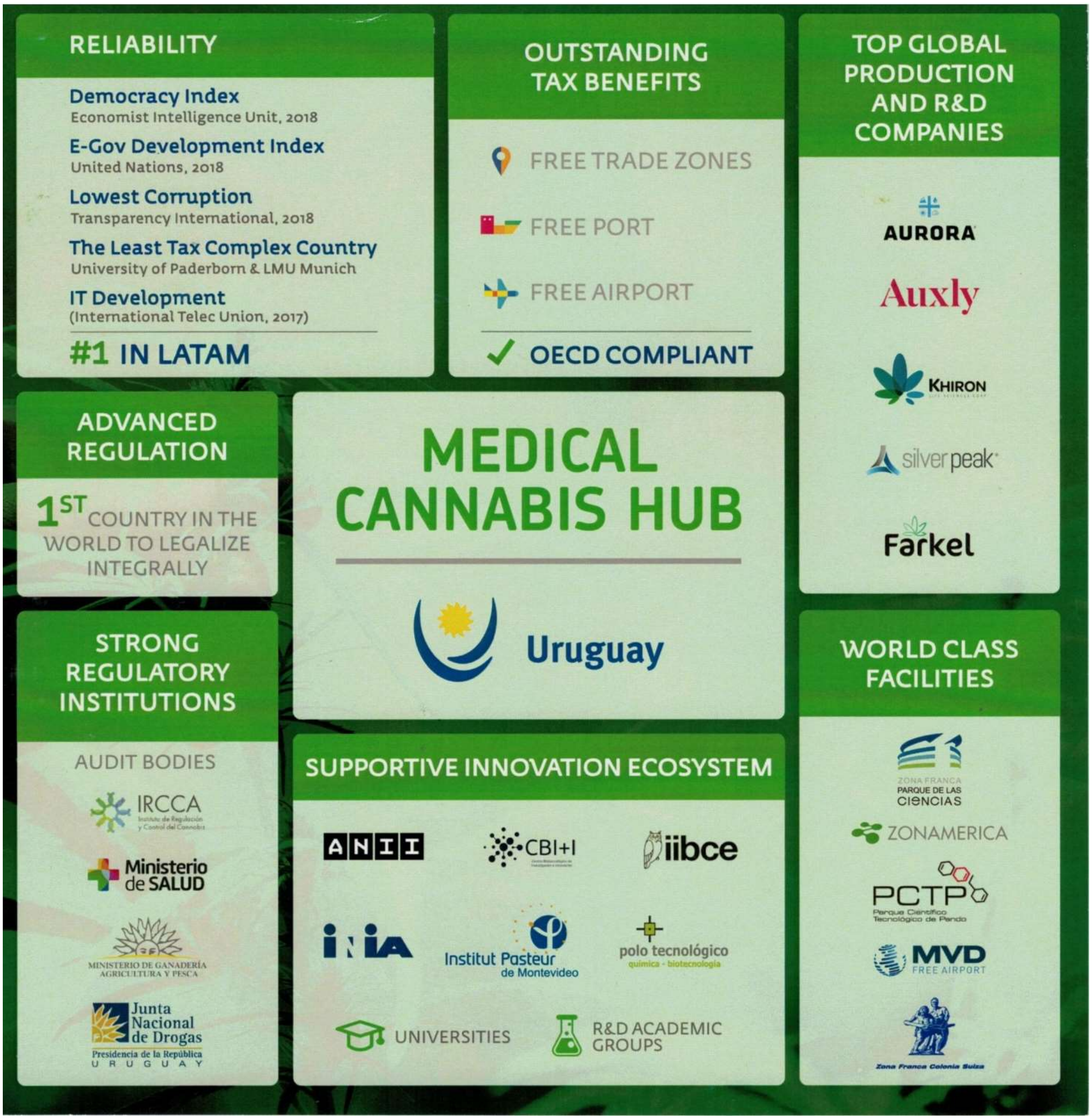


Figure 2.2 Uruguay: MEDICAL CANNABIS HUB

Source: Uruguay XXI, 2019. This is one of the brochures from Uruguay XXI referring to the advantages of investing in the Uruguayan medicinal cannabis sector.

According to Saldías (2019, *Personal communication*), specialist of the Agribusiness Sector and responsible for the cannabis sector in Uruguay XXI, our country offers all what international investors are looking for, that is, not only a clear legislation but also political stability. According to him, the current political campaign is yet another proof that candidates –even cannabis detractors– will keep these legislations on cannabis.

The explanation is simple: large investments have been committed in this sector after these regulations and Uruguay respects both national and foreign investments. Saldías mentioned further examples such as the Law on Investments or the Free Trade Zones regulations, which have gone through many different governments without sustaining major significant changes.

He explained that the Uruguayan medicinal cannabis sector is considered by Uruguay XXI as the country's highest potential industry in the medium and long term. Figures 2.2 and 2.3 show this fact in an unequivocal way.

Figure 2.3 Uruguay as a "Global Business Hub"

Source: Uruguay XXI, 2019. This is another brochure from Uruguay XXI promoting Uruguay as a Global Business Hub (Please note the background picture).

The output of companies in the cannabis industry could be roughly classified in the following categories, according to Nafte (2019, *Personal communication*):

- Therapeutic products
- Pharmaceutical products
- Cosmetic/wellness products
- Recreational products
- Supplementary products

Most of the undertakings start by selling byproducts such as cuttings and seeds, among others, but during this research I noticed that most projects aim to create their own brand of products, most of them being therapeutic products.

Regarding pharmaceutical products involving cannabis, there is a general belief in the market that the **Uruguayan Ministry of Public Health (MSP)** has made the "*unspoken decision*" not to register any pharmaceutical products. It was only after great pressure from many market stakeholders that the MSP decided in December 2017 to register the only pharmaceutical product so far allowed in Uruguay: *Epifractan*. This product is manufactured by Medic Plast S.A.[19] using CBD imported from Switzerland.

Figure 2.4 Epifractan 2%

Source: Medic Plast S.A. 2019. First and so far the only (November 2019) cannabis product registered in the Uruguayan Ministry of Public Health (MSP).

[19] https://medicplast.com.uy

Greenfields is another Uruguayan company engaged in the import of cannabis products to Uruguayan patients, only upon request and with medical prescription.

"*In the case of medicinal cannabis, there are 4 main options:*

- *production of basic cannabis extract (preserving the original mix of cannabinoids from the plant),*
- *production of pure CBD,*
- *production of different mixes not classified as medicine (with specific proportions of CBD and other cannabinoids upon request,*
- *production of medicines with specific concentrations.*" (Uruguay XXI based on a private consultant. Preliminary version.[20])

As stated by Saldías (2019, *Personal communication*), the MSP is currently more open and willing to register further pharmaceutical products. According to him, the main difference in Uruguay compared to other countries is that CBD products are considered pharmaceutical so they require a long registration process. That is not the case with other countries such as Switzerland, where CBD products are not pharmaceutical and, consequently, do not require any licenses (Saldías 2019, *Personal communication*).

According to Uruguay XXI (Table 2.1) there are currently 64 licenses granted, 43 of them for companies. The information is available on IRCCA's web page, which, unlike prior to the update made in September 2019, is quite straightforward. The documents to request licenses are available to download, as well as the details and resolutions for all the licenses already granted. There are even flow charts describing the request procedures.

Table 2.1 Total of Licenses issued (by August 2019)

LICENSES	Crops	Manufacturing	R&D	TOTAL	COMPANIES
Granted	21	5	16	42	26
Under review	11	8	3	22	17
Total	32	13	19	64	43

Source: Uruguay XXI, 2019 (Brochure).

[20] Preliminary version in Spanish. Translation into English was made by myself in October 2019.

According to Saldías (2019, *Personal communication*), many changes took place in 2018 and 2019 in connection with the approaches from different Uruguayan agencies and institutions towards cannabis, with the current situation being as follows:

- **IRCCA**: This Institute regulates the cannabis production and any project related to psychoactive cannabis (more than 1% THC). They have received many enquiries from national and international investors interested in this sector, which was at first not their actual purpose. An alliance was signed in September 2018 between IRCCA and Uruguay XXI, under which the latter became responsible for promoting this sector. Uruguay XXI has currently 3 people working in the Agribusiness Sector specifically on cannabis: 2 of them on "Pharma" and "Life Sciences" projects, and a third one serving the 43 companies already in operation (43 by August 2019)
- **Uruguay XXI**: According to Saldías (2019, *Personal communication*), Uruguay XXI is currently leading this sector by promoting the country in international events and receiving and informing potential investors.
- **MSP**: This Ministry is in charge of dealing with any pharmaceutical products, which in Uruguay include any product containing CBD or THC.
- **MGAP**: The Ministry of Livestock, Agriculture and Fisheries is responsible for any undertaking focused on growing non-psychoactive cannabis (THC content under 1%) which do not include any production side, with the exception of food products. If it includes CBD or THC production, IRCCA must act as well.

According to Saldías (2019, *Personal communication*), this situation was not clear in 2018 and much effort has been made in order to improve it.

As stated by Vázquez (2019, *Personal communication*), responsible for licensing non-psychoactive cannabis projects in MGAP, there are currently three large projects in Uruguay, two of them engaged in the production of API[21] products, and a third one more diversified. Formet Life Sciences and Khiron Life Sciences[22] have made large investments in FTZs and they focus on API products. INNOVATERRA[23] is focused on more diversified products.

I would also add ICC Labs to this list, a company recently acquired by Aurora and with large investments in *Parque de las Ciencias Free Trade Zone* as well. This company has established the first pharmaceutical grade laboratory for cannabis in Latin America (Uruguay XXI 2019, based on a private consultant. Preliminary version)

[21] API stands for Active Pharmaceutical Ingredient.
[22] https://www.khiron.ca/
[23] https://www.innovaterra.com.uy/

Figure 2.5 shows the most evident section of the only banner at the entrance of the MGAP, displaying a field of industrial hemp. Both Uruguay XXI and MGAP are clearly supporting the cannabis business, which is probably part of the international "*green rush*" described by Nafte (2019, *Personal communication*), already arrived in Uruguay as well.

Figure 2.5 Industrial Hemp: Banner in DGSA (MGAP)

Source: Picture of part of a banner in DGSA (MGAP) taken by the author in October 2019.

According to many sources (Saldías, Vázquez, Ecofibre and others), genetics is a key issue in this business. That is probably why INIA, the National Institute for the Research on Agriculture, has signed a research joint venture with Spanish company INNOVA LIFE to develop new cannabis breeds with medicinal purposes[24]. This research undertaking started in 2019 and will be carried out in Las Brujas, an INIA research centre in Canelones.

As reported by Uruguay XXI (2019. Based on a private consultant. Preliminary version), the development of a national cannabis genetics database determining the best sowing time, density under different growing techniques, fertilization, and plague controls for each different cannabis breed is crucial for Uruguay. According to Saldías (2019, *Personal communication*), this is exactly the kind of information that Uruguay has developed for every relevant crop, with specific information on best growing conditions and yields in Uruguay.

[24] Uruguay XXI, based on a report from a private consultant. Preliminary version.

2.1.2 Current Regional and International Situation

The degree of cannabis legalization can vary significantly depending on whether we analyse the medicinal or the recreational side of this industry. Regarding the focus of this research, which is the legalization of medicinal cannabis, figure 2.6 and figure 2.7 displayed on the following pages show the different degrees of medicinal cannabis legalization/implementation in different countries, simply ranked in 3 categories: High, Medium and Low.

We can see that there are only two countries in the Americas ranked as High: Canada and Colombia. The United States, probably the most important market globally, is a very particular case as cannabis is classified as illegal on a federal level but legal in many states[25]. Although the 2018 US Farm Bill (U.S. Department of Agriculture, 2019) legalized industrial hemp containing up to 0.3% THC, its practical implementation will be quite complicated and the federal market is still very restrictive. Interstate transportation of industrial hemp, for example, is now legal. Nevertheless, "*hemp is undistinguishable from cannabis to the naked eye, and therefore, shipping an entire biomass directly from the field across state lines has a good chance of being confiscated.*" (Smart, 2019). Uruguay is classified with a Medium level of medicinal cannabis legalization, together with Brazil, Chile and Mexico. "*Mexico is expected to become the second country in Latin America, and only the third in the world, to fully legalize cannabis on a federal level.*" (Pascual 2019)

Germany, Holland and Australia are the other countries worldwide considered to have a High degree of medicinal cannabis legalization.

According to Saldías (2019, *Personal communication*), Uruguay "competes" directly with Colombia and Mexico for large foreign direct investment in this sector. Notwithstanding the fact that both countries offer much better natural conditions than Uruguay to grow cannabis, their past (and even present) close relation to illegal drug trafficking, coupled with serious security issues, poses a major obstacle to the proper development of the activity. Their "country brands" are not attractive at all, while Uruguay offers trust and solid legislation and authorities.

Uruguay issues a license only after having analysed and approved specific projects, and exclusively upon a thorough analysis regarding potential money laundering, while Colombia has currently 3,000 licenses issued and only 5 in operation, so clearly it has been a speculative wave with no substantial real operations (Saldías 2019, *Personal communication*).

[25] Refer to the Literature Review for more details.

Figure 2.6 Degree of Cannabis Medical Development/Implementation in the Americas, as of 15 August 2019.

Source: Marijuana Business Magazine, September 2019[26].

[26] Marijuana Business Daily, vol. 6, issue 8, September 2019. Page 28. https://mjbizmagazine.com/digital-issues/2019-08-Sept/28/

Figure 2.7 Degree of Cannabis Medical Development/Implementation in Europe, Africa, Asia and Oceania, as of 15 August 2019

Source: Marijuana Business Magazine, September 2019[27].

[27] Marijuana Business Daily, vol. 6, issue 8, September 2019. Page 29. https://mjbizmagazine.com/digital-issues/2019-08-Sept/29/

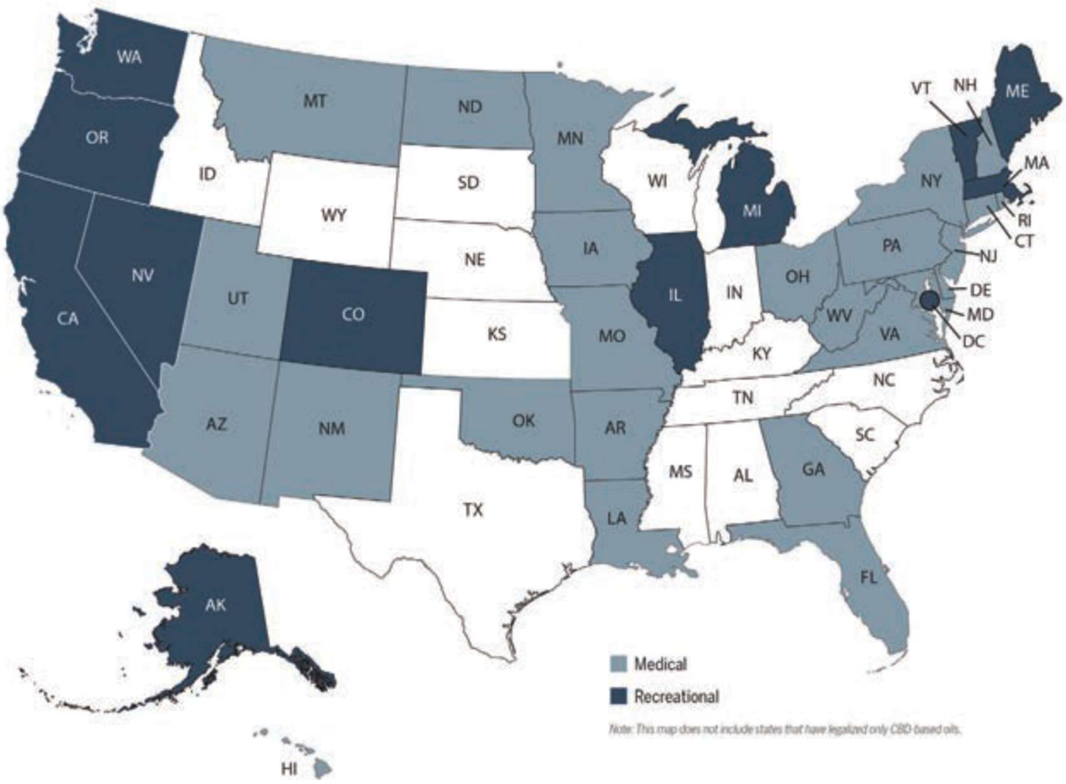


Figure 2.8 Legalization of both Medicinal and Recreational Cannabis in different US states, as of 15 July 2019

Source: Marijuana Business Magazine, September 2019[28].

Figure 2.8 shows the current situation in the United States with cannabis, both medicinal and recreational, as of 15 July 2019. We can clearly appreciate that most of the US states show some kind of legalization, being California and Colorado probably the groundbreaking ones. More information regarding the current situation in the United States will be explained in the following chapter, as this is a key international player with direct impact on most of the world producers, mainly through the international financial system.

According to Wehe (2019, *Personal communication*), the director of *Parque de las Ciencias Free Trade Zone*, Uruguay has an interesting international advantage since there are currently more than 30 countries worldwide which have legalized the consumption of cannabis, and there will probably be 50 in the next years, and only Canada and Uruguay

[28] Marijuana Business Daily, vol. 6, issue 8, September 2019. Page 30. https://mjbizmagazine.com/digital-issues/2019-08-Sept/30/

can legally grow, process, manufacture and export. According to him, using FTZs with this purpose sets a clear advantage related to fiscal issues.

As stated by Vázquez (2019, *Personal communication*), Latin America has a great opportunity regarding cannabis, which is based entirely on legislation. While in Europe and in the United States –after the 2018 Farm Bill– it is possible to grow cannabis containing up to 0.2% and 0.3%, respectively, different Latin American countries laws allow up to 1% THC, such as Uruguay. "*This is a big deal*", according to Vázquez, as the ratio CBD/THC in different cannabis breeds does not change much, so the higher the THC content, the higher the CBD content. This means that putting a limit on THC levels will put a limit on CBD levels as well. It is actually difficult to grow new breeds with proportionally higher CBD content than THC content. Growing cannabis with such a low content of CBD is unprofitable for many industry stakeholders, so if legislation does not change, Latin American countries will have a considerable advantage. This fact is mentioned in almost every international event on cannabis, according to Vázquez.

Pascual (2019, *Personal communication*), international analyst specialized in cannabis markets and regulations, is not so optimistic. He mentioned the FTZs, the easy access to licenses and the possibility to export as positive aspects in Uruguay. Nevertheless, he places our weather, the restrictions to obtain licenses to industrialize, and our lack of experience with the pharmaceutical industry in the negative side. Working with pharmaceutical grade is, according to him, extremely difficult and capital intensive. There is only one company in Germany capable of legally selling medical grade CBD and THC, GMP certified by a German agency, and there is not any non-European company legally authorized to sell pharmaceutical products to Europe. Nothing indicates the inclusion of a Uruguayan company in this list anytime soon (Pascual 2019, *Personal communication*). He believes companies such as Fotmer or Aurora are widely underestimating the complexity of working with API products and that they will probably run out of money and/or time before being able to export pharmaceutical products.

Fotmer announced on 7 November 2019 (Negocios y Tendencias, 2019) to have obtained the GMP certification granted by the MSP. It was regarded as "*another milestone*" by Fotmer CEO Jordan Lewis on his LinkedIn account. After being consulted about this, Pascual (2019, *Personal communication*) replied that *"it is a positive sign, but it does not work to sell to Europe".*

Even though in a technically illegal "*dark grey area*", to Pascual the best current deal is to sell the different CBD products "*on the street*" and without any license. These products have been classified as "novel food" by the EU in 2019 so they require further studies to be legally sold, but Uruguayan companies could sell CBD or THC with this purpose and without the need of pharmaceutical requirements (Pascual 2019, *Personal communication*).

A major issue regarding new (and risky) industries is the political stability of each of the countries which have passed "*cannabis laws*", as it was explained in the previous section. I believe Daniel Podestá, interviewed by Alfredo Pascual from Marijuana Business Daily International, refers to this point very accurately: "*The Uruguayan society, politicians and media have understood the impact of a vigorous cannabis industry for our country in creating jobs, paying taxes and bringing revenues to companies, so any new debate related to this industry is taken very seriously and with no stigmatization.*" (Podestá, 2019, interviewed by Pascual, 2019)[29]. I regard a potential regression in this whole Uruguayan cannabis legalization process as almost nonexistent.

Regarding aquaponics and cannabis, there are indeed companies using this technology to grow cannabis. According to Pascual (2019, *Personal communication*), there are three relevant producers using aquaponics only in Canada: Green Relief[30] rearing tilapia, Habitat Craft Cannabis rearing salmon[31], and Aqualitas[32] rearing koi fish. All of them claim to have achieved great results saving on water and nutrients.

Figure 2.9 Green Relief Inc. Aquaponics Facilities in Hamilton, Canada

Source: McKeil 2018, Cannabis tech 2018[33]

[29] https://mjbizdaily.com/solving-uruguays-adult-use-cannabis-supply-shortfall-and-when-to-expect-the-first-medical-exports-qa-with-attorney-daniel-podesta/?

[30] https://globalnews.ca/news/4924450/aquaponics-cannabis-fish-waste-green-relief/

[31] https://www.newswire.ca/news-releases/habitat-craft-cannabis-ltd-announces-receipt-of-micro-cultivation-license-to-grow-cannabis-at-proprietary-aquaponics-facility-859237028.html

[32] https://cleangreencertified.com/business-directory-2/9201/aqualitas-inc/

[33] https://www.cannabistech.com/articles/cannabis-aquaponics-green-relief-is-the-first-of-its-kind-in-north-america/

2.2 Current National and International Situation with Aquaculture

DINARA, the *National Directorate of Water Resources*, is the agency of the Ministry of Livestock, Agriculture and Fisheries (MGAP) responsible for aquaculture and fisheries.

The following map, according to DINARA, shows the potential of the Uruguayan fishery industry divided by catchments. The degree of suitability is shown from "*not suitable*" (red) up to "highly suitable" (dark green).

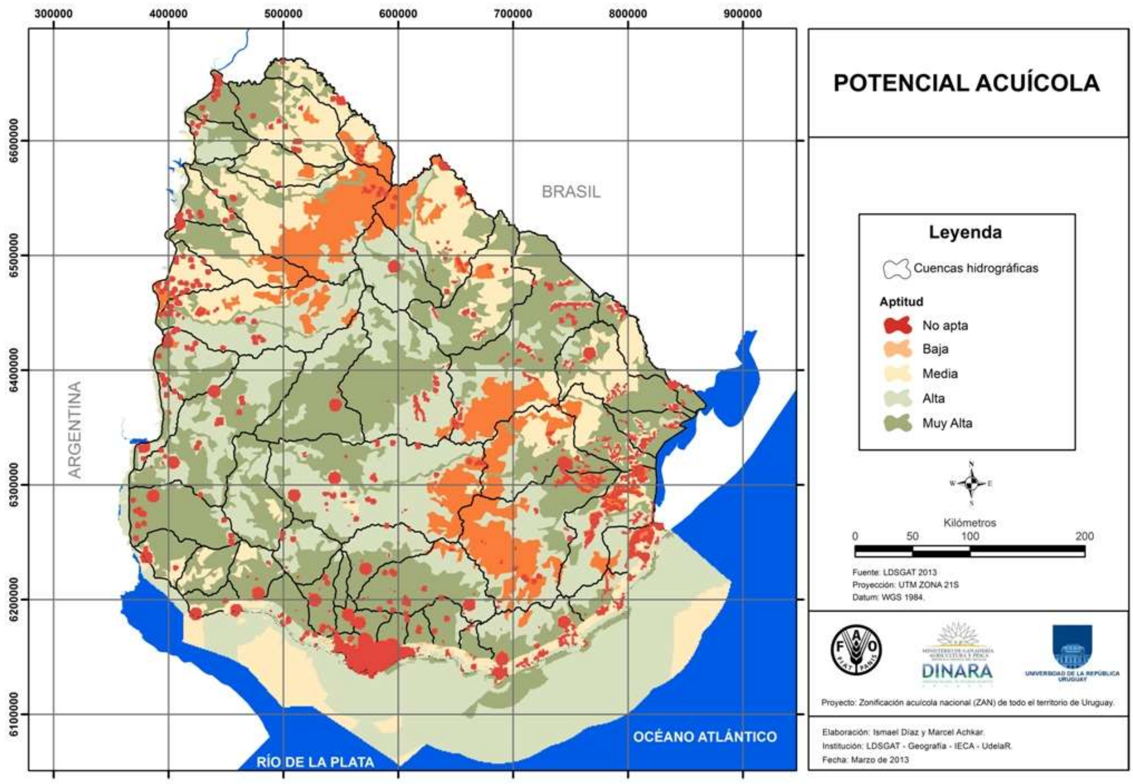


Figure 2.10 Uruguayan Aquaculture/Fishery Potential by catchment (DINARA, 2019)

Source: DINARA, 2019 [34].

Regarding aquaculture[35], although DINARA shows a specific webpage containing a list of "*suitable species for aquaculture*", unfortunately it is "*under construction*" [36]. As explained by Foti (2019, *Personal communication*), barramundi[37] has never been introduced to Uruguay to this date and in fact they have absolutely no knowledge of this particular fish species.

[34] http://www.mgap.gub.uy/sites/default/files/multimedia/mapa_potencial_acuicola.jpg

[35] The activity of rearing aquatic animals, in this case referring only to fish.

[36] http://www.mgap.gub.uy/unidad-organizativa/direccion-nacional-de-recursos-acuaticos/acuicultura/especies-aptas-para-cultivo

[37] SPOILER ALERT: barramundi is chosen in section 3.3 as the best candidate for a cannabis aquaponics system, so this section refers many times to this particular fish species.

Despite not being a very relevant activity in Uruguay, aquaculture has been growing during the past few years. According to DINARA (2019), the first aquaculture undertaking in Uruguay started in 1914 with the introduction of the *Odontesthes bonariensis* ("*Argentinian silverside*" or "*pejerrey*" in Spanish), followed in 1960 by the introduction of the *Ciprinus carpio* (*common carp*) from Brazil.

A new stage in the Uruguayan aquaculture started in 1995 with the introduction of the *Acipenser baerii* (*Siberian sturgeon*) for the company Black River Caviar, as well as new undertakings rearing *Oreochromis niloticus* (*Tilapia)*, *Cherax quadricarinatus* ("*Sweet water lobster*") and *Prochilodus lineatus*, known as "*Sábalo*" in Spanish (DINARA, 2019).

With this new interest in aquaculture from the private sector, this activity was declared of *National Interest* in 1996.

Any new aquaculture undertaking must first start by presenting a thorough project to DINARA including every technical detail of the production process, fish species to rear, estimated quantities and place of origin, as well as notarial certificate of the company responsible for the project. According to Turra (2019, *Personal communication*), a Bachelor in Biological Sciences with vast experience in the Uruguayan aquaculture sector, there is a very important thing to have in this process: *patience*. After having seen the environmental disasters caused by irresponsible introductions of foreign species to many different ecosystems, I am not surprised at all for such a careful and scrupulous approach.

Based on her personal experience, DINARA has very little experience regarding aquaculture and especially considering exotic species. Nevertheless, the whole process looks quite clear and straightforward and all the paperwork is available on the webpage of DINARA. This Directorate even offers a list of experts who can be contacted for support [38].

According to Foti (2019, *Personal communication*), a few previous requests made to introduce new exotic fish species to Uruguay have been declined. When the potential of invasion is assessed as too high, DINARA may rule the prohibition to introduce this particular fish to the country.

Turra (2019, *Personal communication*) is confident that Uruguay complies with all the natural conditions in order to develop a successful aquaculture sector, and considers that the only problem is our mindset. She personally mentioned very successful aquaculture undertakings in southern Brazil right next to our border and in Buenos Aires, so the only difference is our approach to this sector. Argentina and Brazil are in fact supporting aquaculture, while in our country support is only given on papers and intentions, but not on real action (Turra 2019, *Personal communication*).

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[38] http://www.mgap.gub.uy/sites/default/files/multimedia/lista_de_tecnicos_y_profesionales_consultores_en_acuicultura.pdf

Turra (2019, *Personal communication*) believes that another possible explanation for the underdevelopment of this sector is the abundant and good quality of fish offered by our coastline, so prices are extremely low during the season and sometimes during long periods of time. According to her, there is no way for aquaculture products to compete with this situation. She acknowledges, nevertheless, that this situation will probably change in the future due to overfishing, as in many parts of the world. As a result of our great fishing potential, it is no wonder that foreign fishing boats carry out unauthorized fishing activities within the Uruguayan sea area.

She also blamed the general high production costs, for any company, to carry out industrial activities in Uruguay. This issue, combined with low fish prices and lack of government support, make aquaculture in Uruguay a very harsh activity.

Figure 2.11 shows pictures taken by myself in "*Acuicultura Punta Negra*", where Turra successfully grows lobster, Argentinian silverside (*pejerrey*), catfish, herbivorous carp and different ornament fish species from both warm and cold waters. She runs a small but profitable undertaking using semi-intensive techniques, selling fish mainly for ornamental purposes and for farmers and land owners to populate ponds or lakes. The herbivorous carp, for example, is "*like a sheep*" which keeps ponds and artificial lakes free from undesired water plants. The only species she had for meat was lobster and now she only keeps a few animals just as potential breeding males, as it is not profitable.

Santana (2018, *Personal communication*) stated that there are currently no successful projects in operation for meat production in the country (Santana 2018,). There have been aquaculture projects for meat production but only relying on subsidies and governmental support. Most of the fishing industry in Uruguay comes from fishing of wild populations. According to Santana (2018), the only successful aquaculture project in the country is Black River Caviar, which grows sturgeon for both caviar and meat production.

According to Ripoll (2019, *Personal communication*), an international fisheries and aquaculture expert and FAO senior international consultant, Uruguayan aquaculture is definitely a very unattractive sector. He explained that with international prices in such low levels there is no way for the Uruguayan aquaculture sector to compete. He differentiates two clear fish categories: cold water fish species and warm water or "mass consumption" fish species.

