AquaPrawnics™

White Paper

Investments into Integrated Agriculture

According to the UN, world population will rise from 7.6 billion today to nearly 10 billion in 2050[12]. In 30 years', time we will need to feed roughly 2.5 billion people more than today. At the same time, the area available for agriculture is shrinking. Extreme weather events like flooding and drought are on the rise because of climate change. According to the leading Dutch plant scientist at Wageningen University, within the next 40 years we will have to produce as much food as mankind has produced in the whole past 8,000 years.[1] That scenario is one of our major global challenges ahead.

Another challenge is the negative effects of today's agriculture production. According to EPA information[2-5], nutrient pollution (pollution through fertilizers) have various effects on human health, the environment, and the economy. Nutrient pollution causes harmful algal blooms, which subsequently damages the environment, the economy and causes serious health problems in people and animals.

In spite of the billions of dollars that have been spent over the years in the US alone, these problems still increase continuously. According to the EPA, more than 100,000 miles of US rivers and streams, close to 2.5 million acres of lakes, reservoirs and ponds, and more than 800 square miles of bays and estuaries have poor water quality because of nitrogen and phosphorus pollution[6]. Currently, sustainable solutions to all these mentioned problems have not been established yet. However, there are methods that have shown promising results.

Vertical Farming

Modern greenhouses with vertical farming methods are an option of choice to drastically reduce the amount of land needed for farming. An example is the densely populated country of the Netherlands. It has an enormously productive agricultural sector and is the second largest food exporter in the world measured by the value of its agricultural exports with roughly $113 billion in 2017[1]. Only the United States earns more from agriculture, about $140 billion. But, the Netherlands manages its feat with an agricultural area 217 times smaller than that of the US. It does so very economically: using only a little over nine liters of water per kilogram to grow greenhouse tomatoes, for example. The global average is 214 times more. In addition, the Dutch agriculture in general radically changed their use of pesticides and fertilizers to less than half. This huge reduction is mostly caused by the use of greenhouses in farming where pesticides are not needed because the plants grow in a protected and safe environment. The use of fertilizer is reduced to a minimum and can be purely organic. Greenhouse farming has little to no negative impact on the environment. Vertical farming is a completely new and successful approach in the control of plant growth. In such an environment every aspect of plant growth can be measured and adapted to the actual need via high-tech methods and thus increase productivity.

Indoor Farming of shellfish

Meat production is grotesquely inefficient and takes up vast amount of space. Nearly 30% of the global ice-free land area is used for livestock farming. At least a third of all crops are fed to livestock and 15,500 liters of water are needed to produce one kilo of meat. As a reference, vertical farming reduces water consumption to only two or three liters water per kilo tomatoes. Despite all this outlay, meat contributes only 18% to the worldwide calorie intake of human beings[1].

Also, with meat production there are promising approaches, which reduce both use of land area, use of water, and use of fertilizers for animal food production substantially. With indoor saltwater shrimp or prawn farming it is feasible to produce high quality, GMO-free, heavy metal free, and free of micro plastic. Shellfish is also the highest protein seafood available. With modern production systems, an area of 13,000 square feet of floor space can achieve an annual shrimp production of 120,000 lbs.

Such type of shrimp production can compensate the decline of shrimp fishing in the US and also reduce the dependency on shellfish imports. Of the about 1.5 billion lbs. of shrimp consumed in the US in 2017 only 45 % are domestically produced and 55% are imported. Of the 45% domestic production only 10% are farm raised and of this 10% only a tiny fraction are salt water species. Of the 55% imported nearly all are from S E Asia and China. Especially Asian imports sometimes do not have the quality of standards compared to US shrimp. This became increasingly clear after the European Union stated that shrimp farm compliance on antibiotics in India is insufficient[7]. The EU threatened to ban shrimp import from India. However, there is a worldwide trend of higher shellfish production. The current market is pegged at almost $40 billion, and in the next ten years, it is expected to reach $68 billion[13].

The competition now boils down to who can mass produce without sacrificing quality and harming the environment. Due in large part to unsustainable practices especially from Asia, the shrimp industry is coming under increased supply/demand pressure. It appears fairly obvious that the preferred method is going to be closed-system shrimp aquaculture. Such systems can be more effectively maintained and controlled. In particular, the US, which remains a minor aquaculture producer, needs to increase sustainable aquaculture systems. It is estimated that US saltwater shrimp from closed aquaculture is of higher value[13].

