Construction of Sustainable High-Tech Greenhouse

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This project aims to create a business model and construction estimate in order to assess the viability of upgrading from conventional farming to a high-tech sustainable greenhouse. For the intended purposes this paper will make the assumption that a farmer that already owns their own land could use this as a guideline for what they could expect from a high-tech greenhouse in terms of both profits and expenses. Between my business plan, and my partner’s BIM model, we aim to make visualizing what a high-tech sustainable greenhouse could look like for a prospective farmer. The paper results are based on how this system would perform in a Southern California Climate Zone, but modifications could be made to adjust the numbers to any other climate zone. Visiting greenhouses of local farmers helped us in our design, and business plan calculations. The costs and benefits of a sustainable high-tech greenhouse are compiled to come to a ROI on the greenhouse investment. My partner Miguel created a BIM model, estimate, and construction schedule to go along with my business plan to create a realistic business proposal, that could be potentially be useful for farmers and investors alike.

Key Words: Greenhouse, High-Tech, Sustainable, Hydroponic, Agriculture

Introduction

Technological improvements in agriculture have created high-tech greenhouses, and a new opportunity for agricultural construction. A high-tech sustainable greenhouse is an expensive long-term investment. The whole concept of a high-tech greenhouse is for a farmer to create a growing environment in which they have total control of all elements. Greenhouse controllers are intelligent computer control systems that help a farmer manage a greenhouse to the highest level of efficiency. That means incredibly precise temperature and humidity control over acres of greenhouses, as well as exact irrigation control with all fertilizer, mineral, and pH inputs. What that simplifies down to is an acre of land in a greenhouse will yield more yield for less labor cost. I used historical data from the farmers I interviewed to get an accurate estimate of what kind of yields I could expect from plants in
Southern California, and what prices I could expect to receive for them. Additionally, I conferred with Frank (a Southern California high-tech greenhouse builder/operator) about the cost of building his greenhouse in Southern California to keep my estimate as accurate as possible.

The interest for this project came about from talking to farmers in the Southern California area. I've been seeing more and more small farms construct big greenhouses, and it made me curious about both the agricultural and construction related economics around such a project. My partner, Miguel and I toured Franks' 2-acre high tech greenhouse in the early spring, and we learned just how lucrative investing in greenhouses could be. Through further research with other local farmers like Valdivia Farms based out of San Marcos we discovered that many farmers are planning to build greenhouses in the future. It was this discovery that led Miguel and I to the idea of creating a business plan and a model for a theoretical construction of a high-tech greenhouse. The greenhouse would produce exclusively heirloom breed tomatoes in a hydroponic growing system. As the business plan I created, and Miguel's construction estimate shows there is a lot of potential for profit on both the agriculture and construction side of high-tech greenhouses.

**Project Development**

This project came about due to a huge increase in the number of high-tech greenhouses being constructed around my home in Southern California in the last five or so years. This spurred my interest and eventually I met up with Frank who had built his own high-tech greenhouse in San Diego in the 1980's, and he has provided much of the knowledge that backs the figures and design of this greenhouse. Traditional greenhouses are normally just PVC pipe with thin plastic sheets draped over that need to be replaced nearly annually. For tax purposes they can often be written off as equipment because of their lack of longevity. High tech greenhouses change all that by making a permanent space that is always at optimal growing temperature. Once I began to look into this, I discovered just how advanced high-tech greenhouses are from a construction standpoint in comparison to traditional ones. These high-tech greenhouses will have heating pipes, cooling vans and vents, sometimes even geothermal cooling. The end result is that the temperature over a two-acre greenhouse, could have less variance in temperature than buildings much smaller than them. That's because precision is the name of the game, and being able to dial in plants at the optimal temperature and humidity can allow farmers to grow crops all times of the year. In the off-season production in San Diego gets very low and local farmers have told me prices will up to three times what they are in summer months. For the purposes of this paper the prices I used for the business plan are consistent with San Diego commodity prices. The following image shows how prolifically tomatoes can grow in greenhouses.
The greatest advantage of a high-tech sustainable greenhouse is the ability to grow during all times of year thanks to the heating and cooling systems. The peak producing time of year for tomatoes in Southern California is during the summer months. Every single producer is flooding the market with their produce and prices are typically about $1 per lb. During the early spring and late fall the market for tomatoes will generally be around $1.5-2.0 per lb. In the winter months prices for the heirloom varieties of tomatoes the greenhouse would be producing could fetch $3+ per lb. I collected this data from the prices Valdivia Farms in San Diego gets for their tomatoes at wholesale price in the San Diego market. The business plan focuses on optimizing production during the months when overall production is low and prices are high. This competitive advantage will allow this greenhouse model to out compete competition by exploiting the longer growing season available to high-tech greenhouse growers.