Colder water species such as Atlantic salmon or rainbow trout, according to Ripoll, offer high value products with very attractive international markets. Uruguay does not have any natural conditions to raise them, not to mention our warmer summers which are too warm for these species. Regarding warmer water fish species, their international prices are too low and Uruguay does not have natural conditions to raise them either. Our winters are too cold, according to Ripoll. Asian countries enjoy excellent natural conditions and very low production costs. Ripoll made also a very interesting remark about the future of this sector in our country; he believes that the demand for fish will continue to increase in the future, especially for aquaculture products. He sees a future with much more attractive international prices, for most of the current species on the market, so there could be potential for this Uruguayan sector. He mentioned the rising temperatures in our country as well, which could be an important factor for the introduction of new fish species for aquaculture, or for the growth of species currently in our market.

The production process and steps differ much from one species to the other (Turra 2019, *Personal communication*), as requirements between fish species can be quite different. In terms of Uruguayan aquaculture, Turra (2019, *Personal communication*) believes that there are no cases of intensive or extensive fish farming, as most of it is semi-intensive. Extensive aquaculture implies that animals are left in natural environments and feed only and exclusively from natural sources.

From a more international point of view, "*In 2015, aquaculture surpassed wild caught fisheries to supply over half of seafood consumed globally.*" (Richards, 2018 based on Rabobank, 2017). Production from aquaculture is increasing every year while wild caught quantities are decreasing (FAO 2018), so the relative importance of aquaculture has been steadily growing year after year.

Unfortunately, and even though aquaculture does at first seem to be a sustainable practice, it is currently impossible to achieve a completely sustainable intensive aquaculture due to its nutrients requirements (Turra 2019, *Personal communication*). Most of the nourishment for the aquaculture populations is made with fish flour from wild catch. Turra (2019, *Personal communication*) suggests that this is the same situation for most of human activities, and it is even more extreme for livestock or agriculture, so aquaculture should not be to blame.

Figure 2.11 Lobster Aquaculture in "Acuicultura Punta Negra" (Uruguay)

Source: "Acuicultura Punta Negra", lobster production in Maldonado, Uruguay. Picture taken by the author in October 2019.

2.3 Current National Situation with Hydroponics

There are a few hydroponic facilities already in production in Uruguay, with little degree of automation compared to those I visited in Tasmania, Australia (Sanchez 2019, *Personal communication*).

According to many sources interviewed, Álvaro Sanchez is regarded as the leading Uruguayan expert in hydroponics, with a lifetime dedication to this technology and successful international publications translated to many languages. He has personally advised many of the Uruguayan facilities in operation (Sanchez 2019, *Personal communication*) and he referred in a personal interview to many of them, growing from eucalyptus for forestry to strawberries, cantaloupes, watermelons and many different leafy vegetables.

He referred to a specific farmer in *Los Cerrillos* with 3.5 hectares of greenhouses to grow strawberries, so there are indeed large hydroponic facilities. He is currently leading BioCan operations in Uruguay, selling cannabis seeds and growing cannabis plants to Uruguayan companies. With a 10-hectare area in Nueva Helvecia, the first growing stage is 100% with hydroponics.

Figure 2.12 Verde Agua's New Facilities in rural Montevideo, Uruguay

Source: http://www.verdeagua.com.uy/construccion/ (2019)

Verde Agua is one of the largest undertakings working with hydroponics in Uruguay. This company is the only supplier of one of the most important Uruguayan supermarket chains, recently unveiling new facilities of almost 9,000 square meters (Figure 2.12).

2.4 Current National and Regional Situation with Aquaponics

Aquaponics has not been applied in Uruguay as far as I know, at least not in an industrial aquaponics system. There are a few cases in other South American countries which claim to have been successful, although I could not find any reliable scientific proof.

According to Turra (2019, *Personal communication*), this technology is well known among Uruguayan scientists and in general by people interested in aquaculture, but she does not know any project putting it into practice in Uruguay.

Sánchez (2019, *Personal communication*) has personal experience advising a small high school research on aquaponics, but he has no knowledge of any other case in Uruguay.

2.5 Current Situation: Conclusions

The activities and technologies mentioned in this section, not only cannabis growing and aquaponics but also aquaculture and hydroponics, are quite new in Uruguay. The cannabis industry is growing at a rapid pace, nationally and internationally, with permanent changes and new regulations day by day.

Considering cannabis growing and aquaponics, they are brand new worldwide as well, with only a few cannabis undertakings using this technology. Other factors described in this document that raise different ambiguities and controversies have made this research much more difficult than originally expected.

2.6 Regulatory Framework

In this chapter, I have outlined the most relevant laws, decrees, regulations and resolutions that affect this project.

A couple of resolutions regarding and addressed only for psychoactive cannabis, such as Decree 79/2016, are not even listed, as they do not have any impact on this project.

2.6.1 Law 19,172: "Cannabis Law" (2013)

The entire cannabis legalization process in Uruguay started in December 2013 with the passing of this law, commonly known as the "*cannabis law*".

It decriminalized this market completely (consumption had never been illegal), regulating the growing, production and sales of cannabis and its derivatives. Initially, its main objective was the fight against drugs trafficking, so the main focus was not medicinal cannabis but recreational.

2.6.2 Decree 120/2014 (Law 19,172)

This decree of 2014 takes the guidelines from Law 19,172 and regulates non- medicinal psychoactive cannabis, from production and distribution, up to the selling points to the final consumer.

The faculties and responsibilities of the IRCCA are also regulated by this Decree.

2.6.3 Decree 372/2014 (Industrial non-psychoactive cannabis)

Decree 372/2014 defines non-psychoactive cannabis (hemp) and establishes the projects and activities regulated by the Ministry of Livestock, Agriculture and Fisheries (MGAP).

It creates the "*Registro Único de Operadores*" and establishes the documents and administrative procedures for this industry.

2.6.4 Decree 46/2015 (Medicinal cannabis)

This Decree establishes the activities and topics subject to scientific investigation and for manufacture of pharmaceutical products (INFO CANNABIS, 2019).

2.6.5 Decree 298/2017 (CBD and use of medicinal cannabis)

This regulation allows the sale of cannabinoids in pharmacies and with medical prescription. The product must be registered in the Ministry of Public Health (MSP).

2.6.6 Resolution 19/2016 from DNA[39]

In 2016, the DNA (*National Customs Directorate*) issued a resolution to establish the necessary administrative procedures for imports and exports of psychoactive and non-psychoactive cannabis.

2.6.7 Decree 173/2010 ("Microgeneration" from renewable energy sources; 2010 and 2016)

This Decree is a keystone in the development of renewable energies in our country. It allowed any grid user to be able to generate electricity from any renewable energy source (solar, wind, biomass, etc.) and use the grid without any charge. UTE, the Uruguayan electric power utility, must buy the excess energy generated at the same retail price as the consumer/generator is being charged.

The maximum capacity to install is 100 kWp for 230V users and 150 kWp for 400V users, and it is only available to low-voltage users. High-voltage users were not considered for renewable energy generation before the arrival of Decree 114/2014 (described and analysed on the following page).

From 2010 to 2016 it was allowed to install as much renewable energy power as the grid user requested, with the only limitation being the user´s installed capacity. In December 2016 the application of this regulation changed and another condition was introduced: it was possible to install as much capacity as the client's consumption allowed it to, it was not possible anymore to generate/sell more energy to the grid than the amount consumed throughout the year.

As microgeneration started to be a business by itself (together with other political and economic reasons) and not just the possibility to be self-sufficient, UTE added this new restriction which slowed down the rapid growth of this industry right from the introduction of this Decree.

[39] https://www.aduanas.gub.uy/innovaportal/v/15199/5/innova.front/resolucion-general-19_2016.html

2.6.8 Decree 114/2014 (Renewable energy generation “*without injection*”)

This Decree allowed the possibility to generate electricity from renewable energy sources for self-consumption, without injecting electricity to the grid, and it considered any grid user. Nevertheless, it was addressed for high-voltage users not able to use the Decree 173/2010 for microgeneration.

Large high-voltage electricity consumers are now allowed to install renewable energy plants in order to generate electricity for their own use, whereas they do not inject any electricity to the grid at any time. Every new plant must be studied and allowed by UTE, under specific technical requirements.

2.6.9 Law 19,402: Aquaculture (2016)

This Law declared aquaculture a farming activity, such as agriculture and livestock, so the tax benefits addressed to the above industries became also applicable to it. This Law mentions specifically the Value Added Tax for goods and raw materials to be used in this activity, but any tax deduction and credit is tacitly and indirectly included.

2.6.10 Decree 259/1996 (Aquaculture declared of “*National Interest*”)

Decree 259 of 1996, based on the growing importance of aquaculture at an international and regional level and its potential impacts in our country, declared the aquaculture activity of *National Interest*.

2.6.11 Taxes Regulations and Labour Legislation (DGI, BPS, MTSS, etc.)

There are many different laws, decrees, regulations and resolutions regarding income, import and sales taxes that will be relevant to this project. Even though the most important will be those addressed for companies working inside FTZs, most of the regulations for Uruguayan “national” companies will be applicable for those sales to Uruguayan economic agents.

Labour regulations will also apply for this project, with only a few exceptions for carrying out activities inside a FTZ. The most important of these exceptions is applicable for non-residents who choose not to pay social security in our country and do so in their home country instead.

2.6.12 Law 19,574: Comprehensive Anti-Money Laundering Law (2018)

The Comprehensive Anti-Money Laundering Law, passed in 2014 and updated in November 2018, established different obligations for both professionals and organizations concerning the detection of illegal activities of money laundering.

"*This new law will affect any person or company that is regulated by the Central Bank of Uruguay (CBU). The law divides the obligated parties into two categories, 1) financial fellows and 2) non-financial fellows.*

Financial fellows are regulated by the Central Bank and include:

- *Banks*
- *Trustees*
- *Money Exchange Companies*
- *Stock Exchanges*
- *Pension Funds*
- *Investment Fund Administrators*
- *Investment Advisors*

The non-financial fellows are the newly obligated party and include:

- *Lawyers when they act on behalf of their clients*
- *Free Zone companies*
- *Political Parties*
- *Foundations*
- *Any non-profit organization*
- *Public Accountants when they act as an independent advisor*
- *Trusts*
- *Any corporate services provider*
- *Public Notary*

In Uruguay, any private person could be a nonprofessional trustee. They could act as trustee in private trusts which are not regulated by the CBU. This could cause money laundering to occur in the past but now with this law, the situation will change since they will have to adhere to the new AML policies.

This law will help all the regulated companies to collect information about their clients or the beneficial owners of the client. The people affected by this law will have to verify the origination of funds, and analyse their clients and report any suspicious activity to the Central Bank." (Improta, 2018, TMF Group)[40]

[40] https://www.tmf-group.com/en/news-insights/articles/2018/may/money-laundering-law-uruguay/

There are other resolutions and different regulations[41], and even a new law passed in May 2019 (*Law 19,749: Law against the Financing of Terrorism and the Proliferation of Weapons of Mass Destruction*[42]) updating and improving Law 19,574. All of them focus on the same principles explained in the previous page.

2.6.13 Law 19,921: Free Trade Zones (1987)

The *Free Trade Zone (Zonas Francas)* regime was created in 1987, and has undergone several changes in order to improve the system, regulate the interactions between companies inside and outside FTZs, and finally in 2018 in order to align our legislation to OECD[43] requirements.

This Law and further regulations are explained in detail in section 3.6.

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[41] https://www.gub.uy/secretaria-nacional-lucha-contra-lavado-activos-financiamiento-terrorismo/institucional/normativa?field_tipo_de_norma_target_id=All&field_tematica_target_id=All&field_publico_target_id=All&year=all&month=all&page=0

[42] https://www.gub.uy/secretaria-nacional-lucha-contra-lavado-activos-financiamiento-terrorismo/comunicacion/noticias/se-aprobo-ley-contra-el-financiamiento-del-terrorismo-y-de-la-proliferacion

[43] Organization for Economic Co-operation and Development.

3. Research and Analysis

This research work proved to be very complex for me, a completely new area of study for someone with little or no previous experience or knowledge on these fields.

Being such a broad field of study, I had to rely widely on research papers and experts, and then make a few important assumptions. Most of these assumptions were based on solid experts' perspectives and opinions, research data and information.

3.1 Hydroponics

Even though this research focuses on the production of cannabis using hydroponics and aquaponics, I have briefly analysed the current hydroponic systems based on field research (Australia and Uruguay), experts' interviews and data from different research papers.

3.1.1 Brief Introduction to Hydroponics

According to Maucieri et al. (2019), hydroponics systems can be classified in two main categories: *open cycle systems* and *closed loop systems*. According to the same research, "*regarding economics and environmental concerns, soilless systems should be as closed as possible*" (Maucieri et al. 2019)

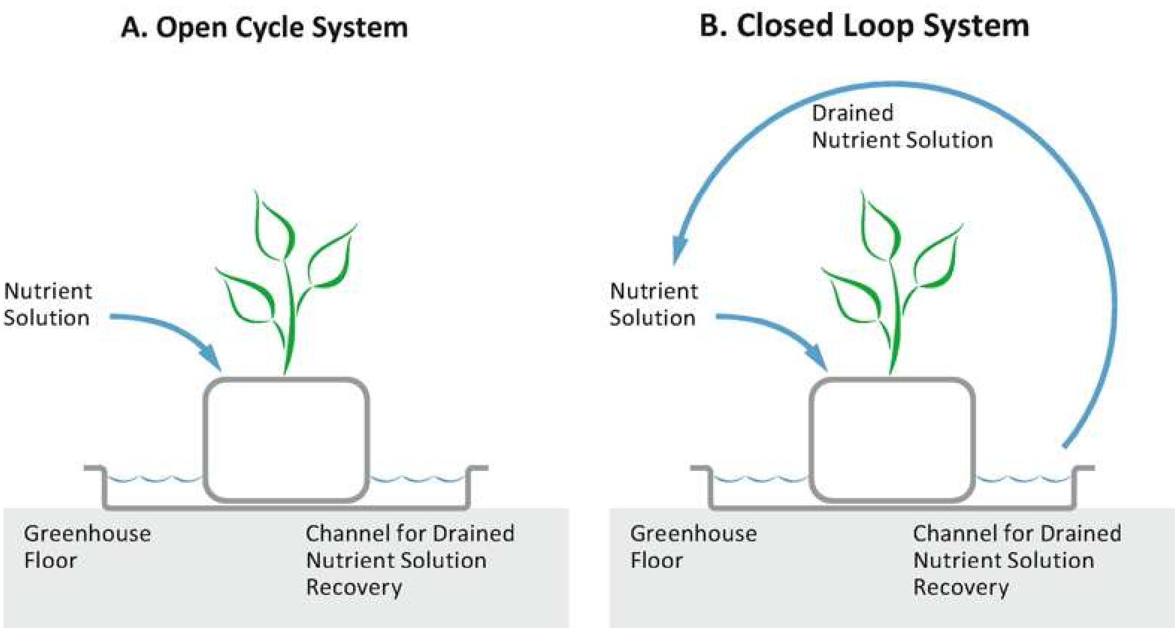

Figure 3.1 "Scheme of open cycle (a) and closed loop systems (b)" (Maucieri et al. 2019)

Source: Maucieri at al. 2019

Characteristic	Categories	Examples
Soilless system	No substrate	NFT (nutrient film technique)
		Aeroponics
		DFT (deep flow technique)
	With substrate	Organic substrates (peat, coconut fibre, bark, wood fibre, etc.)
		Inorganic substrates (stone wool, pumice, sand, perlite, vermiculite, expanded clay)
		Synthetic substrates (polyurethane, polystyrene)
Open/closed systems	Open or run-to-waste systems	The plants are continuously fed with "fresh" solution without recovering the solution drained from the cultivation modules
	Closed or recirculation systems	The drained nutrient solution is recycled and topped up with lacking nutrients to the right EC level
Water supply	Continuous	NFT (nutrient film technique) DFT (deep flow technique)
	Periodical	Drip irrigation, ebb and flow, aeroponics

Figure 3.2 "Classification of hydroponic systems according to different aspects" (Maucieri et al. 2019)

Source: Maucieri at al. 2019

"The advantages of soilless systems compared to soil grown crops are:

- *Pathogen-free start with the use of substrates other than soil and/or easier control of soil-borne pathogens.*
- *Growth and yield are independent of the soil type/quality of the cultivated area.*
- *Better control of growth through a targeted supply of nutrient solution.*
- *The potential for reusing the nutrient solution allowing for maximizing resources.*
- *Increased quality of produce gained by the better control of other environmental parameters (temperature, relative humidity) and pests."* (Maucieri et al. 2019)

Maucieri et al. (2019) made an extremely comprehensive review about the current situation with hydroponics in the publication “Aquaponics Food Production Systems” (Goddek et al. 2019). Not only that, but this research was released right during the development of my research. For these reasons, I have based most of my hydroponics introduction on this particular research undertaking, as well as most of the information on aquaponics.

According to this research, “*The advantages of closed systems are:*

- *A reduction in the amount of waste material.*
- *Less pollution of ground and surface water.*
- *A more efficient use of water and fertilizers.*
- *Increased production because of better management options.*
- *Lower costs because of the savings in materials and higher production.*

There are also a number of disadvantages such as:

- *The required high water quality.*
- *High investments.*
- *The risk of rapid dispersal of soil-borne pathogens by the recirculating nutrient solution.*
- *Accumulation of potential phytotoxic metabolites and organic substances in the recirculating nutrient solution.*” (Maucieri et al. 2019)

According to Maucieri et al. (2019), hydroponic systems can be classified according to the categories listed in Figure 3.2. From those with substrate, the different categories are listed in Figure 3.3. Some kind of substrate is important mainly to serve a support for the plant, and it should be inexpensive and readily available (Maucieri at al. 2019)

This is not the main focus of this research, so I will not get into much detail about the different kind of substrates and their respective advantages and disadvantages.

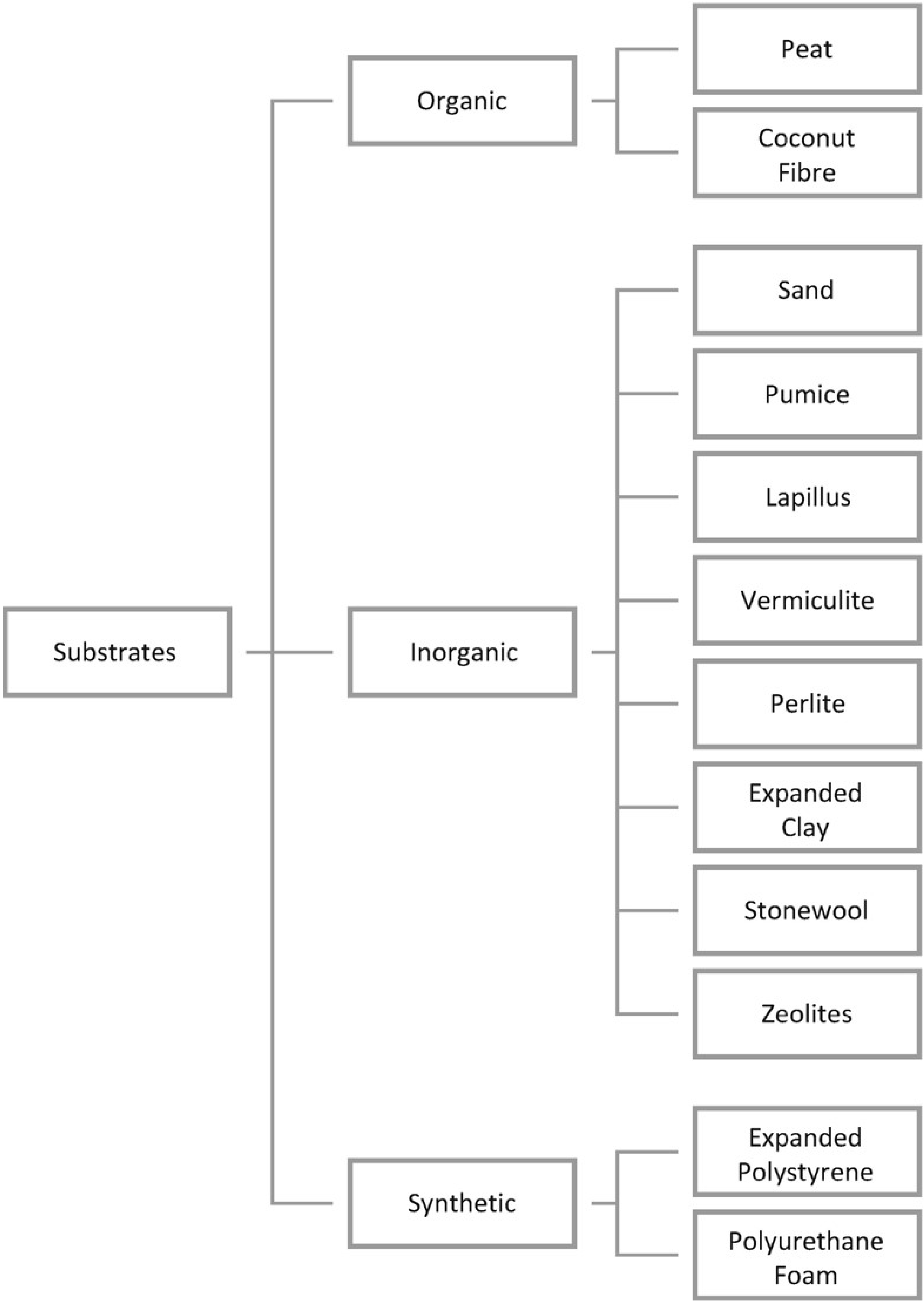

Figure 3.3 "Materials usable as substrates in soilless systems" (Maucieri at al. 2019)

Source: Maucieri at al. 2019

3.1.2 Different Hydroponic Techniques: Selection for Cannabis

I will briefly analyse the main hydroponic techniques and, mainly based on experts' opinions and information from current market players, I will select one of these techniques.

3.1.2.1 Deep Flow Technique (DFT)

The Deep Flow Technique (DFT) was the first hydroponic technique I encountered in a real commercial facility. This was the technique chosen by Steve Gleeson for his company: *Pure Ponics*. It seems by all means the easiest of all and in accordance with the literature reviewed and to expert's opinions, it is the ideal technique for rapid growing crops such as lettuce, rocket or other aromatic herbs.

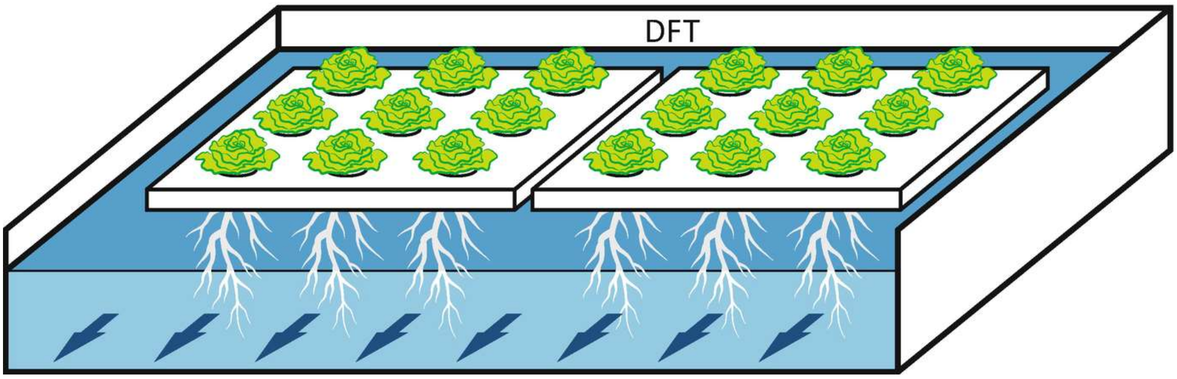

Figure 3.4 Illustration of the Deep Flow Technique

Source: Maucieri at al. 2019

The plants are allocated in holes on floating panels, with or without some kind of substrate. It is also referred to as *raft system* or *floating-raft system* by other researchers. This is clearly not suitable for heavy plants such as cannabis, in any of its varieties.

3.1.2.2 Nutrient Film Technique (NFT)

Hills Nursery (Tasmania, Australia), the second facility visited by me, has been using this technique for decades. It is Tasmania's oldest and largest supplier of vegetable and herb seedlings to the agricultural industry, where I was able to see many different greenhouses, most of them using NFT. Their industrial processes are quite automated.

This technique, such as the DFT, is very suitable for light, small and rapid growing plants.

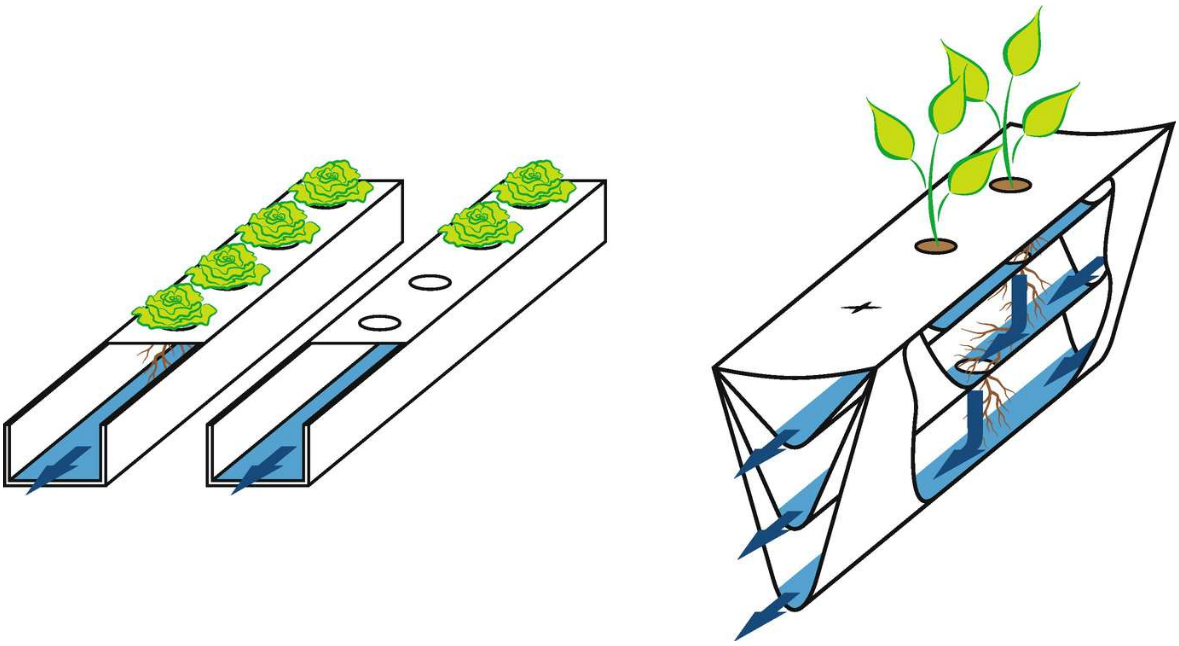

Figure 3.5 Illustration of the Nutrient Film Technique (NFT)

Source: Maucieri at al. 2019

Even though Maucieri et al. (2019) states that this is a technique without substrate, it was not the case in any of the facilities I visited. A small amount of substrate is always needed in order to provide support for the plant's roots.

In highly automated facilities, such as Hills Nursery, the distance between plant rows (Figure 3.5, left image) is automatically changed by mechanical systems, allowing more space for each plant as they grow.

3.1.2.3 Medium-based Systems

Most of the researchers reviewed mention DFT, NFT and medium-based techniques as the most widely used hydroponic techniques. Medium-based hydroponics can be displayed as shown in Figures 3.6 and 3.7, or just using pots.

In figures 3.6 and 3.7 it is possible to observe the heating system on the floor, which works using hot water pumped from a centralized heater to the whole greenhouse. The thin white tubes carry the water with the nutrients right to the roots of each plant, and at the end of each row there is a drain for the spare water.

Both figures are pictures taken by the author of this research in November 2018 when visiting Brandsema's hydroponics. The level of automation of this facility was impressive, at least for someone with no previous experience in hydroponics.

In Brandsema's hydroponics, water is automatically pumped to the roots of each plant by a centralized system according to each row's water and nutrients needs. The water running out of the plants is automatically measured and registered by a centralized system. Water nutrients level is permanently and automatically analysed by salinity analysis, based on which either more nutrients or more water is added. If salinity is too high, more water is added, but if it is too low, more nutrients are added to the system. Nutrients come from tanks with a pre-set mixture of nutrients. This mixture depends on each plant's needs. There is a specific mixture for tomatoes and another for cucumber, for example.

Atmospheric CO2 inside the greenhouse is kept at 1,200 ppm[44], three times higher than the average level in the atmosphere. This is automatically regulated by the system "deciding" on the heating system to use to raise the temperature (gas or wood) and the opening of the top windows of the greenhouse. Using wood to heat up the greenhouse, for example, offers more CO2.

Crops grown for fruits, such as these in Brandsema's (tomatoes, cucumber and capsicum) receive a "cold strike" every late afternoon by opening the windows, right at the time when temperature reaches a certain point. The system quickly reduces the temperature down to a point where every plant is "shocked", and after a natural reaction the fruits receive more energy and nutrients, as a response of a potential death of the plant. This is not the case with "leafy plants" (lettuce, kale or aromatic herbs), as they are grown for their leaves and not for fruits.

Substrate is changed for a new one every 4 to 5 years. This particular company uses coconut fibres. The whole system information is displayed in graphs in real time.

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[44] Ppm stands for parts per million

Figure 3.6 Medium-based Hydroponics in Tasmania (Tomatoes)

Source: Brandsema's hydroponic tomato production in Tasmania, Australia.
Picture taken by the author in November 2018.

Figure 3.7 Medium-based Hydroponics in Tasmania (Capsicum)

Source: Brandsema's hydroponic capsicum production in Tasmania, Australia. Picture taken by the author in November 2018.