Producing saltwater shellfish in closed aquaculture systems is the highest quality available and has the following advantages:

a) Taste better with better texture;
b) Cannot become invasive in cold northern fresh water environments;
c) Our planned sites in the Inter Mountain West have no natural reservoir of pests, predators, parasites, or diseases;
d) Are preferred by chefs and food services;
e) Bring a premium in the market place;
f) Have the highest output and economic return of any aquatic class.

Biochar and Soil Fertility

Biochar is considered by experts as one of the most “climate saving” products in the long run. Biochar is a charcoal carbon product derived from biomass that can enhance soils, sequester or store carbon, and provide usable energy under production. The wide use of mineral fertilizers is responsible for most of the nutrient environmental issues. Its application shows decreasing yields, reduced nutrient cycling and reduced nutrient-use efficiency if soil organic carbon declines. However, soils containing charred plant materials are among the most productive soils in the world. High levels of charcoal carbon resulting from repeated historical burning of grasslands, open woodlands, and agricultural crop residues have been reported in soils from Australia and Germany[8]. With certainty, charcoal was intentionally used in

US and European agriculture. The book "Brief Compendium of American Agriculture" published in 1847 mentioned multiple uses of charcoal mainly for nutrient conservation purposes. The author recommends the mixing of nutrient rich materials such as guano with charcoal in order to absorb ammonia. Combined with the ability of charcoal to store water in the soil and increase soil fertility, these old methods of fertilizing soil are a viable and possibly a much better alternative to mineral fertilizers, or they can be used in combination with mineral fertilizers in order to limit its negative effects on the environment.

There is an abundance of bio waste in the US, which can be used as feedstock for energy production and the simultaneous production of biochar. Over 1.3 billion dry tons of biomass are generated in the US forestry and agricultural sector per year. Using at least a small part of this biomass as a soil amendment could reduce the environmentally devastating effects of mineral fertilizers, and also contribute significantly to US climate mitigation efforts through atmospheric carbon dioxide reductions[8].

First Conclusions: Environmental viability is not necessarily profitable

We have investigated the benefits and pitfalls of the presented approaches like vertical farming, indoor farming of shellfish, and biochar production and its use as organic soil amendment instead of conventional fertilizer. All these production methods do have very positive environmental effects. However, the largest problem connected to large-scale implementation of these methods is economic viability.

There is no doubt that indoor farming reduces the use of land, water, and fertilizer considerably. In addition, it eliminates the need for pesticides altogether. The key economic issue with indoor farming is its need of energy, especially in colder climates. The most successful projects are those where excess heat from other productions could be utilized.

We made a similar observation with indoor farming of saltwater shrimp. While most of the shrimp production is done in countries with a warmer climate (Asia and South America), shrimp farming in the US suffers from high energy costs. In Europe (Netherland and Germany) there have been several failed attempts to establish shrimp farms due to high local electricity costs. One of the more successful attempts in Europe were made by a company in Switzerland. They use the excess heat from salt production.

The production of biochar is often not optimized and also leaves plenty of room for economic improvements with existing companies. A valuable by-product of biochar production is heat. The use of that heat is an important driver of profitability in integrated production systems, if the system is designed in a proper balance. Part of the CO_2 (another by-product) produced via pyrolytic gasification of biomass to biochar can be utilized to increase the growth of algae, which is again used as food for shrimp or prawn production. The CO_2 can also be utilized to accelerate plant growth in the greenhouse. In this way, cost reducing synergy effects can be achieved.

The most prominent examples of questionable investments into "not-integrated" business models in California are the investments of Vinod Kholsa and Plenty. Vinod Kholsa lost $400M, because he built giant centralized biomass plants far from the biomass source. He faced financial trouble due to the cost of hauling the bio-waste from where it was generated to where it would be consumed. On top of that, he overestimated the electricity price the local utilities were willing to pay. They paid him $0.05/kWh for bulk electricity, which the local utilities sold for $0.16/kWh. He never was able to pay off his CapEx.