Secondly, the other competitive advantage the high-tech greenhouse will have is its lower expense to operate. Initially this is offset by the large cost of construction, however a high-tech greenhouse made of glass and galvanized steel will easily last 35+ years with proper maintenance. A high-tech greenhouse that is built in a sustainable fashion will have a recirculating water system. That just means that instead of the water to the plants draining through the roots and being absorbed by the ground, it gets re-circulated and recycled. This is achieved by the tomato plants being raised off the ground by a foot to a foot and a half. Under the plants root ball is a gutter, or a trough. This pipe collects all the excess water not used by the plants and returns it to the pump tank for storage and reinjection. This kind of system can save up to 90% of the water compared to conventional farming claims Valdivia Farms. Reinjection of a system is when all of the fertilizers, nitrates, PH, and oxygen levels are adjusted before the water can be pumped out to the plants again. This whole process is controlled by a greenhouse controller, which is a powerful computer control system. Systems like these eliminate the man power needed to run a greenhouse considerably. All of the greenhouse controls can be controlled by a single person, and can control the climate and nutrient
dosage of all of the thousands of plants in the building. This additionally saves money on labor expenses. Harvesting the fruit is also considerably easier in a greenhouse than conventional farming. All of the fruit is in neat rows that are devoid of hills and holes. Additionally, because of the raised gutter design much of the bending down for low fruit is also eliminated in this system. The image below shows just how efficient a high-tech greenhouse can be when it is fully optimized, with produce leaving the farm like a factory.

![Figure 2: Efficiency in a High-Tech Greenhouse](https://investinholland.com)

Sustainable high-tech greenhouses should be considered by more farmers and investors as a viable investment especially when a farmer has land but no cash, or vice versa. The return on investment is incredibly attractive when optimized to grow heirloom tomatoes. However, that should not be the only way farmers and investors view a high-tech greenhouse. Upon interviewing Frank who built his high-tech greenhouse in the 1982, I discovered that he no longer had any interest in farming himself after 20 years. He now just rents out his greenhouse to multiple different farmers, and collects their rent check as a landlord. Just from an investment perspective a high-tech greenhouse could be an attractive investment for a landlord that doesn’t have any intention of farming themselves.

Frank Bons and Devon Valdivia were the two greenhouse farmers that I interviewed about building and running a high-tech greenhouse. Frank studied agriculture at Cal Poly SLO and Devon studied greenhouses at the university of Arizona. Frank told me that he rents his greenhouse out for about $15,000 every month or $180,000 annually. Nearly regardless of price there is always a large list of applicants for his greenhouses every time they go up on the market. So, after interest payments a landowner could expect to make $30,000 profit per acre of high tech-greenhouse rented annually. The rough return on investment for this angle is about 11 years, at which point the greenhouse would probably have about 20-40 years of usable life left. The loan would be paid off and the landowner would profit the entire rent payment. This flexible business plan is another reason why high-tech greenhouse are such an interesting and potentially lucrative investment.
High Tech Greenhouse Business Plan

Ethan Emery 05/01/2020

2-acre greenhouse holds 20,000 plants

Average yield per plant = 35 lbs.