3.1.2.4 Aeroponics Technique

Maucieri et al. (2019) includes aeroponics as another hydroponic technique, although according to my literature review aeroponics is normally considered as another technology, different from hydroponics.

"*The US National Aeronautics and Space Administration (NASA) describes aeroponics as the process of growing plants suspended in air without soil or media providing clean, efficient, and rapid food production. NASA furthermore notes that crops can be planted and harvested year-round without interruption, and without contamination from soil, pesticides, and residue and that aeroponic systems also reduce water usage by 98%, fertilizer usage by 60% percent, and eliminate pesticide usage altogether. Plants grown in aeroponic systems have been shown to absorb more minerals and vitamins, making the plants healthier and potentially more nutritious*" (Maucieri et al. 2019, based on NASA)

This is an extremely capital intensive technology, with high running costs.

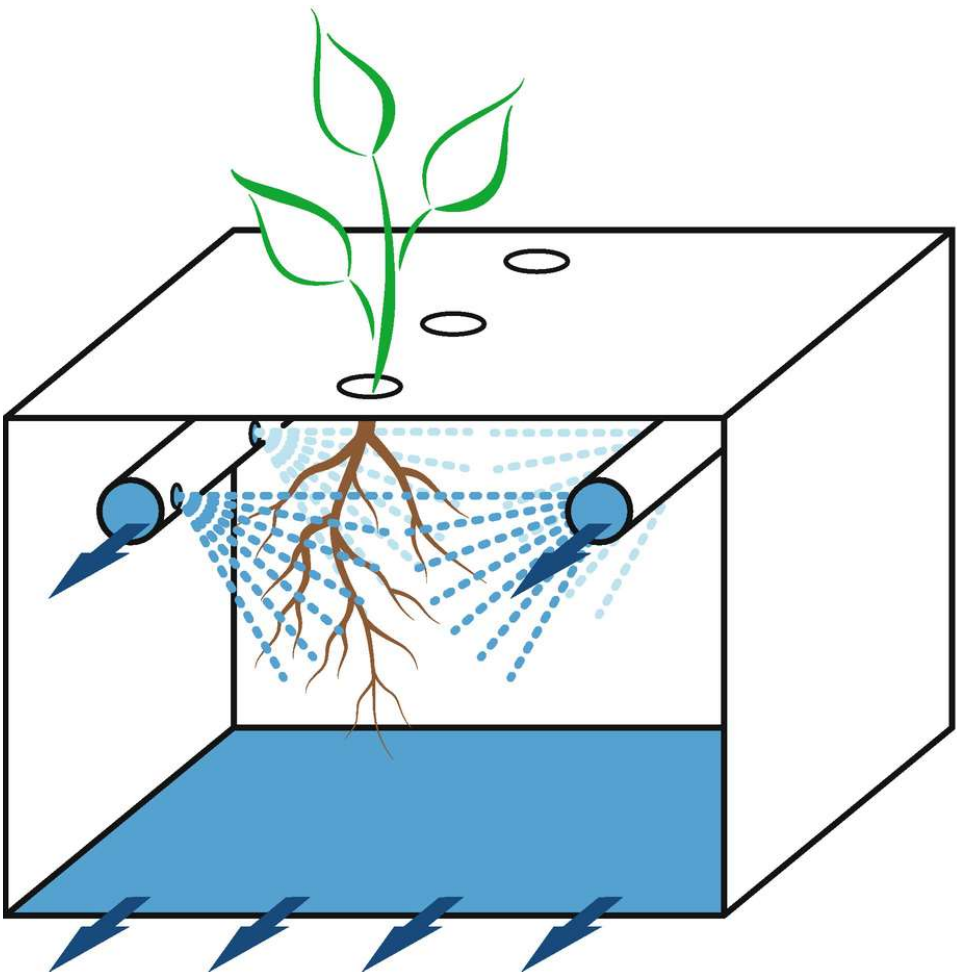

Figure 3.8 Aeroponics System

Source: Maucieri at al. 2019

3.1.2.5 Hydroponic System for Cannabis

According to many experts interviewed (Saldías 2019, Figuerón 2019 and others, P*ersonal communications*), most of the current intensive cannabis production is carried out in medium-based hydroponic systems. One of the most important reasons is probably the average size of a cannabis plant.

Apart from that, another research of Goddek et al. (2019) shows that most aquaponics systems are developed with this particular hydroponic system: medium-based.

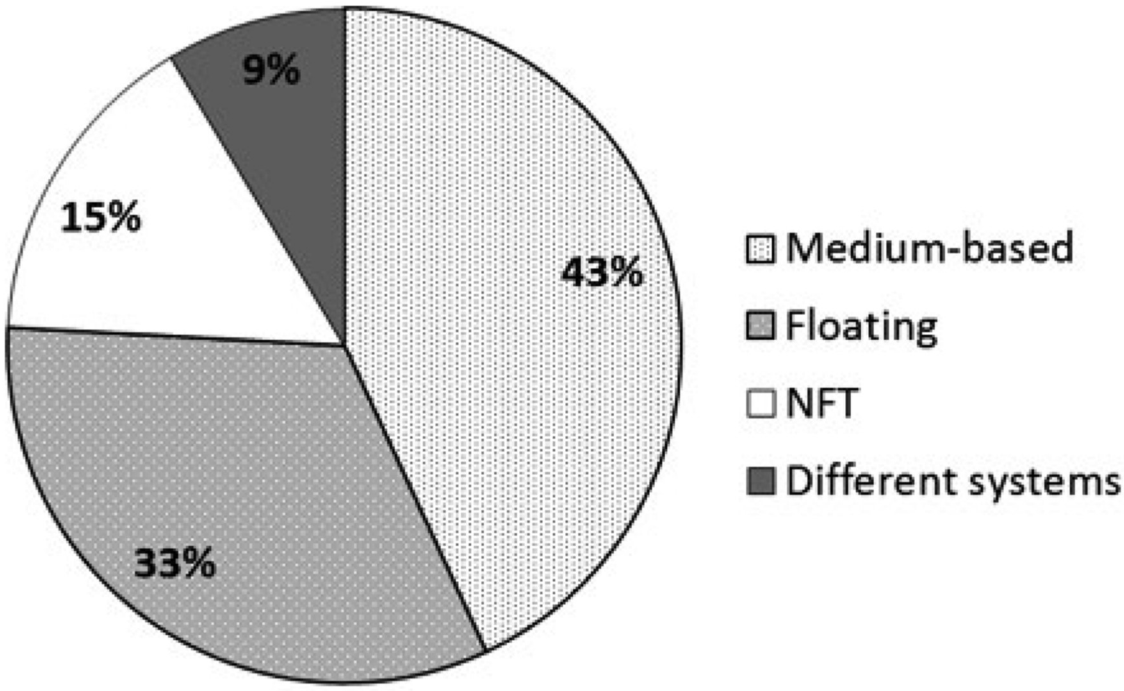

Figure 3.9 Most Frequently Hydroponic Technique Studied on Aquaponics (Maucieri et al. 2018)

Source: Maucieri et al. 2018; Percentage of papers for each type of hydroponics implemented in aquaponic systems (Total number of papers: 58)

I believe there is not much doubt about the kind of hydroponics to use for cannabis, although further research should be conducted in order to better support this decision.

I must also mention that Green Relief, the Canadian aquaponics company that claims to have achieved great results working with cannabis and tilapia, uses a rafting system. The cannabis breed they use looks quite small compared to other cases, which could be one of the reasons.

3.1.3 Current Average "Fully-Automated" Hydroponic Systems

It has not been easy to understand the current state of the art fully automated hydroponic system. In figure 3.10 I have displayed its most important aspects, according to what I have concluded during this research.

I have based my analysis mainly on actual hydroponic facilities I have visited, such as Brandsema's in Tasmania, and from interviewing field experts such as Victor Ulloa (2019). Such a system is completely automated and "self-monitored", displaying the system data in real time. Further details on Brandsema's can be found in section 3.1.2.3.

Farmers need to keep track of the system performance according to the data offered by the monitoring devices, and be sure that there is enough water and nutrients on each of the tanks. The specific mixture of nutrients depends on the plant being grown, so the plants in this section should have the same or almost the same nutrients needs. Should this not be the case, two or more different systems should be set in order to have a different pre-set mix of nutrients for each system.

Analyses on each nutrients tank are carried out every few weeks to be sure that the mixture is the right one. This specific mix is normally made by farmers in large facilities, or purchased premixed and ready to use from suppliers in other cases. For specific or new plants on the market, such as cannabis, I have the impression this mixture is a well preserved "secret".

There is a close loop system in which water runs through the roots of every plant, receiving their nutrients needs from the nutrients tanks. The system automatically monitors the amount of nutrients on the system by doing an instant salinity analysis. If salinity is higher than the desired range, it means that nutrients density in the system is too high and then water is added. If salinity happens to be lower than the desired level, it means that the systems lacks of nutrients and therefore more nutrients are added. This is made automatically.

Water pumps are used to keep the water moving, as well as to add water or nutrients. The amount of water pumped to the plants is also accurately calculated in an automated way, as the residual water that comes out of the plants is permanently measured. If too much water is running out of the plants, it means that less water should be pumped to them. I believe gravity is in charge of moving water from the hydroponic system back to the tanks, and then a water pump does the job from the tanks back to the hydroponics.

Pest control is normally made by natural and ecological means. Brandsema's uses specific insects in order to fight specific pests, and in some extreme cases they use very soft pesticides. These pesticides are applied by an automated and self-controlled machine, which runs row after row doing its job.

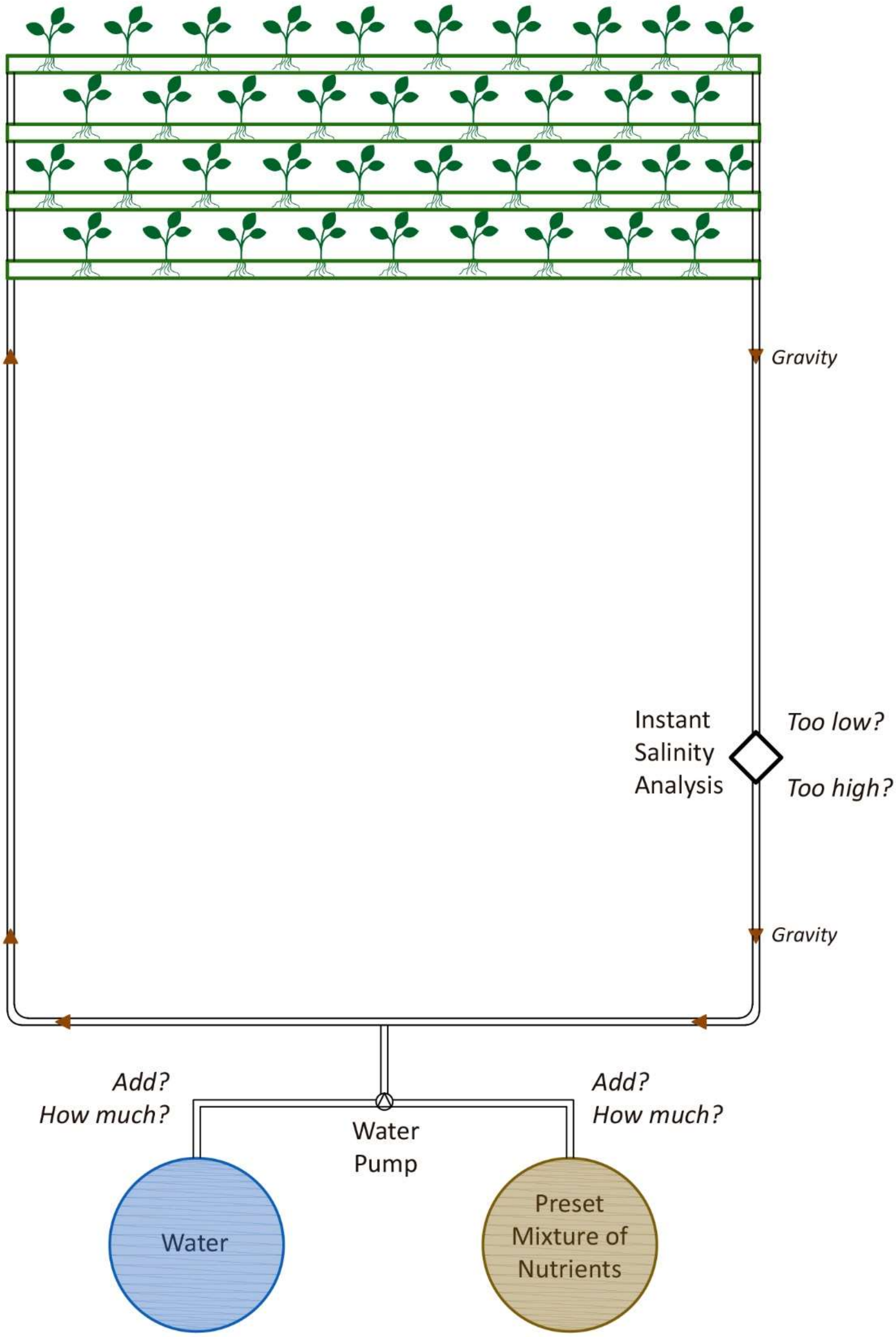

Figure 3.10 Current Average "Fully-Automated" Hydroponic Systems

Source: Self-made (2019), based on interviews with experts and entrepreneurs, and on the review of specialized literature.

3.2 Cannabis

In this section, I will analyse in depth those aspects of the current situation of the cannabis sector in Uruguay directly affecting this project, mainly regarding authorizations.

3.2.1 Registrations and Authorizations

From the moment I started with this research up to the moment when I was about to finish, I noticed changes in the categories of the different licenses available. Most of them were not so relevant but a few others were indeed.

When the IRCCA web page was updated in September 2019, a fourth license category was added: Category T, specific to operate in FTZs and other tax free areas, including goods in transit. This clearly reflects the current situation of this business, further explained in section 3.6.

As of October 2019, there are four types of licenses available to work with cannabis according to the information displayed on Table 3.1. I have decided to keep in this document the tables with the licenses being offered by IRCCA at least in the first semester of 2019, which are in Tables 3.4, 3.5 and 3.6.

For this project I will require:

- A license from the Ministry of Agriculture, Livestock and Fisheries (MGAP) to grow non-psychoactive cannabis
- 1 C license Category 4 from the Institute for the Regulation and Control of Cannabis (IRCCA) to manufacture in order to produce CBD (UI 400,000).
- 1 T license from IRCCA in order to operate in a FTZ (UI 50,000).

The total amount needed for these licenses reaches UI 450,000, which is approximately **USD 52,000 annually**.

Table 3.1 IRCCA's authorizations and licenses available (Nov. 2019) [45]

Project Code	Description	Requires License	Categorization	Amount in UI [46]	Period granted
I	*Scientific investigation financed exclusively with public funds*	*YES*	*N/A*	*N/A*	*Per project*
	Scientific investigation totally or partially financed by private funds	*YES*	Category 1	*10,000*	*Per project*
			Category 2	*25,000*	
			Category 3	*45,000*	
			Category 4	*60,000*	
C	Farming, harvesting, drying, storage and primary commercialization	*YES*	Category 1	*50,000*	Annual
			Category 2	*100,000*	Annual
			Category 3	*200,000*	Annual
			Category 4	*400,000*	Annual
P	Commercialization and industrialization	*YES*	Category 1	*50,000*	Annual
			Category 2	*100,000*	Annual
			Category 3	*200,000*	Annual
			Category 4	*400,000*	Annual
T	*To operation in Free Trade Zones and other tax-free areas with manufactured products or in bulk, in transit*	*YES*	*N/A*	*50,000*	*Annual*

Source: IRCCA 2019; Institute for the Regulation and Control of Cannabis.

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[45] https://www.ircca.gub.uy/proyectos-cannabis/#costos-licencia

[46] UI (*Unidades Indexadas)* means "Indexed Units", a parameter measured in UYU (Uruguayan Pesos) indexed to the inflation in Uruguay, updated every day. By Oct. 30 2019, UI 10,000 equals approx. USD 1,150.

Table 3.2 Criteria to determine P licenses: production of derivatives (Nov. 2019)

Dimension	Category 1	Category 2	Category 3	Category 4
Initial investment (USD)	Up to 200,000	200,001 – 1,000,000	1,000,001 – 5,000,000	+ 5,000,000
Vegetable raw materials to process (Kg)	Up to 750	751 – 2,500	2,501 – 5,000	+ 5,000
Raw material, crude extract and/or modified (< 90% w/w in cannabinoids) (Kg)	Up to 100	100 – 500	501 – 2,000	+ 2,000
Purified extract (≥ 90% w/w in cannabinoids) or technological processed from purified (Kg)	Up to 2	2 – 10	11 – 40	+ 40

Source: IRCCA 2019; Institute for the Regulation and Control of Cannabis.

Table 3.3 Criteria to determine C licenses: Farming, harvesting, drying, storage and primary commercialization (Nov. 2019)

Dimension	Category 1	Category 2	Category 3	Category 4
Initial investment (USD)	Up to 500,000	500,001 – 1,000,000	1,000,001 – 2,000,000	+ 2,000,000
Maximum blooming plants at any moment	Up to 1,250	1,251 – 2,500	2,501 – 5,000	+ 5,000
Maximum vegetative plants at any moment	Up to 1,250	1,251 – 2,500	2,501 – 5,000	+ 5,000
Production per year (Kg)	Up to 750	751 – 2,500	2,501 – 5,000	+ 5,000

Source: IRCCA 2019; Institute for the Regulation and Control of Cannabis.

Table 3.4 IRCCA's authorizations and licenses (valid only up to first semester 2019)

Project Code	Description	Requires License	Categorization	Amount in UI	Period granted
I	Non-profit scientific investigation, with no farming activities	NO [47]	N/A	N/A	N/A
	Non-profit scientific investigation, including farming	YES	Farming of up to 6 blooming female plants and up to 6 vegetative plants	Free of charge	Per project
			Farming of more than 6 blooming female plants and 6 vegetative plants	Between 10,000 and 50,000	Per project
C	Farming, harvesting, drying, storage and primary commercialization	YES	Category 1	50,000	Annual
			Category 2	100,000	Annual
			Category 3	200,000	Annual
			Category 4	400,000	Annual
P	Commercialization and industrialization	YES	Category 1	50,000	Annual
			Category 2	100,000	Annual
			Category 3	200,000	Annual
			Category 4	400,000	Annual

Source: IRCCA 2019; Institute for the Regulation and Control of Cannabis.

The changes in the license categories are probably the result of the experience gained by IRCCA after the first license requests. They are also another proof of the rapid changes taking place in this growing market.

[47] Requires previous IRCCA authorization.

Table 3.5 Criteria to determine P licenses: farming, harvesting, drying, storage and primary commercialization (valid only up to first semester 2019) [48]

Dimension	Category 1	Category 2	Category 3	Category 4
Initial investment (USD)	Up to 500,000	500,001 – 1,000,000	1,000,001 – 2,000,000	+ 2,000,000
Maximum blooming plants at any moment	Up to 1,250	1,251 – 2,501	2,501 – 5,000	+ 5,000
Maximum vegetative plants at any moment	Up to 1,250	1,251 – 2,501	2,501 – 5,000	+ 5,000
Production per year (kg)	Up to 750	751 – 1,500	1,501 – 3,000	+ 3,000

Source: IRCCA 2019; Institute for the Regulation and Control of Cannabis.

Table 3.6 Criteria to determine P licenses: production of derivatives (valid only up to first semester 2019) [49]

Dimension	Category 1	Category 2	Category 3	Category 4
Initial investment (USD)	Up to 500,000	500,001 – 1,000,000	1,000,001 – 2,000,000	+ 2,000,000
Raw material to process (kg)	Up to 750	751 – 1,500	1,501 – 3,000	+ 3,000

Source: IRCCA 2019; Institute for the Regulation and Control of Cannabis.

The **Institute for the Regulation and Control of Cannabis (IRCCA)** has the discretionary authority to analyse specific projects and grant special licenses with different requirements and fees.

[48] In case of conditions verified in more than one category, the higher fee will apply.
[49] IDEM from table above.

Despite not directly related to this research, I have added anyway the characteristics of "I" and "L" licenses, for scientific investigation and laboratories respectively.

Table 3.7 Criteria to determine I licenses: Scientific investigation totally or partially financed by private funds [50]

Dimension	Category 1	Category 2	Category 3	Category 4
Initial investment (USD)	Up to 5,000	5,001 – 15,000	15,001 – 30,000	+ 30,000

Source: IRCCA 2019; Institute for the Regulation and Control of Cannabis.

Table 3.8 Authorizations for laboratories for the quantification of cannabinoids

Type	Description	Amount in UI	Period granted
L	Authorization for laboratories	11,200	First year
		8,000	Annual renewal

Source: IRCCA 2019; Institute for the Regulation and Control of Cannabis.

The **Ministry of Livestock, Agriculture and Fisheries (MGAP)** may also grant licenses to grow cannabis, but only for those projects involved in farming non-psychoactive cannabis (less than 1% THC). This license is considerably easier to obtain and much less costly than IRCCA's authorizations, as it only requires to pay a fee of UYU 200[51]. If it involves production it can only be to produce food (oil, cereal bars, etc.), as CBD extraction requires IRCCA authorizations. Agronomists who act as technical advisors must also register in the R.U.O.[52] of the D.G.S.A.[53] and pay this fee.

This cannabis license request process, either through **IRCCA** or through **MGAP** is always accompanied by a comprehensive analysis carried out by the **SENACLAFT, the (Uruguayan) National Secretariat for the Fight Against Money Laundering and the Financing of Terrorism (SENACLAFT)**. This analysis looks into the real source of the funds in order to avoid/reduce the risk of money laundering.

[50] Requires previous IRCCA authorization.
[51] UYU 200 equals to approximately USD 5 by 30 October 2019.
[52] R.U.O. stands for *Registro Único de Operadores*.
[53] D.G.S.A. stands for Dirección General de Servicios Agrícolas.

The National Institute for Seeds (INASE, *Instituto Nacional de Semillas*) has a list of current 51 cannabis seeds that can be legally used in Uruguay (See Appendix). This Institute is responsible for checking on genetics after licenses are approved.

3.2.2 Production Yields in Uruguay and Prices

I have received many different versions of potential production yields of an intensive cannabis production in Uruguay. From my initial thought about finding growing tables and estimated yields for different cannabis breeds, I found there is little about that and, according to many stakeholders' opinions, most of the projected yields from wholesalers are only under perfect conditions and in general far from the actual ones. Every stakeholder interviewed mentioned the existence of different opinions in the market and different figures.

According to Rodriguez Lepera (2019, *Personal written communication*), the price for 1 kilogram of dried flowers is around USD 3,500, estimating a 10% yield of CBD isolate. The price for 1 litre of CBD ranges from USD 8,000 without GMP and USD 30,000 with GMP.

Vázquez (2019, *Personal communication*) mentioned that Former sold recently dried flowers to Australia at USD 5,000 per kilogram, and estimated, at the most, a 12% of CBD isolate from biomass after extraction. He assured that international prices are constantly dropping, from extreme prices in 2016 of USD 240/g of CBD isolate, to current prices of around USD 1,300/kg.

As reported by Uruguay XXI (2019. Based on a private consultant. Preliminary version), indoor agriculture is the cannabis value chain with the highest added value, ideal to develop in our country. According to this private consultant, cannabidiol ("*the most important product in the cannabis medicinal sector*") 99% pure from indoor agriculture reached a market value of USD 45,000 per kilogram in December 2018.

According to Vázquez (2019, *Personal communication*), under the "*American model*" growing technique we find small, luxuriant and leafy plants with thick trunks. It is possible to grow 1 plant per 1 or 2 sqmt, depending on the variety, and produce around 400 grams of dried flowers per harvest. He emphasized that industrial levels always imply yield losses compared to more traditional and careful growing techniques. He believes three harvests a year could be a reasonable estimation for Uruguay.

According to Nafte (2019, *Personal communication*), obtaining 15% CBD oil from extraction is a reasonable rate. His company, YVY, is not focused on pharmaceutical CBD but on therapeutic products, so he has no idea about international prices for API grade CBD.

According to Pascual (2019, *Personal communication*), yields vary considerably depending on weather and production techniques, so making a general estimation proves to be very difficult. Despite focusing on international cannabis regulations, he knows that every grower has its own estimations. He mentioned the regulations on this issue, as pursuing high contents of CBD will necessarily lead to high THC content. The same plant can yield different levels under different climates, so the legal limit must be taken permanently into account.

I have looked into declarations made by Warren Bravo[54], CEO of Green Relief Inc. This company is focused on the production of cannabis using aquaponics, together with tilapia, adding very interesting social goals as well. Not only that, but Bravo is convinced that aquaponics is the future of agriculture and wishes to expand this technique, so he reveals precise production data and yields. I could not find formal research on this company, but nevertheless I have found this information quite reliable so I am taking it very seriously.

Bravo claims to have achieved amazing results using aquaponics, and it seems that his company's aquaponics system has not suffered major disturbances, or at least he has not mentioned them. Production is completely indoors with LED lights, using five different "*light recipes*" for different growing stages. Green Relief claims to achieve "*30% more product annually than any other method of growing*" (Bravo, 2018), with almost seven harvests a year, one every eight weeks. The average annual harvest rises up to 450 grams/square foot, according to Bravo, with certain breeds achieving more than 500 grams/square foot, which equals to more than five kilograms/sqmt per year, way over what other sources claim to be the market average. According to Bravo (2018), 25-30% of the cost of growing cannabis goes to fertilizers, a cost which is totally paid by the income[55] from tilapia in the case of Green Relief.

Based on all this information and data, I must make important assumptions in order to make initial estimations for my project. Even though I will probably seize most of these efficiencies from Green Relief if using aquaponics in an appropriate way, projecting the income with these yields would not be conservative at all. I will base my estimations on **2.5 kilograms of biomass per square metre per year**, which will make a total of 25 tonnes a year of dried flowers.

Green Relief process the biomass using the CO2 method (explained in section 3.5.3), with 5 kilogram cylinders. They claim to achieve a 25% yield on the amount of biomass, way higher than the other figures I have gathered from other sources. Therefore, I will estimate my production on a **12.5% yield**.

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[54] https://www.youtube.com/watch?v=AkMGH9910eM

[55] This company donates the whole tilapia production to charity, from which they receive tax credits from the Canadian government.

This data from Green Relief looks incredible, almost too good to be true, but it is even more amazing compared to data from Fotmer Life Sciences, a company with a very good national and international reputation. With 12,000 plants per hectare, Fotmer does only one harvest a year without heating (Figuerón 2019, *Personal communication*). They grow from October to March. This company harvests five tonnes if they had an excellent performance, so the figure of 25 tonnes sounds amazing to the responsible for hydroponics in Fotmer.

Figuerón (2019, *Personal communication*) even mentioned the spaces in the greenhouse which cannot be used due to the need to have walkways and other spaces. This could be from 20% to 25%, so only ¾ of a greenhouse can be actually used for growing. According to Figuerón (2019, *Personal communication*), two harvests a year could be achieved with more personnel and under excellent performance, and perhaps three harvests with heating and extreme care.

The problems with industrial yields is that the scale implies great efficiency losses, according to Figuerón and Vázquez (2019, *Personal communications*). Figuerón even gave as an example that he is achieving five harvests a year in a *cannabis club* with no technology or automation at all, but the care from its members; this is impossible at an industrial level.

Growing outdoors in Uruguay for CBD extraction purposes and with reasonable yields is, according to Figuerón (2019, *Personal communication*), absolutely impossible. He also mentioned that growing indoors is in general less efficient than growing in greenhouses, due to the lack of sunlight (which is replaced by LED lighting).

According to Uruguay XXI (2019. Based on a private consultant. Preliminary version), growing in greenhouses, with LED lighting and controlled heating, allows for up to three or four harvests a year, achieving two tonnes per hectare per harvest. Therefore, this source mentions a potential yield of six tonnes per hectare per year.

As a final comment, I would like to make it clear that Green Relief Inc. claims to achieve a production of more than 50 tonnes a year in a hectare of intensive production. This figure, according to Figuerón (2019, Personal communication), exceeds by far more than 30% the average of the industry, at least compared with the reality in Uruguay.

I will take a price of USD 8,000 per litre of CBD, the price corresponding to non-GMP CBD according to Rodriguez Lepera (20019, *Personal communication*). Most of the sources I have interviewed assured that obtaining a GMP certification for pharmaceutical purposes is extremely complicated, capital intensive and time consuming, and even more difficult from a European company. Therefore, I better not count on it, at least for the first years of this project.

Final estimations are on table 4.5.

3.2.3 Breeds of Cannabis

This section alone could include several research undertakings, but I will just refer to what I could find on my own research on a topic on which I have not made much emphasis.

The first interviewee to mention specific cannabis breeds was Nafte (2019, *Personal communication*), who last year started growing FUTURA 75 and changed this year to FEDTONIC, a breed developed and registered by BioCan, a Swiss company with worldwide activities.

CHERRY WINE, a breed offering good performance for CBD production with 12% content, was mentioned by Saldías and Sánchez. According to Sánchez (2019, *Personal communication*), advisor of Swiss company BioCan, FEDTONIC is undoubtedly the best breed for CBD production with a CBD content of 17%.

As previously stated, I have not researched further into this topic but I have simply estimated a production yield of 12.5%.

Section 7.3 displays a current list of registered cannabis seeds in INASE.

3.3 Aquaculture

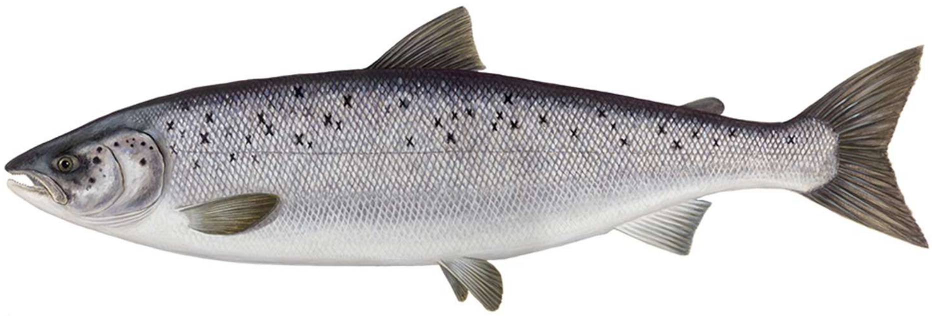
This particular topic focuses on the selection of a specific fish species, and especially on the compatibility with the requirements of cannabis within a hydroponics system.