Plenty is another example. Plenty is a company now with $400M trying to do indoor farming in urban areas. Plenty will lose money until they can purchase electricity for less than $0.05/kWh, according to an interview published in the San Jose Mercury News[14].

Subsequent Conclusions: An Integrated Approach

Based on our analysis of missing economic viability in various failed projects, we have developed an integrated approach to agriculture which is able to address all the mentioned issues. The company AquaPrawnics in cooperation with the renewable energy company Golden Grid Solutions Ltd, London, have developed a concept on the integration of various well-known and independent agricultural production methods, which can be deployed independent from any connection to the electricity grid. These integrated production systems are especially valuable in third world countries and have the potential to establish new villages with new jobs and a thriving organic agriculture. Integrated production systems are of high value in the US too. The following production methods are integrated in AquaPrawnics systems:

- Biochar production,
- Production of saltwater shrimp and prawns in an indoor environment,
- Vertical farming and the utilization of CO_2 from biochar production,
- Production of algae for several purposes such as
    - Food for shrimp
    - Amendment to biochar to create organic soil amendment as replacement for fertilizer.

The different production processes enhance and support each other. Integrated properly, the system creates synergy effects that have a measurable impact on the economic outcome of the entire integrated system. Through this integration the following synergy effects appear:

1) Organic waste (woody biomass & straw) is used as feedstock for the production of biochar;
2) This organic waste can be cheap because it creates problems. For example, it increases the danger of wild fires in forest areas such as in California or causes an imbalance in ecosystems like the spread of piñon-juniper in ten western states;
3) Biochar is used for the production of soil amendment;
4) A side effect of the biochar production is heat, which is used
    a) For the production of electricity,
    b) For shrimp production (heating of water tanks),
    c) For algae production (increase growth of algae) and
    d) For vertical farming (heating of greenhouse);
5) CO_2 from biochar production is used to increase plant growth in indoor farms;
6) CO_2 from biochar production is used to increase growth of algae;
7) Generated electricity drives lighting and control systems in vertical farms;
8) Generated electricity drives pumps in shrimp production;
9) Algae production is used to feed shrimp;
10) Algae production is also used for the production of soil amendment;
11) Algae production is enhanced through sequestration of CO_2 from biochar production;
12) The remnants of shrimp production are used for soil amendment production;