Annual production is estimated at 700,000 pounds or 350 tons

275,000 lbs. Summer
200,000 lbs. Spring
125,000 lbs. Fall
100,000 lbs. Winter

700,000 lbs. Annual Production

Pricing

Spring: 200,000 lbs. X $1.3/lb. = $260,000
Summer: 275,000 lbs. X $1.0/lb. = $275,000
Fall: 125,000 lbs. X $1.9/lb. = $237,500
Winter: 100,000 lbs. $2.8/lb. = $280,000

Gross Revenue Annually = $1,052,500

Figure 3: Spreadsheet Representing Greenhouse Revenues

When creating this business plan, I wanted to take a conservative approach and choose prices and quantities that could very realistically be attained in the Southern California climate and market. Yields from every farm vary significantly, but from talking with Frank and Devon I was able to create a conservative estimate that would have a high likelihood of proving successful in terms of quantity and profits in the eyes of the bank, or an investor (See Figure 3). With a good marketing strategy for high price sales at grocery stores and farmers markets, profits could potentially be much higher than only selling at wholesale. Additionally, farming the tomatoes and growing a greater than estimated yield could greatly increase profits as well.
**Expenses:**

*Construction Cost estimate:* $2,000,000

*Loan Interest Rate:* 4.5%

*Annual Interest Payments:* $120,000

**Operating Expenses Per Plant:**

- *Seeds:* $0.10 \times 20,000 = $2,000
- *Labor:* $10.5 \times 20,000 = $210,000
- *Heating/Electricity:* $3.75 \times 20,000 = $75,000
- *Shipping/Package:* $1.50 \times 20,000 = $30,000

*Total:* $317,000

*Total Annual Expenses:* $120,000 + $317,000 = $437,000

*Net Profit:* $1,052,000 - $437,000 = $615,000

*Annual Net Profit with Bank Loan*

**ROI:** With Angel Investor $2,000,000/ $615,000 = 3.25 years + 6 month construction

**ROI = 3.75 - 4 years**

*Figure 4: Spreadsheet Representing Greenhouse Expenses*

For the expense portion of the business plan I used statistics from the university of Georgia in order to reference per plant growing expenses (Westerfield 2019). The price I used for the construction cost is derived from Miguel's cost estimate and using local greenhouses as reference as well. I tried to be as complete as possible in assessing expenses while being conservative on profits to make sure I have a very achievable conservative business plan. I broke the business plan into two different sources of funding which would be banks in the form of a loan, or with a private investor. I calculated with a 4.5% interest rate on a $2,000,000 loan. This could also be conservative given current low interest rates. Without investor help a farmer would need $400,000 down on a $2,000,000 loan and then would have to pay about $100,000 in interest annually (See Figure 4). With an investor willing to put the whole amount down for construction and operation they could be looking at seeing their money back in about 4 years. Different percentage breakdowns would have to be agreed upon, but both situations could be very lucrative for landowners and farmers.
Lessons Learned

This project was very challenging because Miguel and I had to break down the whole construction process, and weigh our material options to choose the best options. And that best option is based on a number of factors including longevity, price, maintenance, etc. I learned that when you are making a business plan you can always count on there being another expense, and it takes a lot of time to try and accurately estimate how much money a possible future business could make. From our greenhouse visit we learned that spending the extra dollar upfront can save you a pile of dollars down the line. Because of this lesson, we opted to go with the more expensive galvanized steel and glass panel design rather than the less expensive non-galvanized poly carbonate route. The upfront cost is much more expensive, but over the lifetime of the greenhouse it will pay itself off because they don’t need to be replaced.

Conclusion

After creating the business plan and going through this whole project, I see tons of potential for investment in high-tech greenhouses. Additionally, with the way that the agriculture industry is going I think there will be much more collaboration between the fields of construction and agriculture particularly when it comes to greenhouse construction. I believe that an investment in high tech greenhouses is viable for any farmer who currently owns agriculture real estate. For perspective investors that are not already landowners this may be a very difficult business venture to undertake. Current landowners have the option of continuing to farm with greater production from the greenhouse, or they can sit back and collect rent checks while renting the greenhouse out. That option in investment strategy I think makes this investment especially attractive for older farmers that have paid off their land, and may be looking to retire soon.

What’s Next

In the future expanding this project would most likely require participation from a farmer and an investor. We didn’t revolutionize greenhouse design with this project, but we just wanted to get a business plan out there, and test our modeling and estimating skills. For this project to have a future it would likely have to be taken full scale as a business investment.

Disclaimer

This project/paper and its contents are estimated expected returns and results could vary greatly based on a multitude of factors. The conclusions/results contained in this paper should not be used as reference for any investment activities.
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