Unfortunately, and as already explained, the complexity of such a research goes much further than this researcher's possibilities, resources, knowledge and experience. The criteria on which I have based the selection of the most appropriate fish species are explained in section 1.4, Figures 1.7 and 1.8.

My first initial interest was on the *Salmonidae* fish family, paying special attention to the Atlantic salmon and the rainbow trout.

Rainbow Trout

Oncorhynchus mykiss



Atlantic Salmon

Salmo salar

Figure 3.11 Salmonidae Fish Family Alternatives

Quite far from scientific reasons, the attributes of the Salmonidae I was paying so much dear attention were the following:

- Very attractive international prices
- High and sustained international markets
- Worldwide consumption
- Personal interest on the Atlantic salmon and the rainbow trout, mainly because of gastronomic and recreational reasons.

The first experts I had the chance to interview immediately focused on the low water temperature required by Salmonidae. Considering the higher water temperature required by cannabis, which will be grown in greenhouses under environmental temperatures quite higher than the average temperature in Uruguay, neither rainbow trouts nor Atlantic salmons would be appropriate fish species to consider.

It is important to remember that the fish component of the aquaponics system is intended to increase sustainability and not so much profitability. Therefore, if the addition of the fish requires a considerable increase in the energy needed to run the system, there would be no point in working with aquaponics even if this energy comes from renewable sources.

I initially considered other two fish species with good potential to be compatible with a cannabis aquaponics system; barramundi and Murray cod. Both of them were regarded as very appropriate by all the experts interviewed.

Even though this decision would require in-depth and thorough analysis, as previously explained, after having received experts' opinions and after having read about the main fish species under investigation, I decided to consider barramundi as the most interesting and compatible fish species to work with.

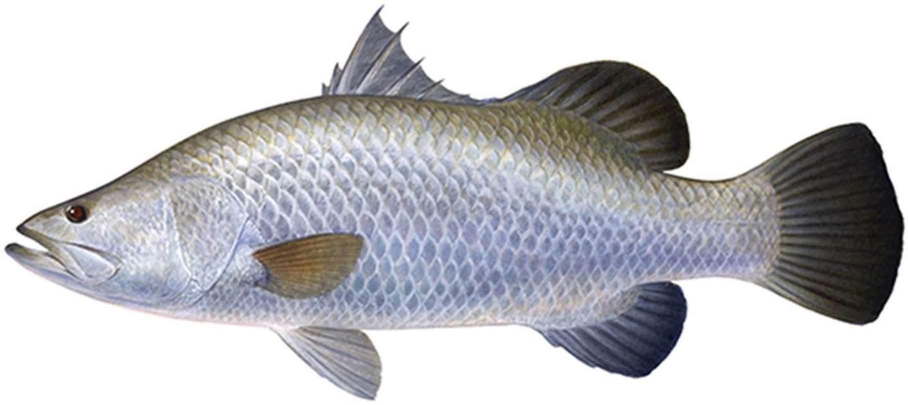
Murray cod offers very good conditions for aquaculture and currently shows an attractive international price, but there are doubts about the future of this fish in the market as it is believed that the current upwards market could be just a temporary trend (Schultz 2018, *Personal communication*). Therefore, and taking into account that international market prices are an important factor to take into account, I have decided for barramundi.

Barramundi, rainbow trouts and Atlantic salmons share something in common: they all belong to the *Diadromous* fish category, as they spent part of their lives in salt water and part in fresh water.

3.3.1 Barramundi Features

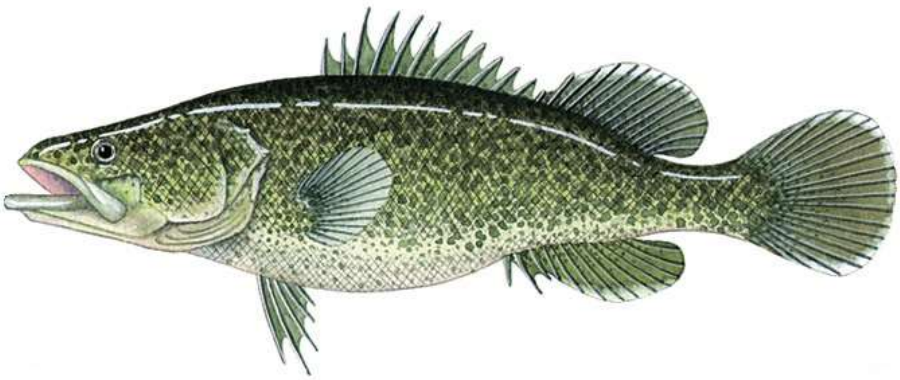
The main reasons behind the selection of Barramundi are the following:

- Great potential to be compatible with cannabis, according to experts' opinions and species' technical information and data.
- Large international upwards market and very good international prices.
- Ideal conditions for aquaculture, with many facilities growing barramundi in several different countries and using different aquaculture systems (FAO).



Barramundi

Lates calcarifer



Murray Cod

Maccullochella peelii peelii

Figure 3.12 Barramundi and Murray Cod

"*Among the attributes that make barramundi an ideal candidate for aquaculture are:*

- *It is a relatively hardy species that tolerates crowding and has wide physiological tolerances.*
- *The high fecundity of female fish provides plenty of material for hatchery production of seed.*
- *Hatchery production of seed is relatively simple.*
- *Barramundi feed well on pelleted diets, and juveniles are easy to wean to pellets.*
- *Barramundi grow rapidly, reaching a harvestable size (350 g – 3 kg) in six months to two years.*

Today barramundi is farmed throughout most of its range, with most production in Southeast Asia, generally from small coastal cage farms." (FAO, *Lates Calcarifer* fact sheet)

Barramundi does not only enjoy a sustained and increasing international market, but there are positive signs of its continuity as well. *Millennials*, who are in many ways a very important generation regarding economic issues, are particularly attracted to barramundi due to its sustainability and culinary attributes (Blank, 2016)[56]. Not only that, but "*Because of its mild, buttery flavor, meaty texture and cooking versatility, it is part of a culinary trend in Europe and North America.*" (EUROFISH INTERNATIONAL ORGANIZATION 2017)

According to the Food and Agriculture Organization (FAO) of the United Nations "*Barramundi are highly fecund; a single female (120 cm TL) may produce 30–40 million eggs. Consequently, only small numbers of broodstock are necessary to provide adequate numbers of larvae for large-scale hatchery production.*" (FAO, *Lates Calcarifer* fact sheet). "*Because barramundi are euryhaline, they can be cultured in a range of salinities, from fresh to seawater. When they are six–eight years old (85–100 cm TL), Australian barramundi change sex to female and remain female for the rest of their lives. Sex change in Asian populations of this species is less well defined and primary females are common.*" (FAO, *Lates Calcarifer* fact sheet)

According to the following figures showing data from the Food and Agriculture Organization (FAO) of the United Nations it is easy to appreciate that the global demand for barramundi has been increasing for the last three decades. Current wild captures rise to more than 100,000 tonnes, while current aquaculture production ascends to approximately 80,000 tonnes.

[56] https://www.seafoodsource.com/news/foodservice-retail/millennials-drive-barramundi-demand-sales

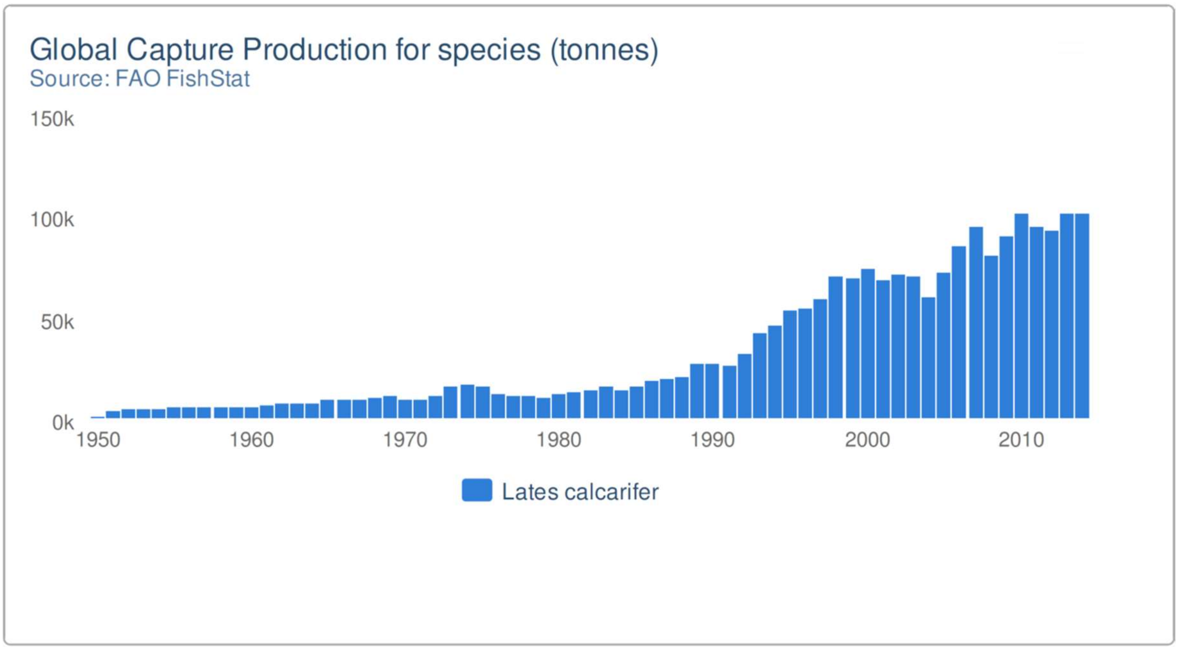


Figure 3.13 Lates Calcarifer (Barramundi) Global Capture Production

Source: FAO Lates Calcarifer Fact Sheet

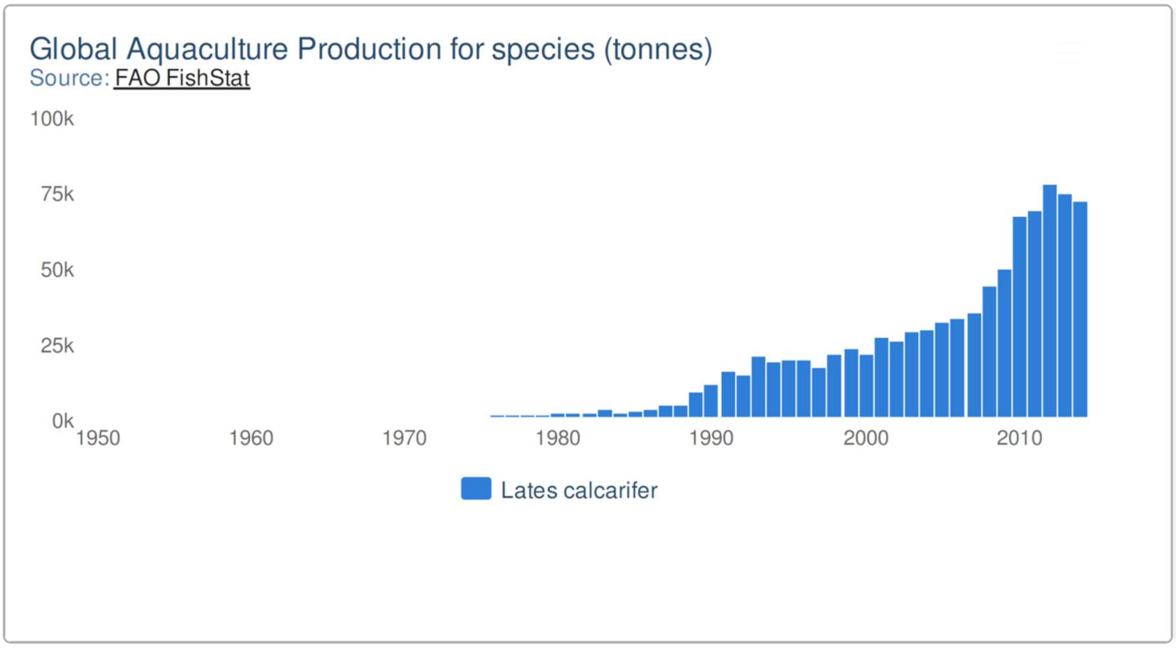


Figure 3.14 Lates Calcarifer (Barramundi) Global Aquaculture Production

Source: FAO Lates Calcarifer Fact Sheet

3.3.2 Barramundi Production

"*Barramundi have a number of biological attributes that make them amenable to commercial production:*

• They are a tropical euryhaline species (living in fresh and salt water);

• Catadromous (born in salt water and naturally migrate to fresh water);

• Start life as male and transition to female;

• Produce large numbers (millions) of eggs during spawning (Davis, 1984); and

• Relatively tough and resilient to low dissolved oxygen and handling compared to many other high value commercially farmed fish species such as salmon, sea bass or king fish (Smullen, R 2017)." (Richards 2018, Based on Smullen, R 2017 and Davis, 1984)

The major production of barramundi comes from Taiwan, Malaysia and Thailand, followed by Indonesia and Australia (Tveteras, 2016, based on data from FAO). Most production is consumed locally, with very few exceptions (EUROFISH INTERNATIONAL ORGANIZATION 2017). The aquaculture production of barramundi is considered to be an efficient and sustainable alternative to other fish species, especially when it is grown in small coastal cage farms in the tropics. When outside the tropics, such as in southern Australia and in the northeastern USA, recirculation production systems are normally used (EUROFISH INTERNATIONAL ORGANIZATION 2017).

Barramundi can be actually grown under many different production systems, according to a study carried out by Dan Richards (2018). He researched many different systems ranging from indoor tank systems in the United States under heavy snowy winters, to sea cages in the Red Sea and "*both fresh and salt water pond culture in South East Asia, the Middle East and Australia.*" (Richards 2018). According to the same author, *"Each production system can present different opportunities and challenges thus the different systems have been able to co-exist. For example, fresh water indoor recirculation farms are capital intensive to establish and expensive to operate. However, they can be located close to large cities and outside of the tropical climatic zones that naturally suit Barramundi so are able to supply high value live fish markets. While tropical North Australian farms are located in the natural climatic zone of wild Barramundi so are able to achieve scale of production without the need for tight environmental temperature regulation. These farms however have to contend with the logistical issues of being thousands of kilometres from Australia's major population centres and therefore their main markets. Sea cage farms are capital intensive to establish and operate, they effectively outsource the treatment of nutrients to the natural* *environment however are particularly exposed to environmental events such as cyclones, with three separate Australian sea cage Barramundi farms having been destroyed by natural events."* (Richards 2018)

Even though Barramundi production methods can be extremely wide ranging, as previously stated, the following figure represents the general production cycle of this fish species according to the FAO:

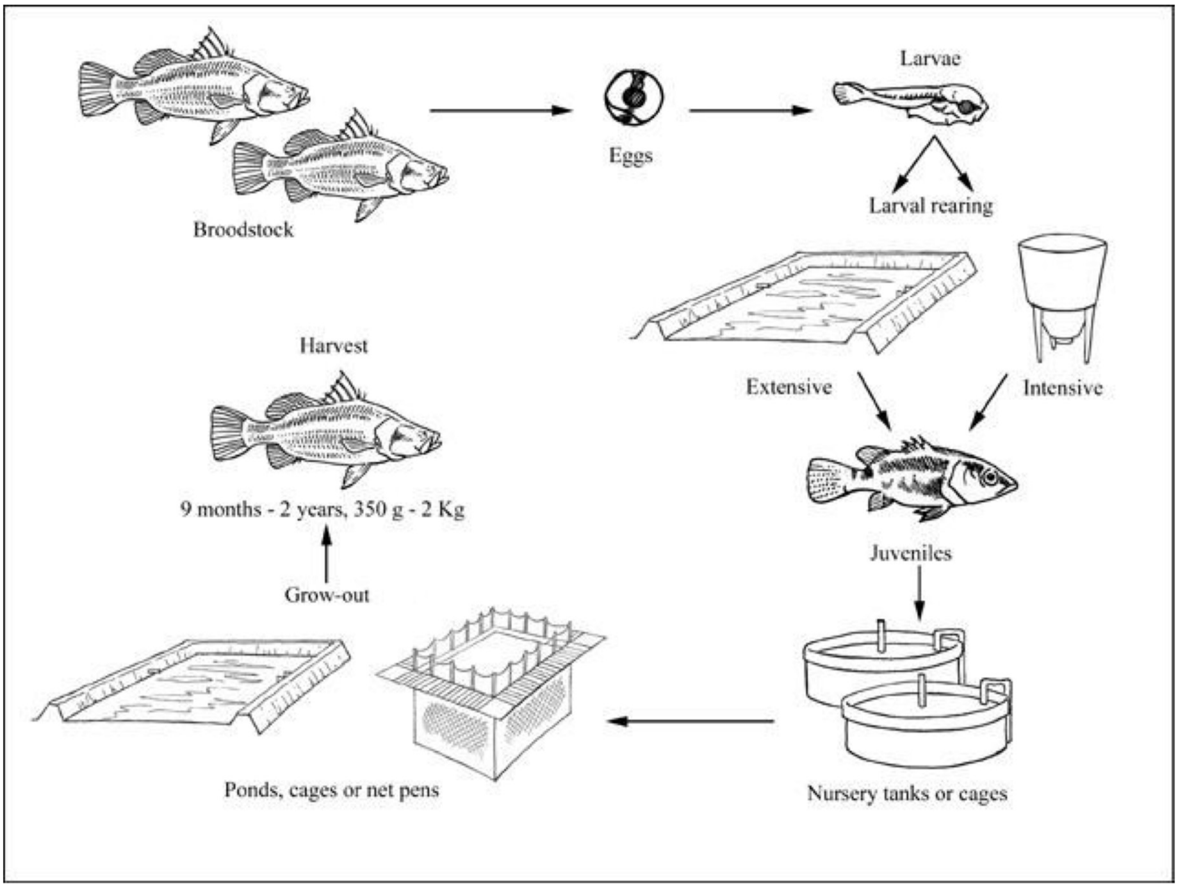


Figure 3.15 Production cycle of Lates calcarifer (Barramundi)

Source: FAO; Lates Calcarifer Fact Sheet

3.3.2.1 Facilities and Layout

There is a wide range of different layouts for intensive aquaculture. I have seen examples with large concrete tanks, small round and square fibreglass tanks, different pools made with plastic film and metal structures, etc.

Considering that I am clearly not an expert on this field, I have taken recommendations from Turra (2019, *Personal communication*) who suggested to use 10,000-liter plastic tanks using them as “production units”, working in a modular way. This should be a practical way to work, easy to set and easy to move if needed.

I have established that the aquaculture area for this project will be of 2,000 sqmt in size, next to a 10,000 sqmt hydroponic facility. The whole 12,000 sqmt will be under the same greenhouse in order to share the same heated environment.

I have not looked further into production details on this research.

3.3.2.2 Yields, Feeding and Mortality

Many different factors are to be taken into account when analysing production yields in aquaculture.

The most important issue is probably the **feed conversion ratio (FDR)**, indicating the amount of feed needed in order to achieve 1 kilo of living fish. According to Ripoll (2019, *Personal communication*) and without knowing specific details from this particular fish species, he estimates a FCR between 1.6 and 1.8. Turra (2019, *Personal communication*) rears mainly herbivorous fish species with a FCR of 1.5, but for a fish such as barramundi she estimates a ratio of around 2. According to her, this ratio may go up to 3 for extreme cases of carnivorous fish species. I will base my estimations on a FCR of 2 kilos of feed for 1 kilo of living barramundi.

This feed could be as pellets or as extruded fish feed. Extruded feed is more modern, while pellets are considered more traditional. The most important factors to analyse when deciding on the kind of feed are the content and the physical characteristics when entering the water (Turra 2019, *Personal communication*). For fish species such as catfish, feed should drop right to the bottom, meanwhile in other cases it should either float for fish which feed on the surface, or descend slowly to the bottom for fish which feed in middle waters.

There are currently two possibilities to acquire industrial fish feed in Uruguay, according to Turra (2019, *Personal communication*). ERRO and SUPRA, two important Uruguayan industrial feed suppliers, include fish feed in their products catalogues. Prices range from

USD 1/kilo for herbivorous fish to USD 2/kilo for predators, as they need to be fed with more proteins.

The second most important aspect to analyse is the **production potential per hectare** for an intensive aquaculture system. There are three categories referring to how intensive the production is (Turra 2019, *Personal communication*): **extensive** (when fish feed from natural sources without any added nourishment, and using a large natural area), **semi-intensive** (using special lakes or ponds and with controlled feeding) and **intensive** (under controlled environment and feeding).

DINARA (2010, based on FAO 2008) estimates production potentials of up to 200 tonnes/hectare/year for intensive aquaculture. According to Turra (2019, *Personal communication*), this figure sounds reasonable, although she does not have any experience with intensive aquaculture. She reaches 5 tonnes a year raising catfish in a semi-intensive way, with a good management and permanent systems monitoring. Ripoll (2019, *Personal communication*) suggested to base estimations on half this figure of 200 tonnes. I have decided to estimate a production of 100 tonnes/hectare/year, so the total net production per year in 2,000 sqmt would be 20 tonnes.

The third most important ratio to consider in order to estimate the production potential is the **fish to fillet ratio**. Both experts (Turra and Ripoll 2019, *Personal communication*) estimated 35%, so I have not made any further analysis on this.

Table 3.9 Aquaculture for Barramundi: Estimated Yields

Aquaculture for Barramundi: Estimated Yields	
Area	2,000 square meters
Annual net estimated production (living)	20 tonnes
Annual net fillets estimated production	7 tonnes
Annual estimated feed consumption	40 tonnes

Source: Self-made, based on experts' opinions.

Mortality rates are extremely low in intensive agriculture (Turra 2019, *Personal communication*), since variations in living conditions are kept to a minimum or are almost nonexistent if the system does not suffer any severe and lasting impact (equipment breakdown, blackouts or other severe events).

In extensive aquaculture, mortality rates in Uruguay might reach 30%, and no more than 10% for semi-intensive aquaculture (Turra 2019, *Personal communication*).

3.3.3 Barramundi Market Presentations

Barramundi can be marketed in many different presentations depending on each particular market. In Australia, barramundi can be sold as “plate size” fish (up to 500 g) or in fillets (around 2kg). It can also be marketed as live fish to live seafood restaurants. It can be rarely seen as smoked fillets.

In the Asian market barramundi is normally sold in street and small markets as a whole fish, from 500 g up to 3 kg in size. It is normally a very low-cost product in this market.

As explained in section 4.3.2, barramundi is offered in Uruguay by only one importer and in very low quantities. In fact, I have never seen barramundi in any Uruguayan supermarket or restaurant. It is sold as skinless, boneless and well-trimmed fillets of approximately 300 grams each.

3.3.4 The Downsides of Barramundi

Most of the authors reviewed compare barramundi to Atlantic salmon or rainbow trout when describing the disadvantages presented by barramundi. As my first intuitive preference for this research was to work with *Salmonidae*, this is also my case.

According to Richards (2018), “*The key shortcomings of Barramundi compared to salmon are its potential for skin and fillet discolouration (melanisation) and lower flesh yield (higher bone ratio) resulting in lower processing recoveries. “*

Even though salmon products vary depending on genetics, origin and production methods, these variations in the case of barramundi are much wider. “*Fish grown in freshwater or indoor Recirculating Aquaculture Systems (RAS) can take up earthy flavours from the organic volatile Geosmin created by fresh water microbes (bacteria and algae)*” (Richards, 2018, based on Poole and Exley, 2009). On the other hand, “*Fish grown in clear water sea cages can present jet black colouration and unpleasant grey colouration of the flesh, which whilst still being acceptable to eat, can be more difficult to market*” (Richards, 2018, based on Cahill, D. 2017). Both skin and fillet discoloration poses serious threats regarding market potential and prices variability.

The Canadian company Green Relief Inc. gives their tilapia “*a salt bath for 5 days*” (Green Relief Inc.), because this makes tender fillets. The same idea was express about barramundi in many studies, which state that saltwater barramundi offers much better quality fillets. It will probably be a good idea to implement the same in this project, maybe rearing the fry and giving the mature fish a final bath in saltwater. After all, not only sustainability but also product quality are important issues on this research.

3.3.5 Conclusions

After all the research and data reviewed and considering the limitations of this study, I have concluded that this particular barramundi aquaculture system will be a **freshwater indoor recirculating aquaculture system**, feeding the fish on industrially prepared dry pellets or extruded fish feed, for every growing stage.

Considering the cold winters in Uruguay and the warm hydroponic waters (from the cannabis production), the nursery and growing tanks will be located under greenhouses. The tanks could be traditional plastic tanks, they could be made of concrete or they could be even custom made with an iron/aluminium structure and PVC (as it was the case with Pure Ponics in Geelong, Australia).

The final product will be, at least at first, sold to the Uruguayan market as **boneless, well-trimmed skin-on fillets**, offered in the following presentations:

- Gastronomy clients: **Cooled (not frozen) 2.5-kilogram vacuum packed polythene (plastic) bag**, in boxes of 4 bags each.
- Retail: **Cooled/frozen 1-kilogram vacuum packed polythene (plastic) bag** (in boxes of 10 bags each for the retailer).

This decision has been made mainly based on the most popular fish presentations offered in our market. Even though barramundi has not been marketed in Uruguay so far (only one importer with very low quantities), I believe its introduction to our market will not be difficult, overall as a result of the increasing curiosity of national consumers for new products.

Most of the packed fish fillets offered in our country are imported packed as stated above but with IQF[57] fillets instead of vacuum packed.

My initial idea was to go much deeper into every aspect of this aquaculture system, determining almost every detail from the plant layout and the number and sizes of tanks, up to the production flow and times of every different production step. The reality proved to be much more complex than expected and the time constraint made it impossible for me to fulfil the initial objectives.

My curiosity and thirst for knowledge turned out to be mere naivety, not just for aquaculture aspects but for the whole research. Nevertheless, I am not disappointed at all with the conclusions I have reached.

[57] IQF stands for *Instant Quick Frozen*: the product is transported by a "*freezing tunnel*", being quickly frozen before packing.

3.4 Aquaponics

According to what I have explained in section 3.1, section 3.4 is mainly based on the newly issued publication "Aquaponics Food Production Systems" (Goddek et al., 2019), obviously taking into account all the literature I have reviewed so far, as well. This is an extremely comprehensive, thorough and technical investigation on aquaponics carried out by 68 high profile researchers from 29 different countries, so I have taken it as an important basis for my research.

Although this publication offers many important conclusions, recommendations and extremely technical data, the researchers acknowledge that "*There are still several aquaponic topic areas that require more research in order to exploit the full potential of these systems.*" (Goddek et al., 2019). Because of my background and knowledge and due to the focus of this research, I did not get into very technical data and details but only general conclusions and recommendations. It is clear that "*Aquaponics are complex technical and biological systems*" (Keesman et al., 2019). It is studied in different ways throughout this new research, but the main issue with traditional aquaponics is always the need for permanent balance upkeep between aquaculture and hydroponics.

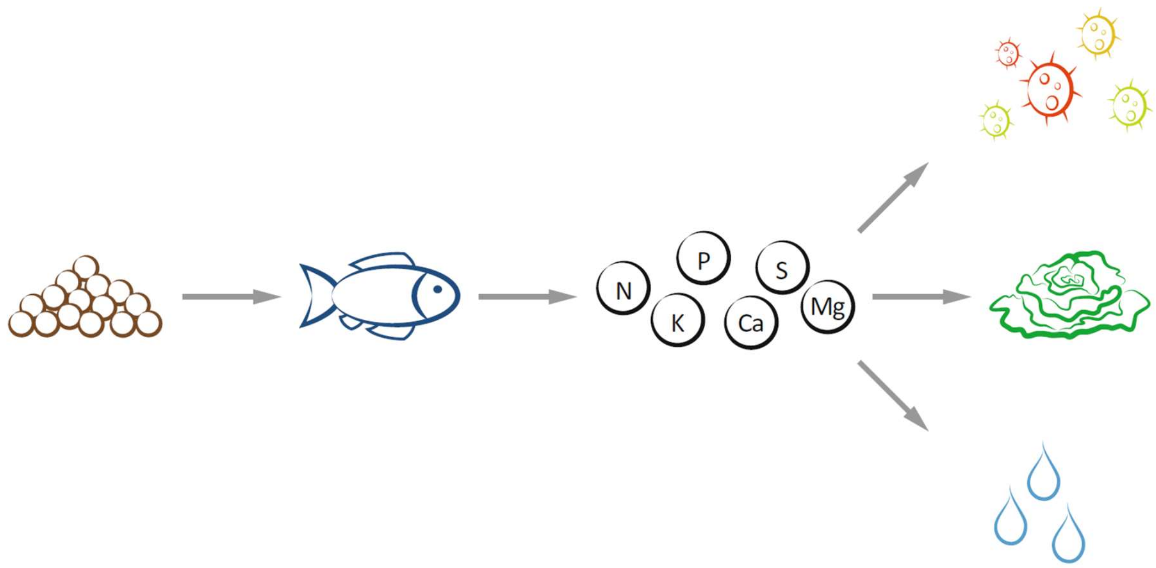
Researchers are extremely confident that aquaponics "*has a role to play in the world's future food production*" (Goddek et al., 2019) and make many different suggestions in order to support this technology.

An appropriate legislation to support aquaponics is quite well studied and explicitly mentioned and requested by Goddek et al. (2019), and one of the main problems regarding this issue is the fact that in many countries there is no specific definition to determine what an aquaponics system is. A large hydroponic facility with one fish could be considered aquaponics if it is not precisely defined. In Europe, aquaponics is defined as "*a production system of aquatic organisms and plants where the majority (> 50%) of nutrients sustaining the optimal plant growth derives from waste originating from feeding the aquatic organisms*" (Goddek et al. 2019, based on EU Aquaponics Hub). Despite the clear definition, there are yet many issues to deal with in the European legislation regarding aquaponics.