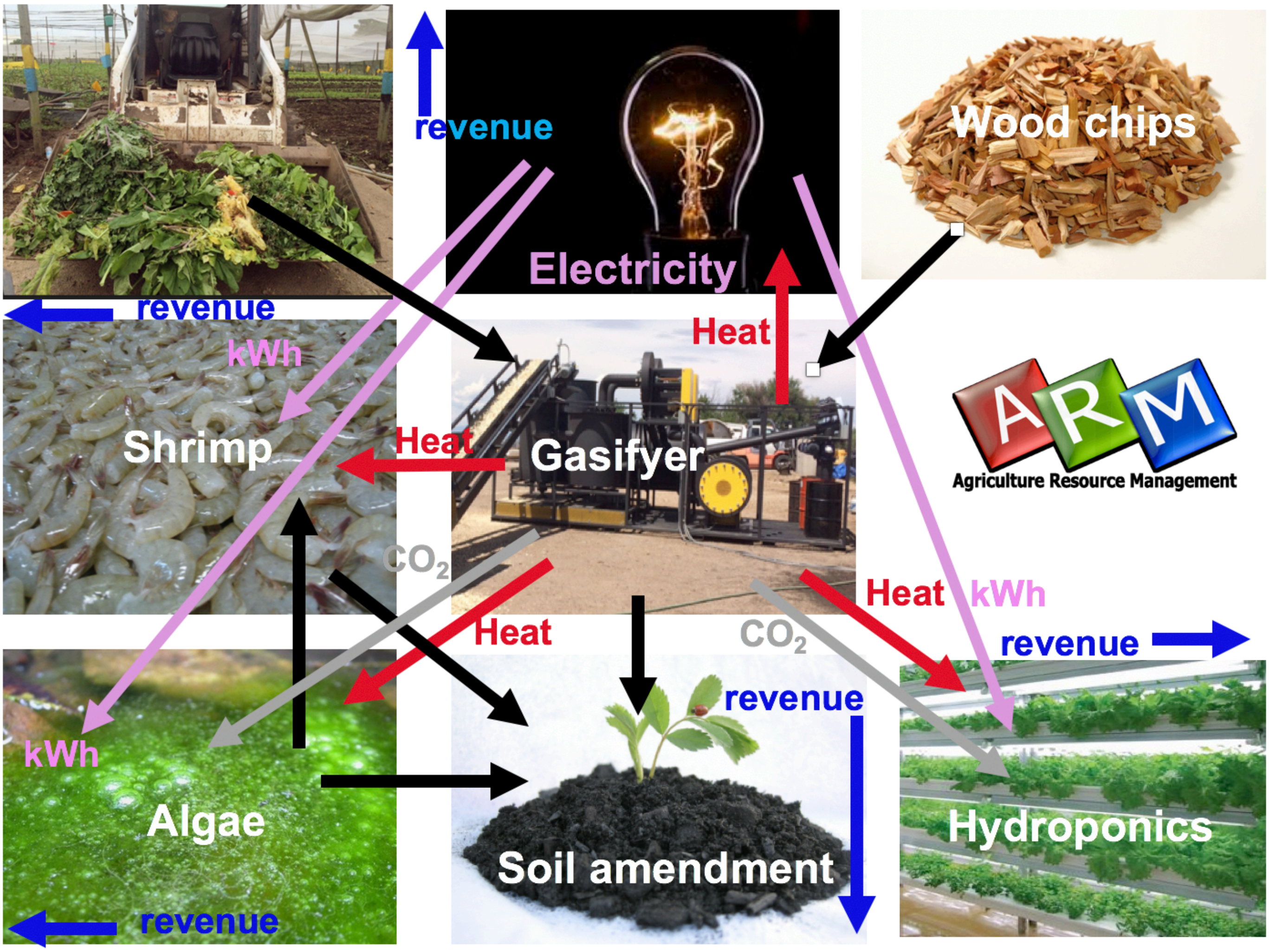

Figure 1: Synergy effects of integrated agriculture

In this way, several revenue streams are utilized in the AquaPrawnics system:

1. Revenue from soil amendment,
2. Revenue from production of saltwater shrimp / prawns,
3. Revenue from vertical farming
4. Revenue from algae production and,
5. Possible revenues from excess electricity generation.

Through our finely tuned integration of various production streams and the achieved synergy effects economic viability is achieved. This is reflected in a payback of investment within five years or less. Integrated agriculture, which can be perceived as the amalgamation of economics and environment is a promising approach.

Integrated agriculture

Integrated farming is a concept well known in Europe. The European Union has defined the term as EU standard (UNI 11233-2009)[9]. It is a farming system where high-quality food, feed, fiber and renewable energy are produced by using resources such as soil, water, air and nature as well as regulating factors to farm sustainable and with as little pollution inputs as possible. Being bound to sustainable development, the underlying three dimensions

- economic development,
- social development and
- environmental protection

are thoroughly considered in the practical implementation of integrated farming.

However, the need for profitability outlined in the European Integrated Farming Framework is a decisive prerequisite: To be sustainable, the system must be profitable, as profits generate the possibility to support sustainable agriculture.

As a management and planning approach, integrated farming is not based on a set of fixed parameters but on informed management processes. This knowledge-based flexibility includes attention to detail and managing all resources available[9]. The managed issues are based on continuous improvements and constant attention to detail in the following areas:

- Organization and planning,
- Human and social capital,
- Energy efficiency,
- Water use and protection,
- Climate change and air quality,
- Soil management,
- Crop nutrition,
- Crop health and protection,
- Animal husbandry, health and welfare,
- Landscape and nature conservation and
- Waste management pollution control.

Internationally seen, the mentioned EU standard is not the only regulatory framework. Following first developments in the 1950s, integrated farming was developed worldwide, in countries like Germany, Switzerland, UK, US, Australia and India for example. Most countries today have national certification practices, which are managed by private or governmental organizations. In the US are products labeled as “organic” if the product has been grown, produced, inspected and certified to follow the standards of the National Organic Program (NOP), a program of the US Department of Agriculture[10 + 11].

Our AquaPrawnics concept is based on a more industrialized approach with a very clear focus on economic sustainability. Our facilities look rather like an industrial production site than a farm. However, similar management tools and objectives are applied as stated in the various national certification requirements for integrated farming. In order to make this difference visible, we refer in our operations rather to Integrated Agriculture.