The definition suggested by Lennard et al. (2019) is the following: "*Aquaponics <u>is</u> defined as an integrated multi-trophic, aquatic food production <u>approach</u> comprising <u>at least</u> a recirculating aquaculture system (RAS) and a connected hydroponic unit, whereby the water for culture is shared in some configuration between the two units. <u>Not less than 50% of the nutrients provided to the plants should be fish waste derived.</u>*"

Another international issue with aquaponics, clearly the case in Uruguay as well, is that "*At present, regulations define production for both aquaculture and hydroponics, but have no provisions for merging of the two. This situation often creates excessive bureaucracy for producers who are required to license two separate operations or whose national legislation does not allow for co-culturing*" (Goddek et al. 2019, based on Joly et al. 2015). It can be really discouraging for many entrepreneurs.

Imagine requesting authorizations for a cannabis growing facility in a Uruguayan FTZ: one for growing, another one for harvesting, a third one for processing and extracting CBD and a fourth one for FTZ operations… On top of that, DINARA must allow the introduction of a new fish (potentially invasive) with and about which they have absolutely no previous experience or knowledge (Foti 2019, *Personal communication*). Even with very professional advisors, it could take years without the existence of a comprehensive aquaponics regulation.



"Schematic representation of the nutrient flows within an aquaponic system. Fish feed is the major nutrient entry point. The fish eat the feed, use what nutrients they need, release the rest as waste and this waste is then partitioned between the microbes, plants and system water." (Lennard et al. 2019, adapted from Lennard 2017)

Figure 3.16 "Schematic representation of the nutrient flows within an aquaponic system" (Lennard et al. 2019)

Source: Lennard W., Goddek S. (2019) Aquaponics: The Basics. In: Goddek S., Joyce A., Kotzen B., Burnell G. (eds) Aquaponics Food Production Systems. Springer, Cham

"One of the key problems in conventional aquaponics systems is that the nutrients in the effluent produced by fish are different than the optimal nutrient solution for plants. Decoupled aquaponics systems (DAPS), which use water from the fish but do not return the water to the fish after the plants, can improve on traditional designs by introducing mineralization components and sludge bioreactors containing microbes that convert organic matter into bioavailable forms of key minerals, especially phosphorus, magnesium, iron, manganese and sulphur that are deficient in typical fish effluent. Contrary to mineralization components in one-loop systems, the bioreactor effluent in DAPS is only fed to the plant component instead of being diluted in the whole system. Thus, decoupled systems that utilize sludge digesters make it possible to optimize the recycling of organic wastes from fish as nutrients for plant growth" (Goddek et al. 2019, based on Goddek 2017 and Goddek et al. 2018).

Regarding this project, it is clear that profitability will not come from the sales of barramundi but from the cannabis side of the equation. Adding the fish component is intended to achieve sustainability, but it adds extreme complexity to the system, not only for technical but also for logistic and legal reasons.

"From an economic perspective, there are a number of limitations inherent in aquaponics systems that make specific commercial designs more or less viable (Goddek et al. 2015; Vermeulen and Kamstra 2013). One of the key issues is that stand-alone, independent hydroponics and aquaculture systems are more productive than traditional one-loop aquaponics systems (Graber and Junge 2009), as they do not require trade-offs between the fish and plant components. Traditional, classic single-loop aquaponics requires a compromise between the fish and plant components when attempting to optimize water quality and nutrient levels that inherently differ for the two parts (e.g. desired pH ranges and nutrient requirements and concentrations). In traditional aquaponics systems, savings in fertilizer requirements for plants do not make up for the harvest shortfalls caused by suboptimal conditions in the respective subsystems" (Goddek et al. 2019; based on Delaide et al. 2016; Graber and Junge 2009; Goddek et al. 2015; Vermeulen and Kamstra 2013).

Goddek et al. (2019) explain this issue in an extremely clear way: *"Because there are two separate, existing, analogous technologies that produce fish and plants at high rates (RAS fish culture and hydroponic/substrate culture plant production), a reason for their integration seems pertinent. RAS produces fish at productive rates in terms of individual biomass gain, for the feed weight added, that rivals, if not betters, other aquaculture methods (Lennard 2017). In addition, the high fish densities that RAS allows lead to higher collective biomass gains (Rakocy et al. 2006; Lennard 2017). Hydroponics and substrate culture possess, within a controlled environment context, advanced production rates of plants that better most other agriculture and horticulture methods (Resh 2013). Therefore, initially, there is a requirement for aquaponics to produce fish and plants at rates that equal* *these two separate productive technologies; if not, then any loss of productive effort counts against any integration argument. If the productive rate of the fish and plants in an aquaponic system can equal, or better, the RAS and hydroponic industries, then a further case may be made for other advantages that may occur due to the integration process."* (Goddek et al. 2019). According to Palm et al. (2019), "*Plants do not tolerate an under or oversupply of nutrients without effects on growth and quality, and the daily feed input of the aquaponic system needs to be adjusted to the plant's nutrient needs. This can be achieved by regulating the stocking density of the fish as well as altering the fish feed.*" That means that a perfect balance should be kept at all times.

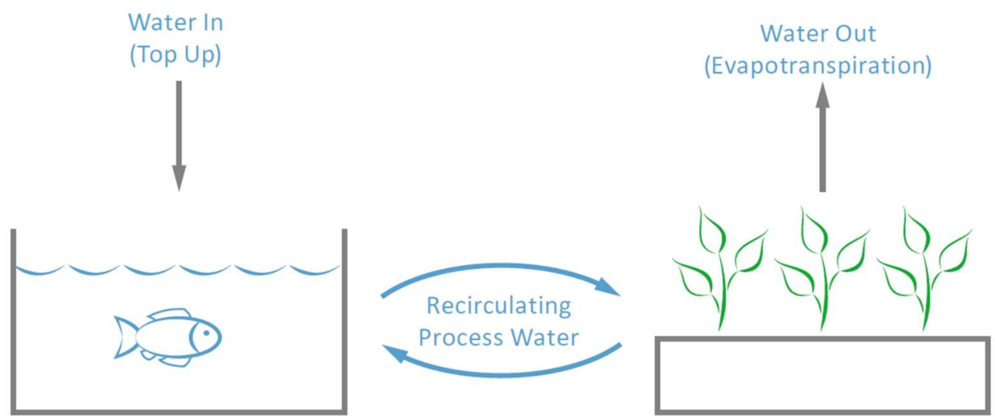
According to Joyce et al. (2019), "*scaling up of aquaponics to an industrial scale requires a much better understanding and maintenance of microbial assemblages, and the implementation of strong biocontrol measures that favour the health and well-being of both fish and crops*". As a non-scientific comment and approach to this topic, I believe that aquaponics probably works in very small scale facilities, as well as it clearly worked in ancient civilizations. Entrepreneurs using aquaponics at small scale claim to have achieved unbelievable results, saving large amounts in nutrients, but scaling it up to industrial levels is probably something completely different. Steve Gleeson in Pure Ponics is convinced that this technique has an amazing future and he clearly sees the results, but they have never been appropriately tested.

Making this analysis from a hydroponics producer perspective, thinking about adding the fish factor to a current fully automated hydroponics facility in operation, the producers I have interviewed agreed completely: "*not even in a million years!*". They see hydroponics itself as extremely complex, so adding aquaculture to it in such an automated way would increase way too much the complexity of the whole system.

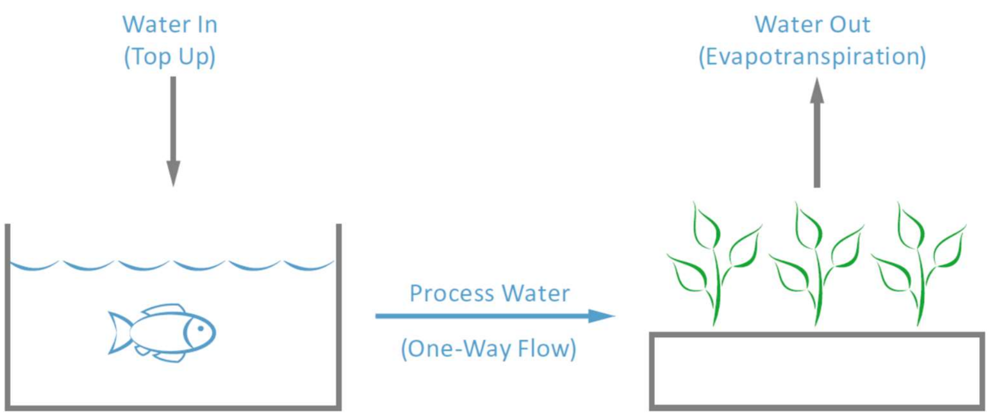
According to M. Turnšek et al., "*…economic evaluations of aquaponic systems are still a very complex and difficult task at present. Although aquaponics is sometimes presented as an economically superior method of food production, there is no evidence for such generalised statements. Up to now, there is hardly any reliable data available for a comprehensive economic evaluation of aquaponics. That is partly because there is not "one aquaponics system", but there exist a variety of different systems operating in different locations under different conditions.*"

I must acknowledge as well that aquaculture is not so sustainable after all because of the origins of the feed (refer to section 2.2), so the analysis of the real convenience of using aquaponics in order to achieve sustainability needs to be further carried out.

Regarding this particular project, the complexity of aquaponics seems to be too high compared to the benefits pursued, and if sustainability is actually not achieved, a simple hydroponics system is probably a better option.



"Simplified scheme of the main water flows within a coupled aquaponic system. The nutrient concentrations in the process water are equally distributed throughout the whole system" (Lennard et al. 2019)

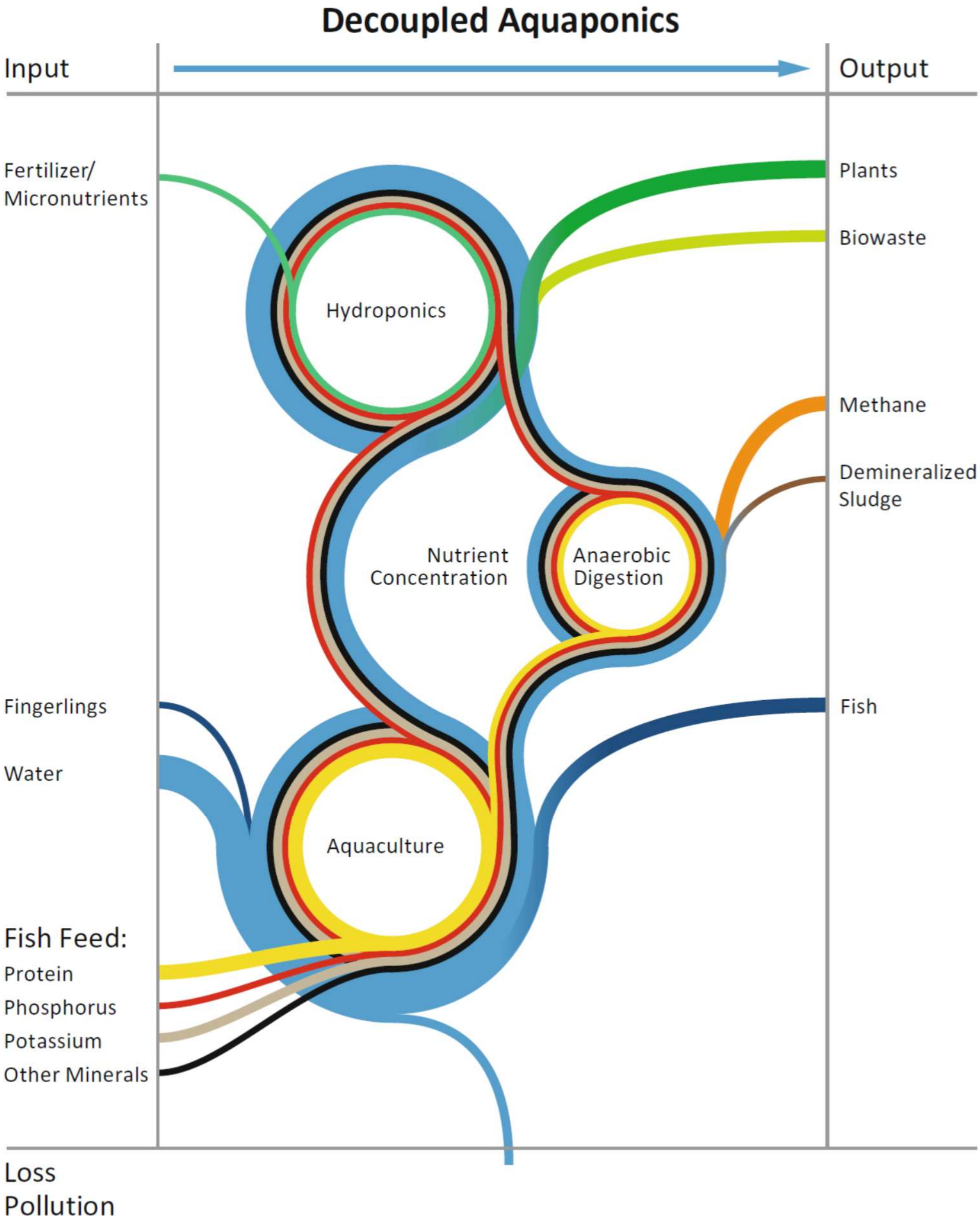


"Simplified scheme of the main water flows within a decoupled aquaponic system. The nutrient concentrations in each component may be separately tailored to the individual component requirement" (Lennard et al. 2019)

Figure 3.17 Coupled and decoupled Aquaponics Systems

Source: Lennard W., Goddek S. (2019) Aquaponics: The Basics. In: Goddek S., Joyce A., Kotzen B., Burnell G. (eds) Aquaponics Food Production Systems. Springer, Cham

The concept of coupled and decoupled aquaponics systems is very well studied by Goddek et al. (2019), even adding another alternative of "Decoupled Multi-Loop Systems". Even though I have not looked into this particular topic, it is important to understand this difference as the aquaponics system to be developed in this research could be either coupled or decoupled.



"Input, output, and loss streams in a decoupled multi-loop aquaponics system comprising an anaerobic reactor system" (Goddek et al. 2019)

Figure 3.18 Decoupled Multi-loop Aquaponics System

Source: Goddek S. et al. (2019) Decoupled Aquaponics Systems. In: Goddek S., Joyce A., Kotzen B., Burnell G. (eds) Aquaponics Food Production Systems. Springer, Cham

Figure 3.18 displays a graphic representation of the main flux of different elements in a multi-loop decoupled system, and offers a good idea of the complexity of such a system, in which very many variables must coexist in perfect harmony if the system is to achieve synergies and therefore productivity and profitability.

According to Goddek et al. (2019), "*Decoupled systems differ from coupled systems insomuch as they separate the water and nutrient loops of both the aquaculture and hydroponics unit from each another and thus provide a control of the water chemistry in both systems.*

The concept of a coupled one-loop aquaponics system… can be regarded as the traditional basis of all aquaponics systems in which water recirculates freely between the aquaculture and hydroponics units, while nutrientrich sludge is discharged. One of the key drawbacks of such systems is that it is necessary to make trade-offs in the rearing conditions of both subsystems in terms of pH, temperature, and nutrient concentrations

In contrast, decoupled or two-loop aquaponics systems separate the aquaculture and aquaponics units from each other. Here, the sizing of the hydroponic unit is a critical aspect, because ideally it needs to assimilate the nutrients provided by the fish unit directly or via sludge mineralization (e.g. extracting nutrients from the sludge and providing it to the plants in a soluble form). Indeed, both the plant area size and environmental conditions (e.g. surface, leaf area index, relative humidity, solar radiation, etc.) determine the amount of water that can be evapotranspired and are the main factors determining the rate of RAS water replacement. The water sent from the RAS to the hydroponic unit is consequently replaced by clean water which reduces nutrient concentrations and thus improves water quality (Monsees et al. 2017a, b). The amount of water that can be replaced depends on evapotranspiration rate of plants that is controlled by net radiation, temperature, wind velocity, relative humidity, and crop species." (Goddek et al. 2019, based in part on Monsees et al. 2017a, b)

I must admit that I have mixed feelings about aquaponics. I suddenly happen to go from the moment in which I believe I have found the future of agriculture, right to the moment when I get convinced that this is nothing but extreme complexity and unsustainability disguised in hidden secrets, proprietary information, taxpayers' money and a costly technology only possible to be financed by profitable crops.

I had the opportunity to interview two people with direct experience on aquaponics: Steve Gleeson and Álvaro Sánchez. Steve believed to have achieved great results with aquaponics and had a similar approach as that of Warren Bravo from Green Relief, willing to spread this well-hidden secret around the world to spread sustainability and efficiency everywhere.

On the other hand, Sánchez had practical experience with a mini aquaponics project and he assured that taking it to an industrial level not only could be a nightmare, but would also require considerable investments, automation and permanent expert surveillance. Exactly the same approach as the Australian hydroponics producers I interviewed in 2018.

Sánchez explained precisely the difficulties with aquaponics and his arguments seemed extremely solid. The main issue, according to Sánchez, is pH. While cannabis and in general plants thrive with a pH from 6.2 to 6.5, fish need a pH of 7. According to Sánchez, without a perfect balance and many processes on the water, "*either fish die or plants suffer, it could be catastrophic and there is no other option*" (Sánchez 2019, *Personal communication*). He also addressed the issue with the fish feeding, as the first thing to take into account is a well-studied diet and permanent surveillance, immediately counteracting any change in the fish population (quantity, sizes, etc.).

A very recent, extensive and comprehensive international publication on aquaponics, "Aquaponics Food Production Systems" (Goddek et al., 2019), which has been cited many times on this research, presents aquaponics as the holy grail and request governmental support, but the authors often state that further research is needed and that economic viability has so far not been, and is far from being, proven.

From extensive and inconclusive scientific publications, permanently going from one extreme to the other, to entrepreneurs with amazing results which are either not measured or not disclosed, I feel somewhere lost in the middle…

Figure 3.19 shows my personal contribution to aquaponics. It comes from a complete outsider to agriculture and from a misunderstanding I had when visiting hydroponic facilities in Australia. At first I had understood that the instant salinity analysis (ISA) measured nutrients by separate and ordered the injection of them one by one, and not acting on a pre-set mixture of nutrients. I understood the great threat for unbalances when I realized of this situation.

I believe that one of the biggest issues with the development of aquaponics is a **technological barrier**: the inexistence of an **Instant Nutrients Analysis (INA)**. This device does not exist at the moment (Ulloa, *Personal communications*) but it could automatically adjust any nutrients unbalance in an aquaponics system. An INA would permanently measure the level of each nutrient on the system water, and based on this results either water or different levels of the due nutrients will be automatically added. Not every problem on an average aquaponics system would be solved with an INA, but it would be a great support for farmers in order to keep the proper balance. According to Sánchez (2019, *Personal communication*), similar technology is currently being developed in Israel.

Although an INA could be applied both on coupled or decoupled aquaponics, I believe it could be easier to automate a decoupled system using this device. Unfortunately, the scope of this research thesis does not allow to explore further this issue.

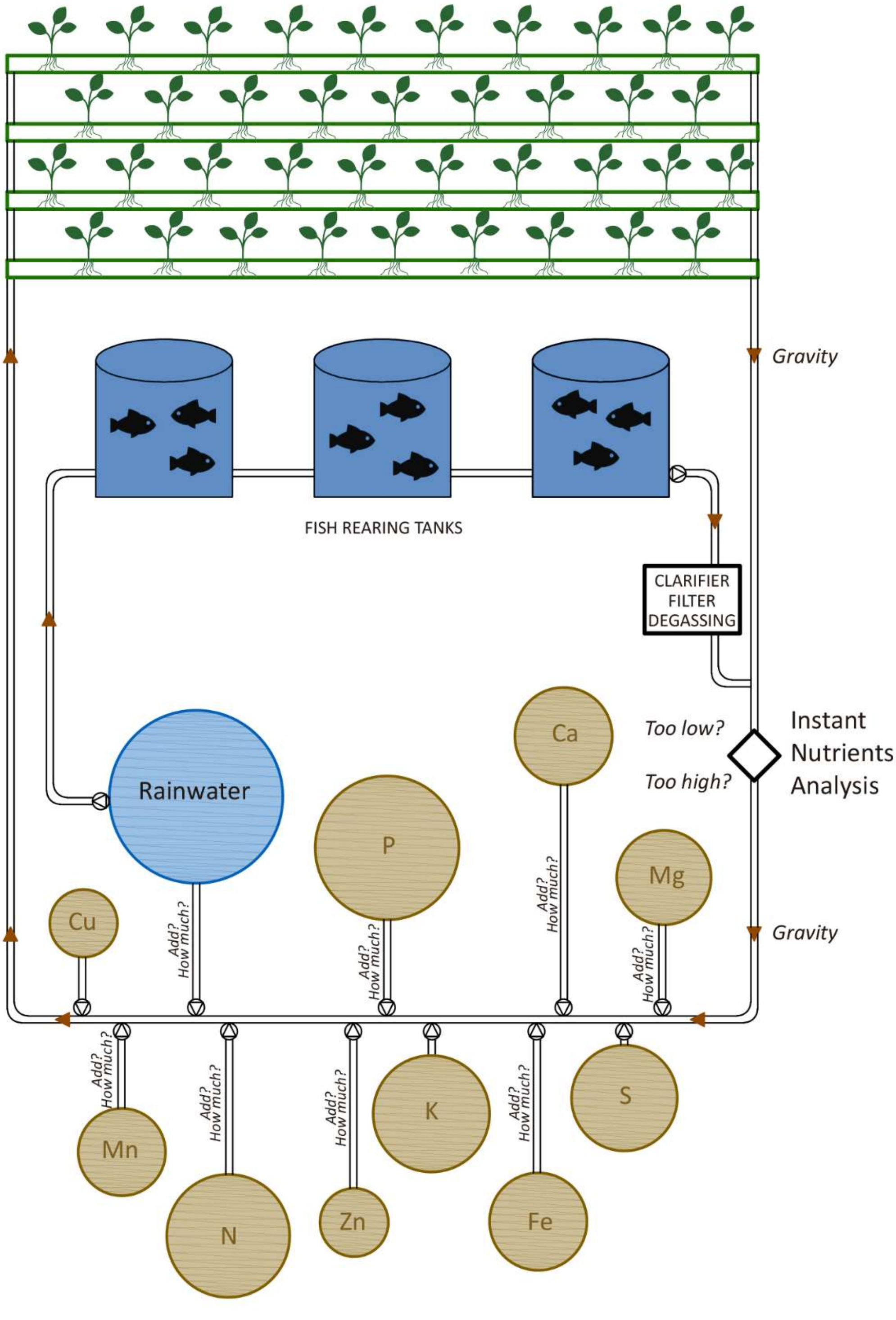


Figure 3.19 The Future of Aquaponics: Instant Nutrients Analysis (I.N.A.)

Source: Self-made (2019), based on interviews with experts and entrepreneurs, and on the review of specialized literature.

3.5 Technical Aspects and Requirements

In the previous three sections I have referred to hydroponics, aquaculture and aquaponics, so in this one I will address different technical aspects of the whole system.

3.5.1 Greenhouse

The greenhouse to be used is a key aspect of the project. There are a wide range of different greenhouse layouts on the market, each of them with their advantages and disadvantages. Figure 3.20 shows a few examples.

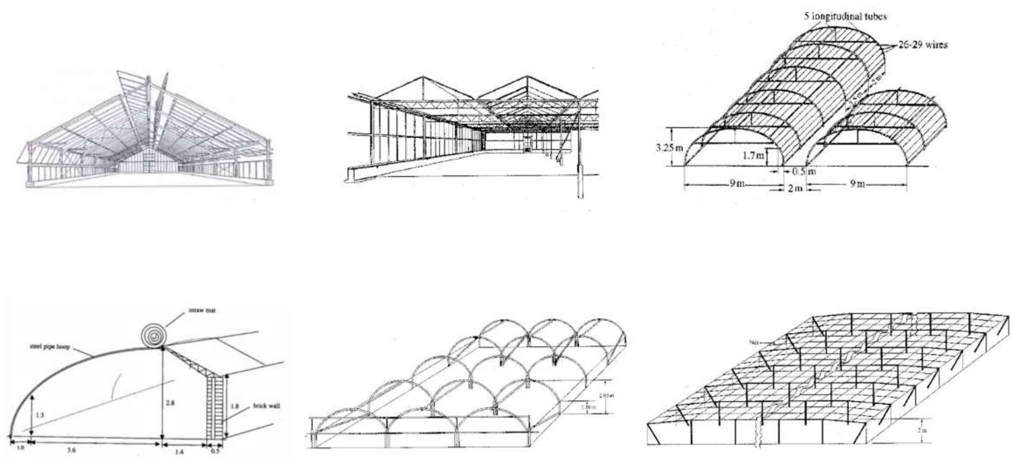


Figure 3.20 Greenhouse Structures

Source: "THE VIRTUAL GREENHOUSE AND AQUAPONICS - PART 1; "A presentation by Dr Oliver Körner (Danish Technological Institute) given during the EU Aquaponics Hub training school on 'Modelling nutrients, energy and growth in aquaponic systems' at University College Cork, Ireland, in April 2017" [58].

Fotmer Life Sciences, a company to which I have referred many times throughout this document, has selected a very particular greenhouse from Airstream Innovations Growing Technology, the Mini-Series Greenhouses[59]. It is shown on Figure 3.21.

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[58] https://www.youtube.com/watch?v=Bsbl1WqdP_U&t=1819s
[59] http://www.makehempgreatagain.com/miniseries/

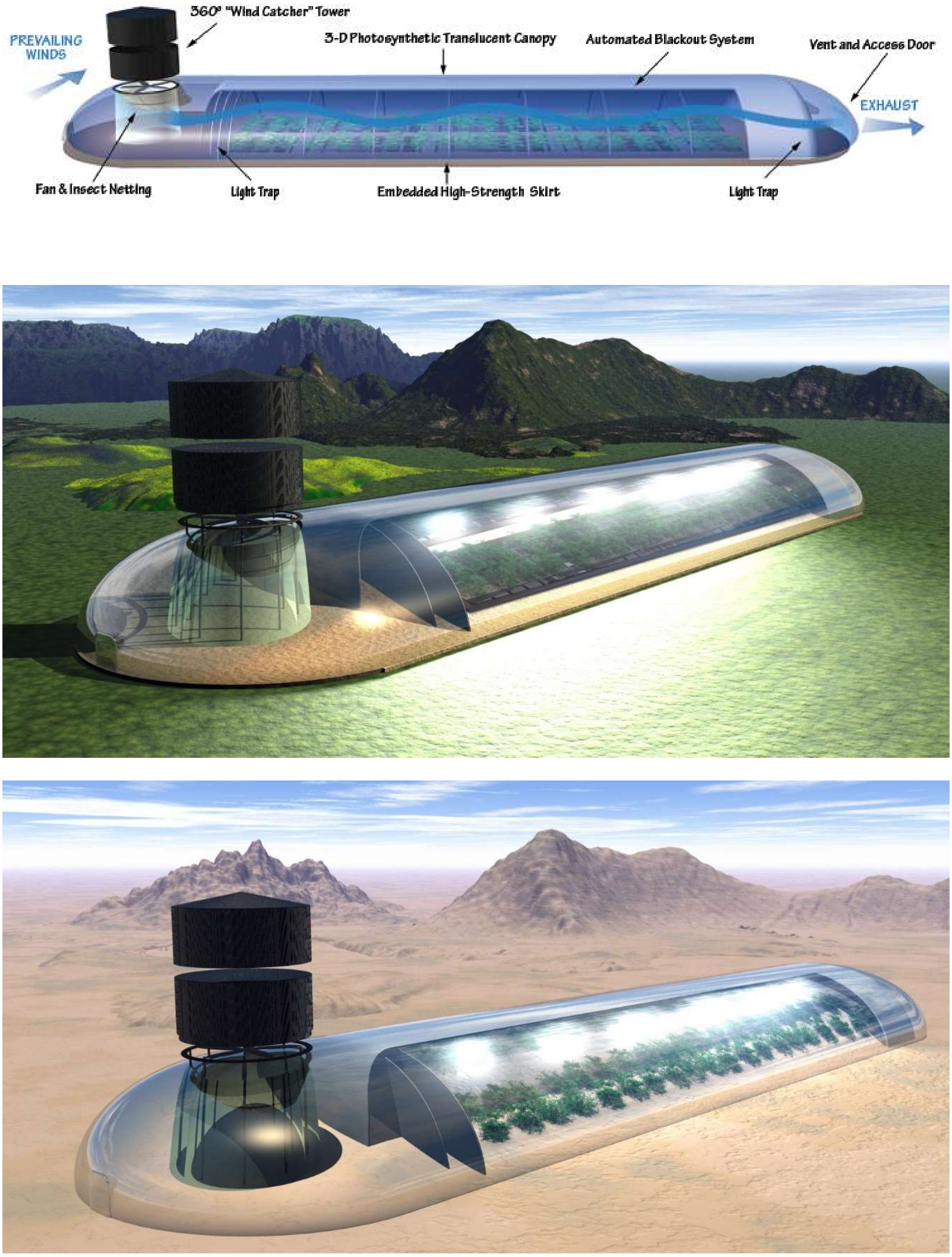


Figure 3.21 Fotmer Life Sciences' Airstream "Mini-Series Greenhouses"

Source: Airstream Mini-Series Greenhouses from Airstream Innovations Growing Technology.

These particular greenhouses do not have an external structure, but they are inflated by natural wind. The manufacturer claims that they can be used anywhere on earth, as they can be heated in cold regions or ventilated under very warm weather. It also includes devices that work as pest control, avoiding the entrance of any kind of insects.

Fotmer greenhouses can be clearly seen when driving by Colonia Suiza FTZ, and there are several of them installed and in operation. David Chelf (2019, *Personal written communication*), Director of Airstream Innovations Growing technology, explained to me that his invention serves many purposes in order to better attend cannabis needs. The recommended *Mini* for our country is a "*7m x 90m x 3m high in approximately a long, half-circular cylindrical shape*" (Chelf 2019, *Personal communication*), with a usable area of approximately 200 sqmt. It will be necessary to cover a total of approximately 10,000 to 12,000 sqmt.

Ulloa (2019, *Personal communication*), an expert on hydroponics, currently offers a hectare of fully-automated hydroponics, including greenhouse and the whole equipment, for USD 1.8 – 2.2 million. Chelf (2019, *Personal communication*) disclosed similar figures.

Even though the kind of greenhouse to use is a key aspect of this project, mainly due to time constraints I have not looked further into this issue.

3.5.2 Operations

According to many sources interviewed during this research, using cuttings is a more standardized way of growing cannabis than using seeds (Nafte 2019, *Personal communication*). This is mainly because the use of cuttings allows the reproduction of exactly the same plant, growing in a much more standardized way than by using seeds. On the other hand, the purchase of cuttings should be made from nearby suppliers due to logistics reasons. Seeds can be purchased almost anywhere and then be transported without major inconvenient.

Purchase of cuttings in Europe made by Uruguayan companies have not succeeded (Nafte 2019, *Personal communication*). They need to be transported in a very short time, and combining logistics issues with a plant that many forwarders "handle with care", and in some cases have refused to ship, may result in delays, and any delay can be devastating.

According to many experts interviewed, Uruguayan companies work both with seeds and cuttings, but most of them plant their own seeds or make their own cuttings. There is apparently only one Swiss/Uruguayan company currently focused on the production of seeds and seedlings; BioCan. Others will probably start coming out as soon as the market starts building the different parts of its value chain.

Every interviewee (Figuerón, Pascual, Saldías, Vázquez and others) made it clear that a GMP certification is a must in order to sell pharmaceutical products. And this certification must be from a European company if we are to export to Europe, the dream market for its prices and volumes. Selling to pharmaceutical German companies requires a GMP certification from a German certification company (Vázquez and Pascual 2019, *Personal communications*), which does not only require considerable time and money, but also "*waiting in a long queue for your turn*" (Pascual 2019, *Personal communication*). Even the MSP requires a GMP certification to register any pharmaceutical product.

"*The challenge that CBD producers have are certifications requested for being accepted as medical suppliers, Good Agricultural Practice (GAP) and Good Manufacturing Practices (GMP) are usually requested by purchasers when buying CBD for medical purposes, in order to achieve a better price in destination markets.*" (Podestá 2019, interviewed by Pascual, 2019). Apart from GMP (and probably GAP) and in order to improve internal processes, quality standards and the company's reputation, I would recommend the implementation of an integrated management system with ISO 9001, ISO 14001 and OHSAS 18001 (quality-, environmental- and occupational health and safety management, respectively).

Needless to say that operations involve much more, but this is as far as I will put my efforts in this section regarding obvious time restrictions.

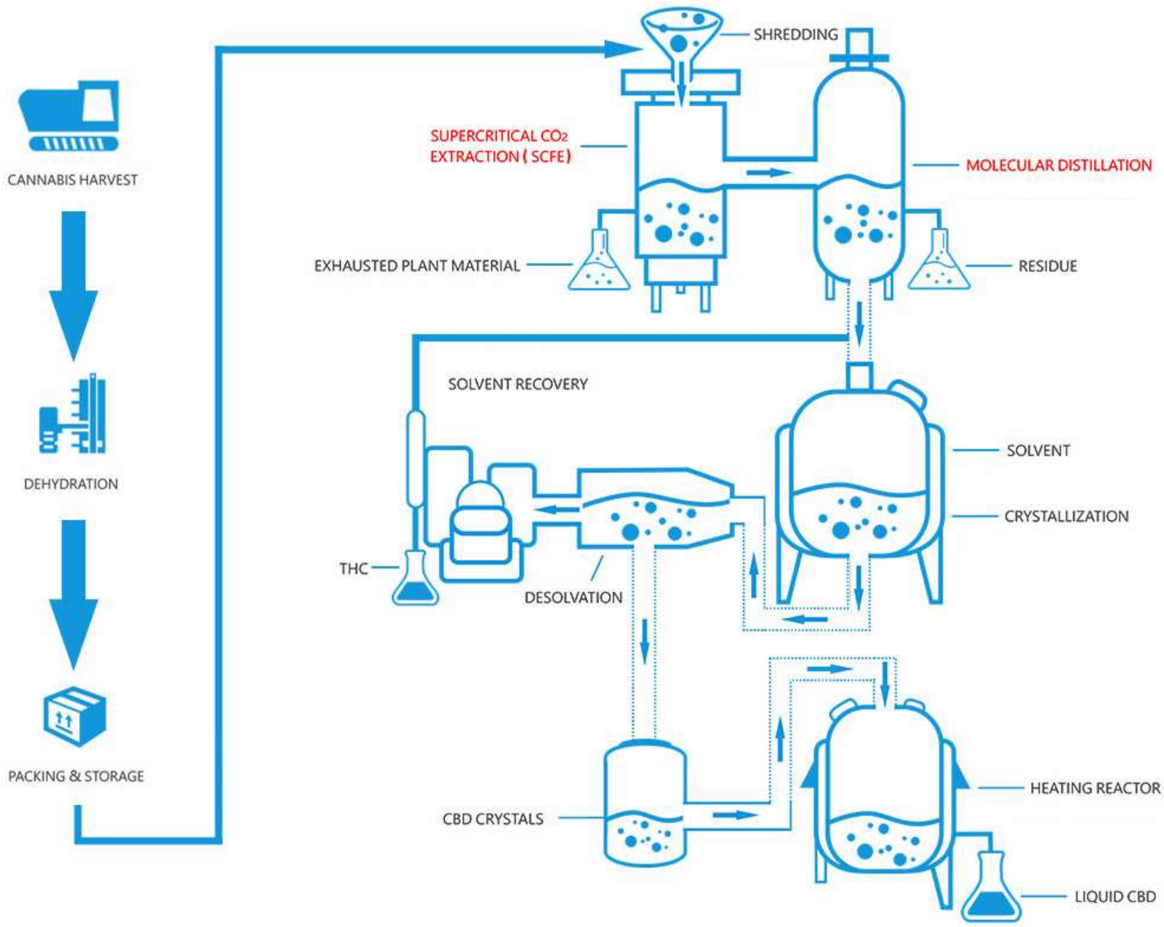
3.5.3 CBD Extraction Methods and Equipment

This section refers to the technology and devices used to extract the oil and CBD from the biomass. From several extraction methods available on the market, the most commonly used are **ethanol** and **critical CO2** (Nafte 2019, *Personal communication*)

The ethanol technique is the most inexpensive, traditional, rough and filthy of all (Vázquez 2019, *Personal communication*). It is normally used to extract oil from hemp grown outdoors, as the biomass/oil ratio is extremely low and only an inexpensive process could be used. The biomass is simply put together with ethanol in order to separate the oil.

The critical CO2 method is much more expensive and sophisticated. Special cylinders are filled with biomass, normally with good quality dried flowers with high contents of oil, and then this biomass is put into specific combinations of pressures and temperatures in order to extract the oil in a much "cleaner" way. These specific temperature/pressure combinations are the "*special recipe*" from the grower/manufacturer, according to interviewed sources, and this extraction should be done by an experienced technician.

The ideal situation requires a HPLC available next to this process in order to measure, at all times, the quality of the extraction result (Vázquez 2019, *Personal communication*). Outsourcing the laboratory analysis will not allow this permanent verification.



"*Process Flow Diagram-cannabis Extraction; The supercritical CO2 method uses carbon dioxide under high pressure and extremely low temperatures to isolate, preserve, and maintain the purity of the medicinal oil. This process requires expensive equipment and a steep operational learning curve. the end product is safe, potent, and free of chlorophyll.*" (Joda-Tech, 2019)[60]

Figure 3.22 Processing and Extraction Process

Source: Joda-Tech, Chinese CO2 extraction machines manufacturer (2019)

After searching the web and analysing different suppliers and price ranges, I have determined that investing **USD 300,000** is more than enough in order to acquire a good quality middle-size CO2 extraction equipment.

Another key equipment in this extraction process is an automatic dryer (Sánchez 2019, *Personal communication*). The biomass must be dried up to 12% humidity, and the ideal situation would be to use a dryer that does so in 24 hours and could cost **USD 200,000**.

[60] https://www.joda-tech.com/cbdoil/?g=g&keyword=cbd%20co2%20extraction%20equipment&matchtype=p&creative=381156552625&device=c&6480301426=6480301426&target=&placement=&gclid=Cj0KCQjwi7DtBRCLARIsAGCJWBo8_nUDp8ZBsueJX8PXrUH7rIImKzY0YA7r2k7QYFHJbO5fZzVp0bQaAi2MEALw_wcB

3.5.4 Equipment and Facilities for Aquaculture

I have to admit that I do not feel comfortable estimating the investment for a barramundi aquaculture project with the little knowledge I possess. However, I believe the most important elements of the system are the following:

- **Tanks and circulation systems**: According to what I have been told by experts, I will work with 10,000-liter PVC tanks. Its diameter varies depending on the manufacturer, but it is approximately 3 metres, so the area of each one is approximately 9 metres. Its retail price is around USD 2,000 each and I have estimated to install 100 tanks. For this purchase there will probably be very competitive international manufacturers willing to offer good prices, so I guess that the worst case scenario would be to get the tanks with their whole installation at a total of USD 200,000.
- **Processing facilities**: Fish fillets should be processed in our own facilities, so the whole equipment should be purchased for this. I have not gone into much detail about the precise equipment, but I guess that USD 50,000 should be enough.
- **Walk-in cooling/freezer**: In order to preserve the fish fillets before exporting them to Uruguayan customers. Not sure about the required size or performance, another USD 50,000 will be more than enough. It will probably be used for the cannabis products as well, not only for aquaculture.

Total investment: **USD 300,000**.

3.5.5 Personnel

The projected facilities will be quite automated, although workers will be indeed necessary for many of the internal processes. Harvesting will be highly labour demanding, as according to Sánchez (2019, *Personal communication*) around 40 people are needed full time for 7-10 days in order to harvest only one hectare. They will be outsourced.

Apart from that, five workers will be permanently working on other internal processes together with a General Manager, an expert cannabis grower and an expert in aquaculture. The workers have an estimated annual salary (considering all annual compensations) of USD 30,000 and the General Manager USD 150,000.

I believe I have been quite generous with the aquaculture expert (part-time) with an annual salary of USD 12,000, and extremely generous with the expert cannabis grower. The grower will be a key player in this project, they are highly demanded and there are not many qualified people in the market, for obvious reasons. According to Sánchez (2019, *Personal communication*) based on real and confidential cases, this amount will be very attractive.

3.5.6 Laboratory Equipment

The price for the CBD oil (and therefore most of this project's income) will depend mainly on its quality and on the company's international certifications (GMP and others).

Permanent analysis on the growth evolution of the plants, and of course on the final product, is another key component in determining its quality. The necessary **laboratory equipment** for production and permanent quality control is really costly to acquire and to operate; however, it is also possible to outsource these analyses with a laboratory authorized by IRCCA (Nafte 2019). As of September 2019, the only authorized laboratory is KEMIA, but there are others applying to IRCCA so there will probably be more soon (Nafte 2019, *Personal Communication*).

There are a wide range of analyses to do on cannabis in order to obtain good quality CBD, so a complete laboratory should include the following equipment (Nargoli 2019, *Personal communication*):

- Pesticide Analyses
- Analyses on cannabinoids
- Heavy metals analyses (Cadmium, Lead, Arsenic, Mercury)

According to Nargoli (2019) from Ridaline, a company specialized in laboratory equipment, such equipment from recognized international manufacturers would cost around USD 1,000,000, but it is possible to acquire good equipment from other good manufacturers for USD 600,000. According to the same source, none of the companies on this market have so far purchased similar equipment; not even Fotmer, a company which has so far invested around USD 50 million (Nafte 2019, *Personal communication*). INNOVATERRA, another relevant cannabis company in Salto (northern Uruguay) is considering the possibility of purchasing a comprehensive laboratory such as the one described above (Nargoli 2019, *Personal communication*)

This project is quite smaller than INNOVATERRA or Fotmer, so mainly for this reason and because of the large investment required, I should conclude that the best option so far would be to outsource the analyses with an authorized laboratory. The simplest and least expensive analysis is for CBD and THC levels, and it costs around USD 200 (Nafte 2019, *Personal communication*). Several ones are necessary throughout the production cycle and they are critical in the CO2 extraction process.

Nevertheless, taking into account such attractive income projections and bearing in mind that quality has an amazing impact on the selling price, I have decided to purchase the laboratory equipment at an estimated price of **USD 600,000**.

3.5.7 Energy

This project has the firm intention of reaching 100% energy self-sufficiency. The easiest way to achieve that is by solar photovoltaic energy (PV), as we will not count on relevant amount of biomass to install bioreactors or the possibility to install a windmill.

The most energy demanding equipment will be the heating system for cannabis, but energy will also be necessary for the walk-in cooler/freezer, water pumps, lighting, laboratory and equipment to process the biomass. Heating devices for greenhouses are normally run with gas or wood (Brandsema 2018 and Figuerón 2019, *Personal communications*), not with electricity, so more research will be necessary on this particular issue.

State monopolies do not apply in FTZs[61], but they are optional (Muzio 2019, *Personal communication*). In the case of Florida FTZ, UTE serves the users directly (Calachi 2019, *Personal communication*).

Since an estimation of the annual energy consumption of the fully running project is impossible for me to make at this time, I will simply assume that 150 kWp installed of solar PV will be enough to be self-sufficient. This is the maximum power possible to install according to the Microgeneration Decree[62]. The solar panels will somehow need to be installed on the top of the greenhouses, as paying for more area in the FTZ would be too costly. BIPV, Building Integrated Photovoltaics, integrates this technology "into" buildings in order to achieve efficiency and aesthetic.

Figure 3.23 shows an example of BIPV, which could perfectly be one of our greenhouses with special solar PV panels instead of regular glasses. This way, sun energy could be seized without losing precious greenhouse space.

The annual energy generation is estimated at 210,000 kWh, and 380 modules will be necessary if using 400W monocrystalline solar panels. They will require approximately 850 sqmt of the roofs, and the estimated turnkey price is **USD 250,000**.

[61] UTE, a state Uruguayan monopoly, is legally the only electricity supplier in Uruguay, with the monopoly to generate, distribute and charge for electricity.
[62] More details in section 2.6.7.

Figure 3.23 Building Integrated Photovoltaics (BIPV)

Source: Yukbiznis 2019.

3.5.8 Water and Nutrients

According to Figuerón (2019, *Personal communication*), 100,000 litres are present on one hectare of cannabis hydroponics at any moment. An adult mature cannabis plant consumes 60 litres per month, so a reasonable estimation would be a total monthly consumption of 800,000 litres with matures plants, according to Figuerón. In his personal undertaking, Verde Agua, he has a 1.2 million-litre underground tank collecting only rainwater and it is enough for a whole hectare of vegetables. He estimates such a tank is enough as well for a whole hectare of cannabis.

With such a strong statement from such a qualified informant, I did not feel the need to work on future climate scenarios in order to determine whether rainwater will be enough in the future. Sánchez (2019, *Personal communication*) was not so sure about this, but he believed it could be possible with a large-enough tank.

Fotmer is currently spending USD 3,500 a month on nutrients for a whole hectare of adult cannabis plants (Figuerón 2019, *Personal communication*). While being aware that expenditure on nutrients does not follow a linear tendency as a result of nutrient requirements differing from one growing stage to another (Sánchez 2019, *Personal communication*), I nonetheless took this number as valid.

3.6 Location and Company Type: *Florida Free Trade Zone*

This is not the first time that I witness, first hand, the birth and growth of a new industry in Uruguay. It is amazing to see how paradigms change so fast, not only from the general population but also from specific groups of people. The birth of the Uruguayan renewable energies sector took place in 2012[63], and it has been developing quite well since then. Despite negative changes introduced in 2016 and 2018[64], which did not help in the then steady growth of solar PV[65] microgeneration plants, the solar energy paradigm changed completely in only a few years from an unreliable and expensive technology, to a new, reliable and ever-cheaper one.

I am even more fascinated by the rapid changes in the cannabis sector. When I started looking into this sector, in middle 2018, my first intuition was that this business was perfect to be developed in FTZs for a simple reason: **large amounts of money from the sale of products addressing foreign markets**. "*There are products sold locally, such as drops, creams or yerba mate, but quantities are not considerable. The main objective of the companies is to export.*" (Podestá, 2019, interviewed by Pascual, 2019)[66]. I even thought about my "ideal" FTZ where to carry on this activity, and it was *Zona Franca Colonia Suiza*[67] in Nueva Helvecia, as I used to drive by it often and I knew that it had plenty of space available.

I immediately started enquiring experts on this, and the first response was more or less what I had expected: agriculture is not allowed in FTZs, but only trade, services and industrial production. These answers, though expected, came as a disappointment. Even experts advising potential cannabis clients had no clue about this potential opportunity and my question was often taken as very weird.

A few months later, in November 2018, I came back to Uruguay and happened to drive by *Zona Franca Colonia Suiza* and could not help to see large greenhouses, exactly in the areas where I had imagined to set my own greenhouses; Fotmer Life Sciences[68], the company which made the first cannabis exportation from Uruguay, had established its own facilities there. Fotmer has other facilities in another free trade zone: *Zona Franca Parque de las Ciencias*. Their greenhouses are located in *Colonia Suiza*, while production and R&D are in *Parque De Las Ciencias* (De León, Figuerón and Nafte, 2019).

[63] I am referring to the beginning of the real "*mass use*" of renewables with the Microgeneration regulation. It is not that they did not exist in Uruguay before this year, but they were very rare.
[64] The conditions for new generators changed in 2016 (explained in section 2.6.7), and the tax incentives for companies installing renewables decreased in 2018 with a new Decree (Law on Investments).
[65] PV stands for photovoltaic.
[66] https://mjbizdaily.com/solving-uruguays-adult-use-cannabis-supply-shortfall-and-when-to-expect-the-first-medical-exports-qa-with-attorney-daniel-podesta/?
[67] http://zonasfrancas.mef.gub.uy/1052/4/areas/zona-franca-colonia-suiza.html
[68] https://fotmer.com/es/category/ro/

Not exactly sure why this activity is allowed in FTZs, I heard that this activity had been allowed as long as plants are not grown on the ground, but in pots or other “industrial” techniques. Muzio (2019, *Personal communication*), an expert in international taxation, believes that the Law was slightly “*twisted*” in order to include the cannabis business in it, due to its clear potential. I had previously made the same assumption. According to Saldías (2019, *Personal communication*), this is a “*grey area*”. Major investments in this Uruguayan business are now being made in *Free Trade Zones*.

A Free Trade Zone (FTZ) is a special economic zone in Uruguay, initially regulated in 1987 by Law 19,921 (refer to sections 2.6.13 and 7.1 for further details), in which national taxes do not apply under certain circumstances. As long as FTZ *users* (the companies working in a FTZ) add real value within the FTZ, they are allowed to carry on their activities as any other company outside the FTZ and export to other countries without paying any taxes, with the only exception of social security contributions for employees who are Uruguayan residents.

Figure 3.24 Florida Free Trade Zone

Source: MEF 2019, Uruguayan Ministry of Economy and Finance[69]*.*

[69] http://zonasfrancas.mef.gub.uy/1053/4/areas/zona-franca-florida.html

Law 19,921 has undergone several changes since its creation in 1987, and was last modified in 2018 with the introduction of new regulations to comply with OECD requirements (Muzio 2019, *Personal communication*).

According to the Uruguayan Ministry of Economy and Finance (MEF, 2019) there are currently 11 FTZs[70] in Uruguay. More than half (57%) of the FTZ users have exported in 2017, representing 27% of the total exports from Uruguay this year.

Operating a company from a FTZ is very expensive. Users must pay a certain fee and common expenses per square meter, so it is particularly expensive when a large area is needed. According to Uruguay XXI (2019), the monthly rent/fee per square meter for a standard office in a FTZ ranges from USD 13 to USD 46, and common expenses range from USD 4 to USD 8.9. The most expensive are *Zonamerica* and *World Trade Center*, both of them located in Montevideo.

According to experts I have interviewed, *Florida FTZ*[71] is one of the least expensive and with spare area available. It is located in southern Uruguay, about 100 kilometres away from Montevideo near national route 5.

I was able to interview the director of Florida FTZ, Alejandro Calachi, and he explained to me that the total area currently available is around one hectare, but they are considering the possibility to purchase nearby pieces of land in order to increase it. Current demand is very high (Calachi 2019, *Personal communication*) and prices for new users depend on supply and demand, as in any other business.

For a clean area outside warehouses, *Florida FTZ* is currently charging USD 3 for rent and USD 1 for common expenses, per square meter per month. These figures are negotiable for the whole hectare, and they do not have any user with such a large area at the moment.

[70] http://zonasfrancas.mef.gub.uy/19344/4/areas/zonas-francas.html
[71] http://zonasfrancas.mef.gub.uy/1053/4/areas/zona-franca-florida.html

3.7 Assumptions

In this last section of chapter 3, I have outlined the most relevant assumptions made during this analysis. Even though most of such assumptions are, from my point of view, quite reasonable, it is very important to shed some light on them if this project is to be carried out.

The most important assumption is probably the fact that **I will be able to find an active Free Trade Zone (FTZ) with available space, and willing to charge a reasonable fee**. Florida FTZ is by far the cheapest of all, and such a large piece of land available is not normal. If this particular FTZ runs out of space and is not able to purchase nearby areas, it might be harsh to find a suitable place where to start this project.

I expect that **the Uruguayan legislation will not change** with new governments regarding cannabis. This is probably the least risky of all the assumptions I have made. The medicinal cannabis industry has proven to offer great potential, this legalization process is spreading to more countries every month, and new governments in Uruguay do respect previous legislations and private investments.

Another important assumption is the fact that **an aquaculture undertaking will be allowed in a Uruguayan FTZ**. I believe this should not be an issue, as the main project is related to cannabis and not to fish growing. Moreover, it could be argued that this is an intensive industrial activity.

I have also assumed that **DINARA will allow a barramundi aquaculture undertaking**, granting the necessary authorizations in order to introduce this new fish species to Uruguay and start breeding it. According to Foti (2019, *Personal communication*), previous requests to introduce exotic fish species to Uruguay have been declined due to high risk of invasion. Barramundi is a predator and in some cases adapted to cold waters, so DINARA could see it as a threat and assess the invasion potential as too high. However, our winters are probably way too cold for barramundi to survive, and it will also be very well contained, in new state-of-the-art facilities and far from rivers, streams, lakes or ponds. An appropriate production plan should be enough.

Apart from that, I believe that the authorization from DINARA might not be necessary to introduce and rear barramundi in a FTZ. No import operation is technically necessary to have barramundi in a FTZ, so a DINARA approval might not be necessary. According to experts interviewed, there is no doubt that this is a "*grey area*" at the moment.

A regular recommendation from advisors regarding new aquaculture projects (Turra 2019, *Personal communication*) is "*just start working, and when you are too big to be shut down, DINARA will not be able to do it and will start asking for documents to issue an authorization*"

4. Economic and Financial Issues

In this chapter, and based on all the information gathered and assumptions made, I will list and describe every relevant item for the initial investment, as well as for running the project year after year.

4.1 Initial Investment

The initial investment is the amount of capital required to start the project. It includes not only infrastructure and equipment, but also a reasonable amount of working capital available to run the project in a proper way while sales are not enough to do so.

4.1.1 Legal Entity

A company to work inside a FTZ ("*sociedad anónima*") is less expensive than a regular Uruguayan company. The total cost is approximately USD 2.000 (Muzio 2019, Personal communication)

4.1.2 Facilities and Equipment

Table 4.1 displays the estimated total investment necessary in facilities and equipment, based on the analysis carried out in previous sections.

Table 4.1 Facilities and Equipment

Facilities and Equipment	
Greenhouse/s	USD 2,000,000
Laboratory	USD 600,000
Automatic dryer	USD 200,000
CO2 extraction equipment	USD 300,000
Aquaculture facilities and equipment	USD 300,000
Solar PV plant	USD 250,000
Underground tank	USD 50,000
TOTAL	**USD 3,700,000**

Source: Self-made, 2019.

4.1.3 Working Capital

The higher the investment, the running costs and above all the business risks, the higher the working capital that should be provided to a project.

In this case, I regard the risk as quite high. Therefore, I have set the WC at **USD 6,000,000**.

4.1.4 Registrations and Authorizations

As explained in section 3.2.1, the licenses for this project cost **USD 52,000**.

4.1.5 Total Estimated Initial Investment

Table 4.2 shows the estimation of the total initial investment for this project.

Table 4.2 Total Estimated Initial Investment

Total Estimated Initial Investment	
Legal entity	USD 2,000
Facilities and equipment	USD 3,700,000
Working capital	USD 6,000,000
Registrations and authorizations	USD 52,000
TOTAL	**USD 9,754,000**

Source: Self-made, 2019.

4.2 Running Costs

This section describes the most important annual running costs.

4.2.1 Free Trade Zone

As analysed in section 3.6, the total annual costs of Florida FTZ for 12,000 sqmt is estimated at **USD 576,000** (USD 4/month per sqmt).

4.2.2 Registrations and Authorizations Upkeep

As explained in section 3.2.1, the amount needed to request the licenses is the same for their annual upkeep: **USD 52,000**.

4.2.3 Administration

This section includes expenses for lawyers and accountants' fees, general administration costs and banking fees (hopefully…), among others. Total annual estimation: **USD 20,000**.

4.2.4 Personnel

Hoping not to offend any HR specialist, I have listed personnel under "running costs" due to my professional deformation.

Table 4.3 is based on section 3.5.5 and shows the estimated human resources for this project with their due annual salaries in USD, including all the annual compensations for each one of them.

Table 4.3 Personnel

POSITION	#	Annual Salary	
General Manager / Director	1	USD 150,000	USD 150,000
Expert cannabis grower	1	USD 36,000	USD 36,000
Expert in aquaculture	1	USD 12,000	USD 12,000
Operators	5	USD 30,000	USD 150,000
Outsourced harvest crews			USD 150,000
TOTAL			**USD 498,000**

Source: Self-made, 2019.

4.2.5 Nutrients and other Expenses

As previously explained in section 3.5.8, the estimated monthly expenses on nutrients rise up to USD 3,500, so this annual figure goes up to **USD 42,000**.

I contacted Warren Bravo, the CEO of Canadian company Green Relief regarding their savings on nutrients, but he kindly replied that this is proprietary information and, accordingly, cannot be disclosed or revealed. Habitat Craft, unfortunately, never replied.

Therefore, the savings on nutrients derived from aquaponics has not been considered in this estimation.

4.2.6 Barramundi Fries and Cannabis Seeds

Barramundi fries will be purchased only once at the beginning of the project, as breeders will be available for following fry batches. Fries are normally extremely inexpensive (Turra 2019, *Personal communication*), they usually cost only a few cents of US Dollars each.

BioCan offers 1 kilogram of FEDTONIC seeds, EXW Switzerland, for around USD 90,000 to USD 100,000 (Sánchez 2019, *Personal communication*). It contains 90,000 seeds. For a few seeds they charge USD 2.5 each one, but the industrial retail price could go up to USD 7 per seed (Nafte 2019, *Personal communication*).

Planning to have four or five harvests a year, from 50,000 to 60,000 seeds a year will be required. This represents an annual estimated budget of around **USD 60,000**.

4.2.7 Total Estimated Annual Running Costs

Table 4.4 Total Estimated Annual Running Costs

Total Estimated Annual Running Costs	
FTZ	USD 576,000
Registrations and authorizations	USD 52,000
Administration	USD 20,000
Personnel	USD 498,000
Nutrients and other expenses	USD 42,000
Fries and seeds	USD 60,000
TOTAL	**USD 1,248,000**

Source: Self-made, 2019.

4.3 Projected Output / Income

Based on the whole analysis from previous sections, I will project gross and net income from the sale of barramundi and from the sale of cannabis.

4.3.1 Cannabis

I had initially thought this would be the easiest part of the whole research; projecting the income of a project focused on elaborating a commodity, with precise information on the yield per hectare of the most important plant breeds and very clear international market prices… I could not be further from reality.

The following are the current facts of this business:

- CBD isolate is not a commodity, and I believe it is far from being so,
- therefore, there are no public, specific and clear international market prices published anywhere,
- the different cannabis breeds yields vary very much depending on weather conditions (Pascual 2019, *Personal communication*) and growing techniques,
- there is so far not enough industrial experience with cannabis in order to determine, with a reasonable degree of certainty, potential growing yields.

I have interviewed many national and international market stakeholders regarding reasonable yields and prices, receiving many different versions. The analysis on the estimated yields and prices for this project are explained in section 3.2.2, so based on this analyses the projected output is displayed on Table 4.5:

Table 4.5 Projected Output / Income from Cannabis

Projected Output / Income from Cannabis	
Annual production	25 tonnes of dried flowers
Yield: biomass to CBD	12.5%
Annual CBD production	3,125 litres
Price per litre	USD 8,000
Total annual income in USD	USD 25,000,000

Source: Self-made 2019, based on different sources of information.

4.3.2 Barramundi

Even though the output of aquaculture is intended to add sustainability to this project, making it much more environmentally friendly, it will also offer a high quality product to an increasing national market of fresh and frozen foods (mainly imported).

The final products of aquaculture are described in section 3.3.5, and they are **boneless, well-trimmed skin-on barramundi fillets** in the following presentations:

- **Cooled (not frozen) 2.5-kilogram vacuum packed polythene (plastic) bag**, in boxes of 4 bags each (for gastronomy clients).
- **Cooled/frozen 1-kilogram vacuum packed polythene (plastic) bag** (for retail).

According to Avdalov (2019, *Personal communication*), the market value of different fish species does not always go hand in hand with its quality, but in the case of barramundi, it does indeed. Barramundi offers high quality products, very well valued by consumers.