Designed as a lucrative business, integrated approaches in agriculture may be the missing link to solve some of our most challenging global environmental problems.

What distinguishes investments into integrated agriculture from any other investment?

Investments into AquaPrawnics may appear to be difficult to distinguish and to understand from an investor point of view. On one side, the investment can be compared to a utility investment. Seen from a different perspective, an AquaPrawnics investment may also be understood as agricultural investment, but owns aspects that are not typical for agricultural investments either.

Investments into AquaPrawnics can be considered in a certain degree as utility investments, even though power production is only a fraction of the overall business model. AquaPrawnics investments are infrastructure investments (amalgamation of power & biochar production, shrimp growing operations, indoor farming, etc.). However, an AquaPrawnics utility is certainly not as capital intensive as a power utility. None of our various projects exceed a CapEx size of 1-digit Million US$ and our financial models indicate a relatively high rate of payback in all projects – usually within 5 years after full production is established. In this sense, investments into AquaPrawnics utilities are a unique type of utility investment. They do not have the disadvantages known to utility investments, such as very high capital requirements and the typical sensitivity towards interest rate fluctuations. Neither are governmental regulations (for example environmental regulations) nor changing commodity prices or natural disasters reason for substantial influences on AquaPrawnics profits, something which can be risk factors with normal utility investments.

However, utility stocks are generally known for paying reliable dividends instead of showing strong growth. That applies to AquaPrawnics stock differently. Once established, the utilities generate returning income, but they also can increase their valuation considerably. Hence, AquaPrawnics investments may not only have the attention of conservative investors, or investors who plan for a defined amount of utility investments in their overall portfolio. Investments into AquaPrawnics may also be favorable in times of economic downturns when other stocks can become more volatile.

AquaPrawnics investments also need to be considered as agricultural investment. But, the typical trend in agriculture investments "Go big or get out", is not typical either for AquaPrawnics. Since economy of scale is a typical element in large-scale international ag companies like Nutrient and Monsanto, AquaPrawnics utilities are organized as a network of relatively small entities. They balance feedstock availability, local market access, labor, transportation costs, etc. in favor of local project profitability. Economy of scale, the driver of the "Go big or get out" investment strategy, does not apply to AquaPrawnics utilities. The main advantage of the AquaPrawnics concept is replicability and intelligently adapted structures to the specific local conditions of each site, which also can be in Opportunity Zones.

Seen from a market perspective, the various revenue streams AquaPrawnics utilities generate are all focused on markets with solid growing demands. The global shrimp market currently pegged at about $40 Billion, is expected to reach $68 Billion within the coming 10 years[13]. That is an increase of 70%. The US organic food market size was valued at 43.7 Billion in 2017 and is expected to reach a market size of $70.4 Billion by 2025, an increase of over 60% during the coming 8 years[16]. The organic fertilizers market (organic soil amendment) was valued at $5.87 Billion in 2016. It is projected to grow at a CAGR of 12.1% from 2017, to reach $11.16 Billion by 2022[17]. With other words, AquaPrawnics has focused on solid growth markets in agriculture with excellent perspectives.

Finally, there is also a non-economic reason for AquaPrawnics investments: The positive impacts AquaPrawnics utilities have on the environment. This impact is closely connected to our production of organic soil amendments. Organic soil amendments are the backbone of any organic farming and one of the remaining viable strategies to limit effectively greenhouse gas emissions. In 2012 researchers described for the first time the link between greenhouse gas emissions and conventional agriculture. According to the Consortium of International Agricultural Research (CGIAR), "One-third of greenhouse-gas emissions come from agriculture, and conventional fertilizers providing the lion´s share of greenhouse-gas emissions from the global food system"[18].

The AquaPrawnics business concept is one of the few economically sustainable methods, which have the potential to actually reduce greenhouse-gas emissions permanently. Hence, an AquaPrawnics investment is in its true sense a pure-play green investment.

Walter Kraus, President
AquaPrawnics, USA and
Golden Grid Solutions International Ltd., United Kingdom
Email: 2walter.kraus@aquaprawnics.com,
websites: https://aquaprawnics.com/

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