I have identified similar products which are currently on our market, both from sea and fresh water, as well as their current wholesale prices (September 2019):

Table 4.6 Fish Fillets Wholesale Prices in Uruguay (September 2019)

Product	Common name in Uruguay	Average wholesale price (USD per kg. + VAT[72])
Atlantic salmon (in different presentations and origins)	*Salmón*	15 – 18
Barramundi (only 1 importer)	*N/A*	11.25
Cod (natural raw fillet)	*Bacalao*	12.88
Dogfish	*Cazón*	6.08
Grouper	*Mero*	7.32
Hake	*Merluza*	4 – 6.5
Pangasius	*Pangasius*	3.9 – 5.1
Pollack	*Abadejo*	12.36
Sea bass	*Corvina*	2.42
Sole fish	*Lenguado*	7.8 – 10.0
Tilapia	*Tilapia*	5.15
Whiting	*Pescadilla*	5.36

Source: Wholesale price lists of the main national importers.

[72] VAT stands for value-added tax, which in Uruguay is 10% for this type of products.

One of the importers sets its wholesale prices in US Dollars, but most of them do it in Uruguayan Pesos (UYU). Nevertheless, fluctuations in UYU/USD tend to reflect in local prices in the short term (from one to two months) and most of these products are imported. For these reasons, I believe that not only this analysis but also the final price for our product can be set in US Dollars.

Barramundi is being offered only by one importer (as far as I could find) as skinless, boneless and well-trimmed fillets of approximately 300 gr each, in 5kg boxes IQF, 30% glazing[73] and in a bulk plastic bag. When the product was requested it was available in stock (And by the way, it was obviously frozen but delicious!).

I believe a reasonable and attractive wholesale price for our product could be USD 10 per kilo plus VAT (10%).

For the **commercialization** of this product to Uruguayan companies, it will clearly not be feasible to make export operations for every sale. It would be too costly and it would discourage many potential customers. Therefore, two alternatives are possible:

- Open a company outside FTZ in order to export the barramundi final production to it, and then commercialize from this company in Uruguay to the different clients (national sales)[74]
- Sign an agreement with one or more food wholesalers, so that they can import and take care of the sales in Uruguay.

Either way, the analysis made on this section should not differ much from one alternative to the other, as the margin for the importer should be more or less the same in both cases.

Based on a USD 10 wholesale price in Uruguay, I have estimated in table 4.7 the export price for each kilogram of fillet considering import taxes and expenses, and the margin for the importer. From these analyses I have estimated an export price of USD 6.46.

[73] In food processing, "*glazing is the application of a protective layer of ice formed at the surface of a frozen product by spraying it with, or dipping it into, clean seawater, potable water, or potable water with approved additives, as appropriate. When frozen fish are to be stored, depending on packaging, they are exposed more or less to the cold air of the freezing chamber. Without glazing, the oxygen of the air will react with the fats (turning them rancid) and drying and dehydration of the product will not be prevented (which may lead to freezer burn). In addition, glazing is a physical barrier that protects the product from damage during production, packaging, transport, and retail.*" (Soares, 2016, based on FAO's Code of Practice for Fish and Fishery Products)

[74] In this case, transfer pricing rules should be followed and pricing should be fair.

Table 3.9 shows my initial yield estimations for the production of barramundi in the conditions of this project, with an estimated net annual filet production of 7 tonnes and an annual estimated feed consumption of 40 tonnes. Following this analysis, I will project annual gross and net income in Table 4.8. We can see that, according to these figures, the income from selling barramundi does not even cover the expenses on fish feed, let alone the rent of 20,000 square meters in Florida FTZ.

Table 4.7 Barramundi Selling Price

Barramundi Selling Price		
Estimated wholesale price	USD 10.00	
Wholesaler's estimated margin	20%	USD 2.00
Import expenses and logistics	5% (est. approx.)	USD 0.57
Import taxes on selling price	15%[75]	USD 0.97
Selling price (for export)	**USD 6.46**	

Source: Self-made 2019, based on different sources of information.

Table 4.8 Barramundi Sales: Gross and Net Income on an Average Year

Barramundi Sales: Gross and Net Income on an Average Year	
Annual net fillets output	7 tonnes
Price per kilogram	USD 6.46
Gross annual income in USD	USD 45,220
Annual feed in tonnes	40 tonnes
Price for 1 ton of feed	USD 2
Annual feed in USD	USD 80,000
Annual income from aquaculture (net from feed)	**(USD 34,780)**

Source: Self-made 2019, based on different sources of information.

Although this calculation should add an estimation of savings on nutrients, I do not have at the moment the necessary information to make it.

[75] 10% customs duties + 5% "*consular fee*" (Lago 2019, *Personal communication*)

4.4 Cash Flow and Analysis

The cash flow is shown in the Appendix, section 7.5. With an investment of almost USD 10 million, an IRR of 243%, an NPV (12%) of USD 126 million, and a repayment period of only a few months, I got very sceptical about it and doubted several times whether to disclose it or not.

My first reactions pointed to something being wrong with the calculations or with my yield estimations. I contacted real experts on this field (Sánchez, Rodríguez Lepera, Figuerón and others) and analysed with them my estimations. Logics appear to be alright, the internal processes are correct, and the projected yields, despite more than average compared to the Uruguayan current situation, are not impossible at all. In fact, they are way lower than the yield achieved by Green Relief in Canada.

I was tempted to increase the projected income in 2025, for example, expecting to achieve a European GMP certification. This would imply a great increase in the price of the product. Nevertheless, the cash flow looked already too attractive, prices in general are falling and the production quantities play a role as well. I should have also started with a not so steep income flow, as there will obviously be a considerable learning curve to go through, but I preferred not to make so many assumptions. The complexity and uncertainty for me are, at this moment, too high.

Beginning part of my analysis in this section, I could partially explain these results from the fact that the project aims to achieve a complete vertical integration, from the growing up to the selling of the CBD isolate. According to Sánchez and Vázquez (2019, *Personal communication*), "*the real business is in the whole process*". "*There are attractive profits to make in separate parts of the medicinal cannabis value chain, but the business is then not so attractive*" (Sánchez, *Personal communication*).

Table 4.9 Economic Analysis on Aquaponics

Economic Analysis on Aquaponics	
Gross annual income	USD 45,220
FTZ	(USD 96,000)
Annual expenses on fish feed	(USD 80,000)
Aquaculture expert's annual compensation	(USD 12,000)
Savings on nutrients (for hydroponics)	¿?
TOTAL Preliminary result	**(USD 142,780)**

Source: Self-made 2019.

According to my analysis, aquaponics is clearly not an option for this project. On top of being expensive, working with this technology does not add sustainability (as already analysed, it is a mere illusion), and poses a great distraction to scarce resources that should otherwise be focused on the real business: medicinal non-psychoactive cannabis.

Table 4.9 shows my estimations of the real return of aquaponics on this business. I am sure that every aquaponics advocate will disagree, but these are the facts according to my analysis.

4.5 SWOT Analysis

I have made the following SWOT analysis from a "business" point of view on this particular project, not focusing particularly on any of the different technologies analysed on this document.

Strengths

- Experience with different businesses in operation.
- Strong experience with international business operations.
- Strong national connections.

Weaknesses

- No previous experience, neither with cannabis nor with aquaculture.
- Inconclusive analysis on aquaponics.
- Operations not even started and registrations and authorizations not even requested yet, with the complexities and risks that they imply.

Opportunities

- Large and rapidly growing international markets.
- Production of THC.
- New products related to cannabis.

Threats

- Ever decreasing national and international prices of cannabis, according to many sources interviewed.
- International irreversible cannabis legalization threatening to expand the international offer to low cost countries.
- High market entry barriers: capital, *know-how*, etc. (which could be a strength).

I had the initial intention of making a **scenarios and sensitivity analysis**, but after studying my whole research I decided it would not have been a professional approach. They are indeed valuable tools, but in this case the main variable is income: selling price and production. Making a sensitivity analysis on this case is like "futurology on steroids", making hypothetic changes to variables of which I am not even sure at the present time.

5. Conclusions and Further Research

I feel I must start by answering the initial research question presented in section 1.4:

Which are the characteristics of the optimum aquaponics system in Uruguay for the industrial medicinal cannabis growing production in order to achieve the best sustainability, efficiency and profitability indexes?

However, there is no simple and straightforward answer to this question. This research has shown that there are several variables involved, being most of them not easy to analyse, understand or foresee.

5.1 Cannabis

With regard to the main focus of this research, i.e. the pharmaceutical/medicinal cannabis industry, my analysis, forecast and conclusions are extremely positive.

I have reached the conclusion that the cannabis legalization process will spread worldwide, with global legalization being probably just around the corner. The medicinal/pharmaceutical cannabis market will strengthen and keep on growing following a clear trend, which started only a few years ago, and it will soon become a global multi-million dollar business. I believe that the pharmaceutical cannabis sector will sustain special growth in the medium and long term, with much larger investments and specialization.

The most important variable of this analysis is revenues, not only in terms of production quantities but mainly of price. As I have explained throughout this research, pricing is still not clear and it differs considerably based on CBD quality and origin. Regardless this issue, it is absolutely clear that current pharmaceutical cannabis production with a vertical integrated strategy is an extremely profitable field.

The choice to work on the topic of cannabis in Uruguay particularly derives from the pioneering stance of the country in this sector, both regionally and internationally. Jordan Lewis, CEO of Fotmer Life Sciences, could not have explained it better: "*Uruguay has clearly established itself as the leading Latin American country in the incipient world cannabis industry. The projections show that medicinal cannabis will play an important role in the Uruguayan economy by providing jobs, attracting international investment and bringing necessary income for [marijuana-related] investigation and development, which is vitally important.*" … "*Our goal is to create a billion-dollar industry here in Uruguay in the next five to seven years*" (Jordan Lewis 2019, according to Cannabis Europa 2019). I am quite confident that he is absolutely right. This new business sector has come to Uruguay definitely to stay, and it will probably account for a great share of our exports soon.

Although this research allowed me to learn about the most important aspects of this business, many of my questions still remain unanswered. Despite the high entry barriers and steep learning curves, the complexity lies mainly on the general lack of *know-how* and in putting a simple idea into practice at an industrial level. After all, this business requires growing a plant which any friend of mine could successfully grow at home (in fact, they do!) and with no great technology. Moreover, permissions and registrations do not pose major uncertainty or complexity.

Nevertheless, these difficulties do not explain the amazing returns on investment. In spite of the importance of the required initial investments, this does not constitute a limitation at all for large pharmaceutical players, which are to be the main clients of this business. Pfizer declared revenues of almost USD 54 billion in 2018 (Pfizer 2018 Financial Report), so companies like this one should be heavily investing on the cannabis business according to my analysis.

According to Wehe and Vázquez (2019, *Personal communications*), cannabis will probably be soon the solution for many diseases and it will be widely used, somehow or another, as a pharmaceutical product. Being a potential substitute for many extremely profitable products from large pharmaceutical companies, which have invested millions to develop, there is no particular interest in the rapid growth of this sector. Having said that and according to Wehe (2019, *Personal communication*), large pharmaceutical companies are indeed taking interest in the business by investing in different companies, so they have a clear stake on this sector in order not to be left behind.

I can also conclude that industry profit margins will sharply fall during the next few years as the market evolves, only with the survival of the best and the most efficient, as in any other business.

Most of the experts interviewed stated that the current real business rests on the entire vertical integration, from growing the seedlings to processing final products. I believe that, in a more mature market, there will be room for highly specialized companies to work only in one of the steps of the industry value chain.

The first two specific objectives set in section 1.4 relate to cannabis and both have been achieved. Despite further research being necessary on the second specific objective regarding the most appropriate cannabis breed to grow, I have been able to reveal the current market situation on this matter, concluding that FEDTONIC is *a priori* the best alternative.

5.2 Aquaponics

I had great expectations on the idea of aquaponics. Knowing that my research did not include any practical experience, my intentions were to find the most appropriate technical combination to reach the highest potential of this technology when growing sustainable cannabis. Unfortunately, I have not even been able to determine whether aquaponics would actually work at an industrial level.

It is certain that aquaponics actually works, as it is an essential part of any natural water environment. It is also a fact that the aquaponics idea has been used for centuries by humankind as an agriculture technique, which has indeed worked. It has been probably applied in very primitive ways, so these "production processes" were very similar to natural environments themselves. However, I am certain that the industrialization of aquaponics is a whole new area of study.

I have reached the conclusion that aquaponics could be so problematic, expensive and dangerous to this project, that the idea of using it should be discarded. Moreover, if carried out, aquaponics will be a luxury only afforded by the existence of a highly profitable crop such as cannabis.

My only real expectations on aquaponics could be to potentially achieve important savings on nutrients and gain sustainability. Unfortunately, I have contacted Green Relief requesting data about the savings on nutrients from using aquaponics but they replied that this is proprietary information. The only thing I know, according to statements from Bravo, is that the nutrients they purchase are fully financed by the tax credits they receive from the donation of tilapia to charity. This only means that they need indeed to add nutrients, so the fish component of the system does not provide them all. I have also contacted Habitat Craft but received no reply whatsoever.

Considering that worldwide research on this technology has failed to reach so far any conclusive general guideline about industrial aquaponics, I believe that such industrialization is either extremely difficult (perhaps only applicable to specific fish/plant combinations) or contrary to any potentially positive cost-benefit relation.

On top of all this, it would appear that current aquaponics systems, if they actually work, are not so fully sustainable after all. Most of the most profitable fish species are carnivorous, highly protein demanding. Their feed comes from completely unsustainable sources, so this simple idea makes me think that an average aquaponics system is actually not sustainable. This could be solved either by feeding carnivorous fish species under new and sustainable feed processing techniques, or by simply rearing herbivorous fish species.

My personal contribution to industrial aquaponics is the development of an Instant Nutrients Analysis device. I am quite confident that this technology could automate internal aquaponics processes, making them more accessible and applicable to industrial facilities. Nevertheless, I have also found that the main bottleneck for the growing of aquaponics not only includes nutrient unbalances, but also unbalances related to other issues, such as pH.

This research set initial specific objectives in section 1.4, being the third and fourth directly linked to aquaponics. Even though further research should be conducted in order to better support my recommendations, I successfully concluded that the best fish species to work with is barramundi, and determined the plant layout based on different experts' opinions and current industry situation.

5.3 Contribution to Sustainable Regional Development

I am quite confident that this research could serve as a great contribution to sustainable regional development, which is the main focus of this Master's Degree.

My country is a clear example of successful regional development derived from the cannabis industry, as this crop has been creating and will continue to create thousands of permanent and seasonal job positions in regional rural areas. These positions have been mainly for Uruguayans, including not only highly skilled labour but also low skilled labour.

5.4 Further Research

As a final thought and perhaps as a recommendation for further research on these topics, I believe that a really scientific and objective research undertaking to tackle these research issues would necessarily require at least a considerable budget and, if possible, cooperation with a specialized governmental agency. I feel I have missed much of the relevant information to make conscientious recommendations, such as:

- the kind and amount of nutrients offered by the waste from barramundi, in each of its different growing stages;
- data and information to formulate any universal recommendation on aquaponics, including the different realities of different fish species and under different growing methods in different growing stages;

- a thorough analysis of the different currently available cannabis breeds, and selection of the best breeds to produce a high amount and quality CBD. I could not even get into this topic but only base my analysis on experts' testimonies.
- further analysis on the potential development of an Instant Nutrients Analysis device.

Nevertheless, I am confident that the main conclusions to which I have arrived are not affected at all by the above mentioned issues. After all, the scope of my initial research proposal did not include a thorough analysis on any of these topics.

6. References

6.1 Articles, News and other References

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- Bright, Bill. Hydroponics expert installer in Tasmania, Australia. *Interviewed 5 November 2018.*
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- Chelf, David. President of Airstream Innovations. *Personal written communications in October 2019*.
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- Fontes, Enrique. Director; José C. Fontes e Hijos SRL. Wholesaler of foods in Santa Lucía, Canelones, Uruguay. *Interviewed 4 September 2019*.
- Foti, Rosana. Director of the Department of Aquaculture in the Uruguayan National Directorate of Aquatic Resources (DINARA) *Interviewed 7 October 2019*.
- Francis, David. Senior lecturer in Aquaculture Nutrition, Deakin University. *Interviewed 2 October 2018*.
- Gleeson, Steve. Pure Ponics, Australian company with experience in Aquaponics. *Interviewed 7 September 2018*.
- Halliwell, David. Director of Research Partnerships; Center for Regional and Rural Futures; Deakin University. *Interviewed 2 October 2018*.
- Henderson, Rob. Hydroponic Capsicums in Tasmania, Australia. *Interviewed 5 November 2018.*
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- Lago, Gustavo. Amespil Moreno Despachantes (Customs agents). *Interviewed several times in 2019.*

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- Melgarejo, Esteban. Embassy of Uruguay in Canberra, Australia. *Interviewed several times in 2018 and 2019*.
- Mercado, Martin. Investment Promotion Agency, Canelones, Uruguay. *Interviewed in June 2018*.
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- Nargoli, Javier. Technical advisor at Ridaline, company especialized in laboratory equipment. *Interviewed 13 September 2019*.
- Pascual, Alfredo. "*International Analyst at Marijuana Business Daily, specializing in international cannabis markets and regulations*"[76]. *Interviewed 16 October and 8 November 2019.*
- Patrón, Lucía. Lawyer; expert in Uruguayan cannabis legislation issues. *Interviewed several times in 2018 and 2019*.
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- Rodríguez Lepera, Gastón. HGSM Consulting/Greenfields Health Care/SIMBIOSYS. Advisor in cannabis projects. *Personal written communications in October 2019*.
- Saldías, Rodrigo. Specialist of the Agribusiness sector in the Investment Promotion department of Uruguay XXI. *Interviewed 8 October 2019.*
- Sanchez, Álvaro. Expert international consultant in hydroponics and BioCan AG advisor in Uruguay. *Interviewed 24 October 2019*.
- Santana, Rafael. Marine Biologist. Expert in Uruguayan fisheries. *Interviewed several times in 2018 and 2019.*
- Schultz, Aaron. Faculty of Science, Engineering & Built Environment, Deakin University. *Interviewed 2 October 2018*.
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- Wehe, Leonardo. Director of Parque de las Ciencias Free Trade Zone. *Interviewed 16 October 2019.*
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7. Appendix

7.1 Free Trade Zones in Uruguay: Overview

"***What Are the Benefits Of Free Trade Zones in Uruguay?***

by Team Uruguay | Feb 17, 2019 | LATAM, Uruguay

The Free Trade Zone Regime in Uruguay provides companies with tax and customs benefits. Likewise, it is an effective tool for businesses to efficiently manage their business ventures, allowing them to avoid long delays, unnecessary bureaucratic administrative processes, and of course, providing attractive fiscal benefits.

Uruguay is one of the most attractive Latin American jurisdictions for the establishment of companies. Uruguay allows 100% foreign ownership of local companies and companies can be formed with only one shareholder.

Additionally, the government's implementation of legislation relating to tax regimes and free trade zones has turned Uruguay into a commercial paradise for companies looking to establish their operations abroad. Moreover, we cannot overlook Uruguay's political, economic and social stability.

What are the Features of Free Trade Zones in Uruguay?

Free trade zones are areas in Uruguayan territory which can be both public and privately owned. These are highly secured locations with the following features:

State monopolies do not govern.

The business activities of companies operating in these zones have tax and customs exemptions.

There is total freedom for the entry and exit of goods, fixed or capital assets, with exemptions in taxes and duties.

Companies can develop any business, industrial and service activity in these zones. Some examples are given below:

Marketing, deposit, storage, conditioning, selection, fractioning, assemble, disassemble, handling or mixture or goods or raw materials with foreign or national origin.

Installation and operation of manufacturing equipment.

Financial, IT, repair and maintenance services, professional services and others required for the operation of the activities.

To date, Uruguay has eleven free trade zones with a variety of specializations. These areas are located near the metropolitan area. The eleven free trade zones are:

Zona Franca Punta Pereira

WTC Free Zone

Zona Franca Colonia Suiza

Aguada Park

Zona Franca Nueva Palmira

Parque de las Ciencias

Zona Franca Florida

Zona Franca Libertad

UPM Fray Bentos

Zona Franca Colonia

Zonamerica.

How Are the Free Trade Zones Managed?

In Uruguay, both private owners and the state operate the free trade zones. The government duly authorizes companies to manage some the free zones and the government manages others. Additionally, the government is responsible for the supervision and *monitoring of the whole system throughout the General Agency of Commerce – Free Zones Areas (Dirección General de Comercio – Área Zonas Francas).*

How to Operate in Free Trade Zones?

Operating in free trade zones will grant companies various attractive tax advantages, granted by law. In order to be granted the status of a user of a free trade zone, the company will need to be registered at Dirección de Zonas Francas. It should be noted that there are two types of users of free trade zones:

The Direct User: *This user gets the right to operate in the free trade zone and the process occurs through signing a contract with the entity that manages the free trade zone.*

The Indirect User: *This user acquires the right to operate in a free trade zone and has to sign a contract with the owner and then has the right to use or exploit the zone for commercial purposes.*

According to national legislation, only legal persons (i.e. companies and corporations) can operate in free trade zones. Most often, Uruguayan corporations are chosen as the vehicle to manage operations in these zones. However, a branch office of a foreign company can also be used to carry out commercial activities.

Companies operating in free trade zones should choose the most appropriate zone to develop their business. The choice of the free trade zone will depend on your companies planned business activity… Do you delivery services? Are you storing inventory? Are you importing products? Are you exporting products?

Infrastructure and Services Offered

The Uruguayan state must have previously authorized Uruguayan free trade zones in order for them to legally operate. Moreover, the state must deliver the necessary infrastructure for them to function – warehouses, offices and a minimum urbanization development. Additionally, free trade zones must include basic services such as electricity, waste disposal, communication, security, and surveillance, etc.

Companies involved in construction can operate free of taxes and with limited paperwork, if they meet the requirements below:

The constructions of buildings with the aim of developing industrial or service activities.

The construction of shipping yards.

The creation of office space.

The development of green areas designed to improve the environment.

Tax Benefits

Free trade zone users are free from all existing and future national Uruguayan taxes. Additionally, fiscal benefits are found within the following taxes for companies operating in Uruguayan free trade zones:

Corporate Income Tax (IRAE)

Net worth taxes (IP)

Value Added Tax (VAT)

Internal Specific TAX (IMESI)

Tax on Public Limited Companies (ICOSA)"[77] (Biz Latin Hub, 2019)

[77] https://www.bizlatinhub.com/benefits-free-trade-zones-uruguay/

7.2 Law 19,172 ("Cannabis Law", 2013)

"Law 19,172

MARIJUANA AND ITS DERIVATIVES

CONTROL AND REGULATION OF THE STATUS OF IMPORTATION, PRODUCTION PURCHASE, STORAGE, MARKETING AND DISTRIBUTION

The Senate and House of Representatives of the Oriental Republic of Uruguay, gathered in General Assembly

DECREE:

TITLE I - THE PURPOSE OF THIS LAW

Article 1.) It is hereby declared that it is in the public interest to protect, promote and improve the health of the general population through policies oriented towards minimizing the risks and reducing the harm of cannabis use, which promote accurate information, education and prevention of the consequences and damaging effects associated with its consumption as well as the treatment, rehabilitation and social reintegration of problematic drug users.

Article 2.) Without affecting what is established by Decree-Law No. 14.294, of October 31, 1974, and its amendments, the State will assume the control and regulation of the activities of importing, exporting, planting, cultivating, harvesting, producing, acquiring under any title, storing, commercializing and distributing cannabis or its derivatives, or hemp in corresponding circumstances, in accordance with what is established in this law and under the terms and conditions established in this respect in its implemented regulation.

TITLE II - GENERAL PRINCIPLES

GENERAL PROVISIONS

Article 3.) Everyone has the right to the highest attainable standard of health, the enjoyment of public spaces in secure conditions and to the best living conditions, as well as prevention, treatment and rehabilitation of diseases in accordance with the provisions of various agreements, covenants, declarations, protocols and conventions ratified by law, ensuring full exercise of their rights and freedoms enshrined in the Constitution of the Republic, subject to the limitations emerging Article 10 thereof.

Article 4.) This law aims to protect the inhabitants of the country from the associated risks in connection with the illegal drug trade through the intervention of the state, attacking the devastating health, social and economic consequences of the problematic use of psychoactive substances, and reduce the incidence of drug trafficking and organized crime.

To this end, measures to control and regulate psychoactive cannabis and its derivatives are made available, as well as those that seek to educate, raise awareness and prevent society from the health risks of cannabis use, particularly the development of addictions. The promotion of vibrant attitudes, healthy habits and community welfare will be prioritized, taking into account the guidelines of the World Health Organization regarding the consumption of different types of psychoactive substances.

TITLE III - ON CANNABIS

Chapter I - Changes to the Legal Framework on Drugs

Article 5.) In substitution of Article 3 of Decree-Law No. 14.294, of October 31, 1974, as amended by Article 1 of Law 17.016, of October 22, 1998, is the following:

> "ARTICLE 3.) The planting, cultivation, harvest and commercialization of any plant out of which drugs and other substances that cause physical or mental dependence may be extracted is prohibited, with the following exceptions:
>
> A) When it is carried out with the exclusive aim of scientific research or for the development of therapeutic products of medicinal use. In such cases, the planting or cultivation must be previously authorized by the Ministry of Public Health and will remain under its direct control.
>
> In the case of cannabis, planting or cultivation must be previously authorized by the Institute for the Regulation and Control of Cannabis (IRCCA)and will remain under its direct control, notwithstanding the obligations that current legislation assigns to corresponding institutions in the course of their normal responsibilities.
>
> B) The planting, cultivation and harvest as well as the industrialization and commercialization of psychoactive cannabis with any other objective, so long as it is carried out under the framework of current legislation and with the previous authorization of the IRCCA, remaining under its direct control.
>
> It is understood that psychoactive cannabis refers to the fertilized or unfertilized buds of the female cannabis plant, excluding seeds and leaves not connected to the stem, including its oils, extracts, compounds of potential pharmaceutical use, syrups or similar substances, which have a natural

Tetrahydrocannabinol (THC) content equal to or greater than one percent (1%) of their volume.

C.) The planting, cultivation and harvest as well as the industrialization and commercialization of non-psychoactive cannabis (hemp). Planting or cultivation, in such cases must be previously authorized by the Ministry of Livestock, Agriculture and Fishing, and will remain under its direct control.

It is understood that non-psychoactive cannabis (hemp) refers to plants or parts of plants belonging to the cannabis genus, their leaves and buds, which do not contain more than one percent (1%) THC, and derivatives of said plants and plant parts.

The varieties of non-psychoactive hemp seeds to be used may not contain more than one-half percent (0.5 %) THC.

D.) Planting, cultivation, harvesting and gathering for research and industrialization for pharmaceutical use, provided it is done within the framework of existing legislation and according to regulations, and must have prior authorization from the IRCCA and remain under its direct control.

E.) The planting, cultivation and harvest of psychoactive cannabis destined for personal or shared domestic consumption. Notwithstanding of this, personal or shared domestic consumption is understood to mean the household planting, cultivation and harvest of up to six psychoactive cannabis plants and their resulting yield, up to a maximum of 480 grams.

F.) The planting, cultivation and harvest of psychoactive cannabis carried out by marijuana membership clubs, which will be controlled by the IRCCA. The aforementioned clubs must be authorized by the Executive Branch in accordance with current legislation, and in the method and circumstances to be established by regulation(s) it may enact.

Membership clubs will have a minimum of fifteen and a maximum of forty-five associates; they may plant a maximum of ninety-nine psychoactive plants and acquire as a product of their cultivation a maximum yield proportional to the number of associates and in accordance with the amount that may be established for non-medical use of psychoactive cannabis.

G.) The IRCCA will provide licenses for the sale of psychoactive cannabis to pharmacies (in accordance with Decree-Law No. 15.703, of January 11, 1985 and its amending laws) under the conditions set out in the legislation and the process and requirements that will be laid out in regulation.

The sale of psychoactive cannabis for personal consumption will require identification with the registry as detailed in Article 8 of this Law, in accordance with legal provisions, while distribution for medical use will require a prescription.

The sale of psychoactive cannabis for non-medical use may not exceed 40 grams per month per user.

Any unauthorized cannabis plot must be eradicated through the intervention of a competent judge. The Executive Branch shall regulate the provisions of the preceding paragraphs, including the means of obtaining seeds, which as long as they are intended for psychoactive cannabis cultivation for personal consumption under the current legislation, shall in all cases be considered a legitimate activity. This regulation is without prejudice to the controls that current legislation establishes for any form of plot or cultivation nationwide, insofar as it may be applicable. Moreover, the regulation will establish the security standards and the usage conditions of cultivation licenses for the purposes states in the preceding paragraphs.

Marijuana resulting from the cultivation and harvest of plots mentioned in paragraphs B, D and E in this Article may not be compressed."

Article 6.) In substitution of Article 30 of Decree-Law No. 14.294, of October 31, 1974, as amended by Article 1 of Law 17.016, of October 22, 1998, is the following:

"ARTICLE 30 - Whoever, without lawful authority, in any way produces the raw materials or substances which, as appropriate, are capable of producing psychological or physical dependence, delineated in Tables 1 and 2 of this law, as well as those substances identified by the Executive Branch according to the authority contained in Article 15 of this law, shall be sentenced to between twenty months and ten years of imprisonment.

Whoever produces marijuana by planting, growing and harvesting psychoactive cannabis plants under the terms listed in the provisions of Article 3 of this law will be exempt from liability. The intent mentioned in paragraph E.) of Article 3 shall be assessed, where appropriate, by a competent judge and in accordance with the principles of sound judgment, if the denoted quantities are exceeded."

Article 7.) In substitution of Article 31 of Decree-Law No. 14.294, of October 31, 1974, as amended by Article 1 of Law 17.016, of October 22, 1998, is the following:

"ARTICLE 31 - Whoever imports, exports, introduces through transit, distributes, transports, possesses without intending consumption, stores, holds, offers for sale or barters in any way, any of the raw materials, substances, precursor chemicals and other chemical products mentioned in the preceding Article and in accordance with what it is stipulated in this one, will receive the sentence stated in said Article.

Whoever transports, has in their possession, stores or possesses a quantity intended for personal use, as determined by a judge in accordance with the principles of sound judgment, will be exempt from liability.

Without prejudice to this, it is understood that the quantity intended for personal use will not exceed 40 grams of marijuana. Moreover, the first paragraph of the present Article will apply neither to whoever holds, stores or possesses the yield of up to six psychoactive cannabis plants obtained in accordance with what is established by paragraph E.) of Article 3 of the present law, nor will it apply to the respective yield of membership club associates in accordance with what is established by paragraph F.) of Article 3 of the present law and its corresponding regulation."

Article 8.) In the case of cannabis, the Institute for the Regulation and Control of Cannabis will maintain a registry of those who fall under the exceptions listed in paragraphs A), B), C), D), E), F) and G) of Article 3 of Decree-Law No. 14.294, of October 31, 1974, as amended by Article 5 of the present law.

The characteristics of these records shall be subject to regulation by the Executive Branch.

The identifying information of those who participate in the registry will be considered sensitive information for what is established in paragraphs E.) and F.) of the current law, in accordance with Article 18 of Law No. 18.331, of August 11, 2008.

The registration of cultivation, in accordance with the current legislation, shall be an essential condition for the exercise of this law's guarantees. One hundred and eighty days after the establishment of said registry, which will come at no cost to petitioners and will have the sole effect of ensuring the traceability and control of cultivation, only the registration of intended plots will be admitted.

Chapter II - Health of the General Public and Drug Users

Article 9.) The National Integrated Health System (SNIS) must prepare policies and strategies relevant to the promotion of public health as well as the prevention of problematic cannabis usage, and devise adequate mechanisms for the assistance, guidance and treatment of problematic cannabis users who may require it.

In cities with more than ten thousand inhabitants, mechanism will be established to provide information, counseling, diagnosis, referral, care, rehabilitation and treatment and social reinsertion of problematic drug users, the management, administration and operation of which will be overseen by The National Drug Council (JND), which can also to these effects establish agreements with the Administration of State Health Services and private health care institutions, departmental or municipal governments, and civil society organizations.

Article 10.) The National Public Education System (SNEP) must prepare educative policies for health promotion, the prevention of problematic cannabis usage with a view towards the development of life skills and within the framework of strategies of risk management and the reduction of problematic usage of psychoactive substances.

Such educational policies will encompass curricular inclusion in primary education, secondary education and vocational education, in order to prevent the damage caused by the consumption of all drugs, including cannabis. The National Public Education Administration will decide on how to implement this provision.

It will be mandatory to include the discipline, "Prevention of Problematic Drug Use" in program proposals and vocational curricula for primary, secondary, and technical-professional training and at the Technological University.

Within said discipline, there will be areas specifically aimed at driver education and the link between consumption of psychoactive substances and traffic accidents.

Article 11.) Any kind of advertising, indirect advertising, promotion or endorsement of cannabis products by any of the various forms of commercial media (print media, radio, television, cinema, magazines, filming in general, posters, billboards, brochures, banners, email, Internet technology and any other pertinent type of media) is prohibited.

Article 12.) The National Drug Council (JND) will be required to conduct educational, publicity and outreach and awareness campaigns for the general population regarding the risks, effects and potential harms of drug use, for which funding may make agreements and arrangements with state enterprises and the private sector.

Article 13.) The protections on social spaces established by Article 3 of Law No. 18.256, of March 6, 2008 will be applied to the consumption of psychoactive cannabis.

Article 14.) Persons under 18 years of age and those declared legally incompetent will not have access to psychoactive cannabis for recreational use. The violation of this provision shall entail criminal liability provided for by Decree-Law No. 14.294, of October 31, 1974, as amended by Law No. 17.016, of October 22, 1988, and by this law.

Article 15.) In accordance with the provisions of Article 46 of Law No. 18.191, of November 14, 2007, every driver will be disqualified from driving vehicles in urban, suburban and rural areas of the country, when the concentration of tetrahydrocannabinol (THC) in their body exceeds the allowable amount according to regulations that will be established in this regard.

The National Drug Council will provide training, advice and input needed to those specifically designated to address such purposes, such as the Ministry of Interior, the Ministry of Transport and Public Works, the Municipalities, the Intendancies and the National Naval Prefecture, in order to update the procedures and methods needed by competent authorities to implement the controls expressly established by the purposes specified in the preceding paragraph, in their jurisdictions and according to their respective powers. These examinations and tests may be ratified by blood tests, or other clinical or paraclinical examinations, by providers of the National Integrated Health System.

The driver who is found operating a motor vehicle while in violation of the limits of THC listed in the first paragraph of this Article shall be liable to the penalties provided in the second paragraph of Article 46 of Law No. 18.191, of November 14, 2007.

Article 16.) The State, the educational institutions referred to in Article 10, the institutions involved in the National Integrated Health System, parastatal organizations and civil society organizations with legal recognition, may apply to the National Drug Council to receive training, counselling and eventually human and material resources for the purpose of performing procedures similar to those defined in Article 15 of this law, with preventive, educational and harm reduction ends.

The procedures and actors referred to in the previous paragraph, shall only be allowed to apply in the cases of a certain risk to the physical or psychological integrity of third parties, under the conditions to be determined by regulation.

TITLE IV - THE INSTITUTE FOR THE REGULATION AND CONTROL OF CANNABIS (IRCCA)

Chapter I - Creation

Article 17.) The Institute for the Regulation and Control of Cannabis (IRCCA) is hereby created as a non-governmental legal entity under public law.

Article 18.) The Institute for the Regulation and Control of Cannabis will have as its objectives:

A.) To regulate the activities of planting, cultivation, harvesting, production, processing, storage, distribution and sale of cannabis, under the provisions of this law and current legislation.

B.) To promote and propose actions to reduce risks and damages associated with problematic cannabis use, according to the policies defined by the National Drug Council and in coordination with national and departmental authorities.

C.) To monitor compliance with the provisions that this law places under its mandate.

Article 19.) The National Drug Council is hereby charged with setting national policy on cannabis according to the objectives established in the preceding Article, with the advice of the Institute for the Regulation and Control of Cannabis. The latter will adjust its activities in accordance with said national policy.

The IRCCA will be linked and coordinated with the Executive Branch through the Ministry of Public Health.

Chapter II - Administration

Article 20.) The organs of the Institute shall consist of:

A.) The Board
B.) The Executive Directorate
C.) The National Honorary Council

Article 21.) The Board shall be the head of the Institute for the Regulation and Control of

Cannabis and its members shall be persons of moral and technical renown. They shall consist of:

- A representative of the National Drug Secretariat, who will preside
- A representative of the Ministry of Livestock, Agriculture and Fishing
- A representative of the Ministry of Social Development
- A representative of the Ministry of Public Health.

The appointment of Board members shall also include that of their corresponding alternates.

Article 22.) The term length for members of the Board will be five years, allowing for only one consecutive re-election.

Outgoing members shall continue to serve until newly-elected members assume their positions.

Article 23.) The Board shall determine its own meeting schedule. Its resolutions will be passed by majority. In the case of a tie, the President's vote shall count as double.

Article 24.) There shall be an Executive Director designated by the majority of the Board, with the approving vote of the President. Their compensation shall be established by the Board in accordance with the Executive Branch and will be drawn from the resources of the Institute for the Regulation and Control of Cannabis.

The Executive Director shall attend all Board meetings as a speaking but non-voting participant.

Article 25.) The Executive Director will be contracted for renewable three-year periods. The termination of their contract without renewal must be determined by a majority vote of the full Board, including the President.

Article 26.) The National Honorary Council shall consist of one representative of each of the following state institutions: the Ministry of Education and Culture, the Minister of the Interior, the Ministry of Economy and Finance, and the Ministry of Industry, Energy and Mining. It will also consist of a representative of the University of the Republic, a representative of the Congress of Intendants, a representative of the membership clubs, a representative of domestic cultivation associations, and a representative of the license holders. It will act in plenary with the members of the Board and the Executive Director.

Membership clubs, domestic cultivation associations and license holders will nominate their representatives to be appointed by the Executive Branch.

The regulation of the present law and any amendments thereto may alter the integration of this Council, expanding its membership.

The Council may be called to meet at the request of the Board or at the request of three of its members.

Chapter III - Duties and Powers

Article 27.) The duties of the Institute for the Regulation and Control of Cannabis include:

A.) The control and supervision of the planting, cultivation, harvesting, production, storage, distribution, commercialization and expedition of cannabis in accordance with what is established by the present law, without prejudice to the powers of other organs and public authorities.

B.) Advising the Executive Branch on:

1.) The formulation and application of public policy aimed at regulating and controlling the distribution, commercialization, expense, proposition and consumption of cannabis.

2.) The development of strategies aimed at delaying the age of initial consumption, increasing awareness of the risks of abusive consumption and the reduction of problematic consumption.

3.) The coordination of specialized technical proposals undertaken in the country on this subject.

4.) The contribution to scientific evidence through research and evaluation of the strategy guiding cannabis public policy.

Article 28.) The powers of the Institute for the Regulation and Control of Cannabis include:

A.) Granting licenses to produce, process, collect, distribute and sell industrial and psychoactive cannabis and its variations, modifications, byproducts and extracts, as provided for in the present law and corresponding regulations.

B.) Creating a registry of users, protecting their identity and maintaining anonymity and privacy in accordance with current legislation and corresponding regulation. Information regarding the identity of the owners of record shall be considered sensitive data in accordance with the provisions of Article 18 of Law No. 18.331, of August 11, 2008.

C.) Register declaration of domestic self-cultivation of psychoactive cannabis, in accordance with current legislation, the present law and corresponding regulations.

D.) Authorizing cannabis membership clubs in accordance with current legislation, the present law and corresponding regulations.

E.) The ability to appeal directly to state organs to seek and receive information necessary to carry out its duties.

F.) The establishment of agreements with public or private institutions for the fulfillment of its duties, especially with those which already have expertise on the subject.

G.) Monitoring compliance with provisions which fall under its mandate.

H.) To issue administrative acts necessary to the fulfillment of its duties.

I.) Determining and applying the necessary sanctions applicable to violations of regulatory norms established by the present law and its corresponding regulations.

J.) Carrying out the sanctions it imposes, for which purpose the statements of its definite resolutions will be considered enforceable. The sanctioned party is subject these resolutions by tacit or implicit consent to the mechanisms of this law.

Article 29.) - The Board, in its capacity as the main organ of the Institute for the Regulation and Control of Cannabis, shall have the following powers:

A.) To develop the Rules and Procedures of the IRCCA to be submitted for approval of the Ministry of Public Health.

B.) To approve the status of its employees within six months of its creation. In this respect the IRCCA will fall under the provisions of private law.

C.) To appoint, transfer and dismiss personnel.

D.) To set the cost of licenses, under the provisions of the previous Article.

E.) To approve its budget and submit it to the Executive for its understanding, together with a business plan.

F.) To approve all plans, programs and special projects.

G.) To carry out the annual report and balance sheet of the IRCCA.

H.) To administer the resources and assets of the IRCCA.

I.) Acquire, develop or dispose of any kinds of good, in the case of real estate it shall be settled by special majority of at least three members.

J.) To delegate such powers as it deems appropriate by reasoned decision and the support of the majority of its members.

K.) In general, perform all civil and commercial acts, run internal management and perform operations appropriate to its general powers of administration, according to the duties and expertise of the IRCCA.

Article 30.) The Executive Director shall have the following responsibilities:

A.) To comply with and enforce the rules of the mission of the Institute for the Regulation and Control of Cannabis (IRCCA).

B.) To implement the plans, programs and resolutions adopted by the Board.

C.) Perform all tasks related to personnel administration and internal organization of the IRCCA.

D.) Any other responsibility that entrusted or delegated by the Board.

Article 31.) The National Advisory Council, as a consultative body of the Institute for the Regulation and Control of Cannabis, will:

A.) Advise the drafting of the general rules and procedures of the IRCCA.

B.) Advise the drafting of plans and programs in their preliminary forms for approval.

C.) Advise the Board in any manner requested.

D.) Express an opinion on any other matters relating to the duties of the IRCCA, when appropriate.

Chapter IV - Resources, Management and Function

Article 32.) The resources of the Institute for the Regulation and Control of Cannabis (IRCCA) shall consist of:

A.) Income from fees charged for processing licenses and permits, in accordance with what is established in the present law.

B.) An annual contribution from the State to cover the sum of general expenses determined in the proposed five-year budget. The Executive Branch may alter this amount in accordance with the evolution of the IRCCA's income.

C.) Inheritances, heirlooms and donations accepted by the IRCCA.

D.) The funds and goods assigned to the IRCCA under any title.

E.) The proceeds of any applicable fines and sanctions.

F.) Any other resource allowed for in current legislation.

Article 33.) Administrative control of the Institute shall be exercised by the Executive Branch through the Ministry of Public Health.

This control shall be exercised for legal purposes as well as reasons of expedience or contingency.

To this effect, the Executive Branch may submit opinions that it deems relevant, just as it may propose the suspension of certain observed practices, sanctions or bans as it sees fit.

Article 34.) Financial oversight of the Institute for the Regulation and Control of Cannabis shall be exercised by the National Internal Audit, and the IRCCA shall submit its accounting and financial records to the Audit within ninety days of the finalization of each project.

The regulation of the present law shall determine the manner and process of the IRCCA's accounting, as well as the deadlines and publication of these records.

Article 35.) Rulings of the Board are subject to administrative appeal, which must be filed within twenty days of the notification of the individual concerned. Once the appeal is filed, the Board shall have thirty days to study and resolve the issue.

If an administrative appeal is denied, the subject may request the annulment of the ruling by the Civil Appeals Court, solely for legal reasons.

This request should be done within days of the concerning ruling, or, failing that, the moment administrative appeal is denied.

The demand for annulment may only be brought by the holder of a subjective right or an interest of direct, personal and legitimate nature which has been violated or infringed by the contested measure. The Court will have the ultimate word on this.

Article 36.) When a ruling is issued by the Executive Director, in conjunction with or independent of an administrative appeal, it may be reassessed by the Board.

This appeal must be filed and resolved in the timeframe provided for in the previous article, which also will apply in the case of an administrative appeal or subsequent court review.

Article 37.) The Institute for the Regulation and Control of Cannabis is exempted from all kinds of taxes, except social security contributions. In matters not specifically addressed by this law, the laws governing the private sector shall apply, especially those addressing matters of accounting, personnel status and contractual obligations.

Article 38.) The assets of the Institute for the Regulation and Control of Cannabis may not be made void.

Chapter V - Violations and Penalties

Article 39.) The Board of the Institute for the Regulation and Control of Cannabis will be responsible for the implementation of sanctions for violations of existing rules on licensing, without prejudice to any criminal liability which may correspond. The procedure in these cases will be subject to regulation.

Article 40.) The violations referred to the previous article, to be viewed in light of their gravity and any prior offenses, shall be sanctioned with:

A.) Warning

B.) A fine ranging from UR 20 (twenty readjustable units, or "*unidades reajustables*") to UR 2,000 (two thousand readjustable units, or "*unidades reajustables*")

C.) Confiscation of the offending goods or items

D.) Destruction of goods, when appropriate

E.) Suspension of the offender from the appropriate registry

F.) Temporary or permanent disqualification

G.) Partial or total closure of establishments and ventures of licensees, be they owned directly or through third parties.

The sanctions established above may be implemented accumulatively and depending on the gravity of the offense and background of the offender.

Article 41.) Without prejudice to the sanctioning powers above, exercised with the cognizance of the Board or the Executive Director, in the course of the duties of control and supervision granted to the Institute for the Regulation and Control of Cannabis, criminal activity will be denounced before a competent judicial authority.

TITLE IV - EVALUATION AND OVERSIGHT OF THE PRESENT LAW

Article 42.) A unit specializing in the evaluation and oversight of this act is hereby created, to be technical in nature and consist of specialists in the assessment and monitoring of policies. It will be independent and issue annual reports which, without binding authority, must be taken into consideration by agencies and institutions responsible for the implementation of this law. This report shall be submitted to Congress.

TITLE V - ON THE APPLICATION OF THE PRESENT LAW

Article 43.) The Executive Branch shall regulate the provisions of this Act within one hundred twenty days after its promulgation.

Article 44.) All provisions contrary to this law are hereby repealed.

Chamber of the Senate, in Montevideo, on December 10, 2013.

DANILO ASTORI,
President.
Hugo Rodríguez Filippini,
Secretary.

MINISTRY OF THE INTERIOR
MINISTRY OF FOREIGN RELATIONS
MINISTRY OF ECONOMY AND FINANC
MINISTRY OF NATIONAL DEFENSE
MINISTRY OF EDUCATION AND CULTURE
MINISTRY OF TRANSPORT AND PUBLIC WORKS
MINISTRY OF INDUSTRY, ENERGY AND MINING
MINISTRY OF LABOR AND SOCIAL SECURITY
MINISTRY OF PUBLIC HEALTH
MINISTRY OF LIVESTOCK, AGRICULTURE AND FISHING
MINISTRY OF TOURISM AND SPORTS
MINISTRY OF HOUSING, TERRITORIAL ORDER AND THE ENVIRONMENT
MINISTRY OF SOCIAL DEVELOPMENT

Montevideo, December 20, 2013.

Let it be known, fulfil it, acknowledge receipt of it and inscribe it in the National Register of Laws and Decrees, the law which establishes state control and regulation of the import, export, planting, cultivation, harvesting, production, acquisition, storage, marketing, distribution and consumption of marijuana and its derivatives.

JOSÉ MUJICA. EDUARDO BONOMI. LUIS ALMAGRO. RICARDO EHRLICH. ENRIQUE PINTADO. ROBERTO KREIMERMAN. EDUARDO BRENTA. SUSANA MUÑIZ. TABARÉ AGUERRE. LILIAM KECHICHIAN. FRANCISCO BELTRAME. DANIEL OLESKER.” (The Transnational Institute)

7.3 Registered Cannabis Seeds (INASE; August 2019)

Species: Common Name	Species: Latin Name	Cultivate	Registration Number	Status with National Registry of Commerce (RNC)	RN: Date of Registration	Name of Applicant	Holder of Rights	Origin
Hemp	Cannabis Sativa	BAMA	2019038	Registered	01/04/2019	Adelnor S.A.	Zhangpu Zhonglong kneaf seed Co.	China
Hemp	Cannabis Sativa	HAN FN H	2019050	Registered	09/04/2019	Adelnor S.A.	Zhangpu Zhonglong kneaf seed Co.	China
Hemp	Cannabis Sativa	HAN FN Q	2019049	Registered	09/04/2019	Adelnor S.A.	Zhangpu Zhonglong kneaf seed Co.	China
Hemp	Cannabis Sativa	HAN NE	2019040	Registered	01/04/2019	Adelnor S.A.	Zhangpu Zhonglong kneaf seed Co.	China
Hemp	Cannabis Sativa	HAN NE 2	2019044	Registered	01/04/2019	Adelnor S.A.	Zhangpu Zhonglong kneaf seed Co.	China
Hemp	Cannabis Sativa	HAN NW	2019039	Registered	01/04/2019	Adelnor S.A.	Zhangpu Zhonglong kneaf seed Co.	China
Hemp	Cannabis Sativa	HAN NW 2	2019045	Registered	01/04/2019	Adelnor S.A.	Zhangpu Zhonglong kneaf seed Co.	China
Hemp	Cannabis Sativa	HAN NW 3	2019043	Registered	01/04/2019	Adelnor S.A.	Zhangpu Zhonglong kneaf seed Co.	China
Hemp	Cannabis Sativa	SI 1	2019041	Registered	01/04/2019	Adelnor S.A.	Zhangpu Zhonglong kneaf seed Co.	China
Hemp	Cannabis Sativa	YUMA	2019042	Registered	01/04/2019	Adelnor S.A.	Zhangpu Zhonglong	China

							kneaf seed Co.	
Hemp	Cannabis Sativa	CHERRY BLOSSOM	2019021	Registered	25/02/2019	Oransur S.A.	Colorado Hemp Exchange LLC	USA
Hemp	Cannabis Sativa	CHERRY WINE	2019020	Registered	25/02/2019	Oransur S.A.	Colorado Hemp Exchange LLC	USA
Hemp	Cannabis Sativa	MED 1991	2019029	Registered	27/03/2019	Nordyan S.A.	Medropharm GmbH	Switzerland
Hemp	Cannabis Sativa	CARMA	2018195	Registered	18/12/2018	Hemporium SRL	Marry Jane Gmbh.	Switzerland
Hemp	Cannabis Sativa	LIPKO	2018194	Registered	18/12/2018	Hemporium SRL	Marry Jane Gmbh.	Switzerland
Hemp	Cannabis Sativa	SS BETA	2018192	Registered	13/12/2018	Federico Ricardo Delgue	Sunstrend LLC	USA
Hemp	Cannabis Sativa	PUMA	2018118	Registered	23/08/2018	Adelnor S.A.	Zhangpu Zhonglong Kenaf Seeds	China
Hemp	Cannabis Sativa	ABOUND	2018168	Registered	18/10/2018	Silva Rodríguez José Antonio	New West Genetics	USA
Hemp	Cannabis Sativa	ELITE	2018169	Registered	18/10/2018	Silva Rodríguez José Antonio	New West Genetics	USA
Hemp	Cannabis Sativa	INTERRA 18-01	2018167	Registered	18/10/2018	Inovaterra Ltda.	Fernando Carrau and Máximo Gragera	Uruguay
Hemp	Cannabis Sativa	BCBD01	2016202	Registered	20/12/2016	BCBD Medicinal S.A.	BCBD Medicinal S.A. and Marcelo Gonzalez Machin	Uruguay
Hemp	Cannabis Sativa	BIALOBRZA SKIE	2017067	Registered	24/07/2017	Cannabis Uruguay S.A.	Institute of Natural Fibres and Medicinal Plants	Poland
Hemp	Cannabis Sativa	CHA	2017079	Registered	09/08/2017	Ecofibre Uruguay S.A.	Ecofibre Industries Operations Pty Ltd	Australia

Hemp	Cannabis Sativa	CHG	2016176	Registered	19/10/2016	Ecofibre Uruguay S.A.	Ecofibre Industrial	Australia
Hemp	Cannabis Sativa	CHY	2017078	Registered	09/08/2017	Ecofibre Uruguay S.A.	Ecofibre Industries Operations Pty Ltd	Australia
Hemp	Cannabis Sativa	CS	2017064	Registered	19/07/2017	ALT3RLAB (Balice, Andrea and Viceconti)	Assocanapa S.R.L	Italia
Hemp	Cannabis Sativa	CW1a	2015003	Registered	07/01/2015	Industrial Crops Ltda.	Stanley Brothers Social Enterprise LLC	USA
Hemp	Cannabis Sativa	CW2a	2015004	Registered	07/01/2015	Industrial Crops Ltda.	Stanley Brothers Social Enterprise LLC	USA
Hemp	Cannabis Sativa	CW2a-b	2017076	Registered	07/08/2017	Tersum S.A.	Stanley Brothers Social Enterprise LLC	USA
Hemp	Cannabis Sativa	FED 17 FS 19	2015130	Registered	11/08/2015	Inovaterra Ltda.	Maripharm B.V.	Holland
Hemp	Cannabis Sativa	FEDORA 17	2017034	Registered	19/05/2017	Industrial Crops Ltda.	Federation Nationale des Producteurs de Chanivre	France
Hemp	Cannabis Sativa	FEDTONIC	2017145	Registered	27/12/2017	Diametril S.A.	Markus Walther	Switzerland
Hemp	Cannabis Sativa	FELINA 32	2017035	Registered	19/05/2017	Inovaterra Ltda.	Federation Nationale des Producteurs de Chanivre	France
Hemp	Cannabis Sativa	FUTURA 75	2015189	Registered	09/10/2015	Inovaterra Ltda.	Ted Beckwith	USA
Hemp	Cannabis Sativa	GLIANA	2016196	Registered	30/11/2016	Industrial Crops Ltda.	Ukranian Hemp Institute	Ukraine
Hemp	Cannabis Sativa	LUMA	2015011	Registered	29/01/2015	Auberna S.A.	Kangbao	China

Hemp	Cannabis Sativa	MS 77	2016178	Registered	19/10/2016	Ecofibre Uruguay S.A.	Ecofibre Industrial	Australia
Hemp	Cannabis Sativa	NRBRASKA FERAL	2016111	Registered	19/07/2016	BCBD Medicinal S.A.	BCBD Medicinal S.A.	USA
Hemp	Cannabis Sativa	PR 13	2017077	Registered	09/08/2017	Ecofibre Uruguay S.A.	Ecofibre Industries Operations Pty Ltd	Australia
Hemp	Cannabis Sativa	SANTHICA 70	2017033	Registered	19/05/2017	Inovaterra Ltda.	Federation Nationale des Producteurs de Chanivre	France
Hemp	Cannabis Sativa	BCBD 02	2016197	Registered	30/11/2016	BCBD Medicinal S.A.	BCBD Medicinal S.A. y Marcelo Gonzalez Machin	Uruguay
Hemp	Cannabis Sativa	HENOLA	2018107	Registered	01/08/2018	Hardolin S.A.	Marry Jane Gmbh.	Switzerland
Hemp	Cannabis Sativa	MONLAG	2019077	Registered	11/06/2019	MENENDEZ ALZUGARAY ESTEBAN ANDRES	CIJA Preservation SL	Spain
Hemp	Cannabis Sativa	BELATE	2019090	Registered	01/07/2019	Silk Hemp Uruguay S.R.L.	Silk Hemp SL	Spain
Hemp	Cannabis Sativa	PURE CBD PUNCH	2019098	Registered	01/07/2019	Colflores SRL	Diseminatium SL	Spain
Hemp	Cannabis Sativa	URBEL	2019100	Registered	04/07/2019	Silk Hemp Uruguay S.R.L.	Silk Hemp SL	Spain
Marijuana	Cannabis Sativa	ÉPSILON IRCCA	N/A	Not registered	N/A	Instituto de Regulación y Control del Cannabis	Positronics Seeds S.L.	Uruguay
Marijuana	Cannabis Sativa	ALFA IRCCA	N/A	Not registered	N/A	Instituto de Regulación y Control del Cannabis	Positronics Seeds S.L.	Uruguay
Marijuana	Cannabis Sativa	BETA IRCCA	N/A	Not registered	N/A	Instituto de Regulación y Control	Positronics Seeds S.L.	Uruguay

						del Cannabis		
Marijuana	Cannabis Sativa	CÉSAR DÍAZ	N/A	Not registered	N/A	Eduardo Bandera	Eduardo Bandera	Uruguay
Marijuana	Cannabis Sativa	GAMMA IRCCA	N/A	Not registered	N/A	Instituto de Regulación y Control del Cannabis	Positronics Seeds S.L.	Uruguay

Source: National Institute for Seeds (INASE) 2019

7.4 Tentative Timetable

	2020		2021		2022		2023	
	S1	*S2*	*S1*	*S2*	*S1*	*S2*	*S1*	*S2*
Registrations and authorizations	X	X	X					
Construction		X						
Purchase of equipment		X						
First batch			X					
First sale of dried flowers				X				
Aquaculture: introduction of barramundi				X				
First CBD isolate sale						X		
Integration of hydroponics and aquaculture							X	X

Source: Self-made, 2019.

7.5 Projected Cash Flow

Cash Flow											
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Initial investment	USD 9,754										USD 6,000
Cannabis: gross income		USD 25,000	USD 25,000	USD 25,000	USD 25,000	USD 25,000	USD 25,000	USD 25,000	USD 25,000	USD 25,000	USD 25,000
Barramundi: gross income		USD 0.00	USD 45.22	USD 45.22	USD 45.22	USD 45.22	USD 45.22	USD 45.22	USD 45.22	USD 45.22	USD 45.22
FTZ		USD 576.00	USD 576.00	USD 576.00	USD 576.00	USD 576.00	USD 576.00	USD 576.00	USD 576.00	USD 576.00	USD 576.00
Registrations		USD 52.00	USD 52.00	USD 52.00	USD 52.00	USD 52.00	USD 52.00	USD 52.00	USD 52.00	USD 52.00	USD 52.00
Administration		USD 20.00	USD 20.00	USD 20.00	USD 20.00	USD 20.00	USD 20.00	USD 20.00	USD 20.00	USD 20.00	USD 20.00
Personnel		USD 498.00	USD 498.00	USD 498.00	USD 498.00	USD 498.00	USD 498.00	USD 498.00	USD 498.00	USD 498.00	USD 498.00
Nutrients		USD 42.00	USD 42.00	USD 42.00	USD 42.00	USD 42.00	USD 42.00	USD 42.00	USD 42.00	USD 42.00	USD 42.00
Fries and seeds		USD 60.00	USD 60.00	USD 60.00	USD 60.00	USD 60.00	USD 60.00	USD 60.00	USD 60.00	USD 60.00	USD 60.00
Annual barramundi feed		USD 0.00	USD 80.00	USD 80.00	USD 80.00	USD 80.00	USD 80.00	USD 80.00	USD 80.00	USD 80.00	USD 80.00
Water		USD 0.00	USD 0.00	USD 0.00	USD 0.00	USD 0.00	USD 0.00	USD 0.00	USD 0.00	USD 0.00	USD 0.00
Energy		USD 0.00	USD 0.00	USD 0.00	USD 0.00	USD 0.00	USD 0.00	USD 0.00	USD 0.00	USD 0.00	USD 0.00
Net cash flow	**USD 9,754**	**USD 23,752**	**USD 23,717**	**USD 23,717**	**USD 23,717**	**USD 23,717**	**USD 23,717**	**USD 23,717**	**USD 23,717**	**USD 23,717**	**USD 29,717**

Source: Self-made 2019.

IRR	243%
NPV (12%)	USD 126,216

Cash flow expressed in thousands