Greenhouse Hydroponic Production:
The Evaluation of Tools, Methods and Guidance: A SWOT Analysis

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Abstract

Hydroponic crops are growing popularity as consumer awareness increases recognizing the need of sustainable and safe food practices. Hydroponic production is considered a 'high-tech' production system to many small farmers. The need to diversify remains within the farmer's mind, while regulatory bodies seem to be more in support of mono cropping as industry guidance changes. The recent implementation of the Food Safety Modernization Act has small farmers in fear of being pushed out of the supply chain. Hydroponic crop production can provide these small farmers with the opportunity to remain diversified, while producing the yields necessary to meet their monetary needs. The dual purpose of this paper is to provide insight on the need in maintaining diversity acknowledging the small farmer's values, while incorporating necessary food safety and food defense. The evaluation and determination of the most valuable tools and guidance was made.

Keywords: hydroponic, sustainable farming, agricultural education, biodiversity, improved yields, food safety, food defense, traceability, food protection, tools, methods, guidance

Introduction

Foodborne microbial risks are a growing public health concern (WHO, 2007). In more recent attempts to control these risks, the government has established the Food Safety Modernization Act (FSMA) of 2010. Crop protection combines the concerns regarding food safety and food defense concerns through mandating the utilization of Good Agricultural Practices (GAP) Standards.

As small farmers are being pushed out of the food chain, the need for further education on alternative crop methods exists. Additionally, the need for the education on risk assessments and protecting what they produce exists. As food legislation changes, so does our food supply chain. Consumer wants and needs change rapidly. The Small farmer must be creative in finding the means to compete with the 'big guys', focusing on a local level. Community Supportive Agriculture (CSA) is gaining popularity, however consumer demands include verification of safe food purchases.

At times, throughout our supply chain, commercial entities are utilizing marketing efforts ensuring the consumer that their production incorporates all precautionary

measures in eliminating microbial contamination. As new technologies, like greenhouse hydroponic production systems, gain popularity in the production of safe, protected food, tools and guidance must be made available.

Methodology

This paper will highlight the Strengths, Weaknesses, Opportunities and Threats (SWOT) in the evaluation of tools offered through the government in meeting consumer and small farmer demands. The SWOT Analysis was chosen as a framework due to the ease of its use, not requiring specific training or software. SWOT analyses have been proven an effective tool in strategic planning, for many years, having the potential to contribute to small production throughout our food chain supply. This paper demonstrates this ease of use in determining the benefits of tools available.

Meeting Consumer Demands on a Local Level

Consumers are becoming very knowledgeable about healthy eating. Unfortunately, some do not have access to healthy foods. States are individually evaluating this and implementing programs such as corner markets, farmers markets, etc. Families are starting to grow their own food through backyard gardening, without the knowledge of GAP, with the intention of recouping their investment by selling local. The fact remains as awareness increases, consumers want to know where their food is coming from and want proof of safety. Food traceability has now become a demand for the consumer. Small farmers must comply to compete, but the resources unfortunately are too spread out and become confusing. Small farmers have been faced with the challenges of new technologies, the fear of GMO crop production, and now with the fact they cannot afford to comply, therefore cannot compete.

Educating the consumer on growing methods should be prioritized. Methods of intervention will be crucial in economic success creating a demand for hydroponic production. Currently, direct product marketing does not involve the words "hydroponic". Alternatively, the words "living", "hot house", "pesticide-free" and "heirloom" are words to describe growing processes. Market interventions can take on many forms, but all of them seek to address the fundamental information problem and the need for appropriate incentives for producers and consumers. It is unknown how the consumer would react to the word 'hydroponic' as technical as it sounds.

Changes in demand and supply will continue to support the need for overall food protection. Interventions in consumer demand are made everyday, (i.e., certified organic). There is a definite need for potential market interventions in marketing of hydroponically produced products. Potential market interventions are defined and distinguished illustrating achievable reduction in market failure of hydroponic greenhouse crop production. With the implementation of GHAP, small-scale hydroponic producers should have the option of distributing products to any outlet

that their yields allow within a set parameter (i.e., 100 mile radius) without having to meet the same regulatory standards as commercial producers. GHAP certification provides all necessary standards in safe, protected food production on a local level.

Addressing the Need for Farmer Education

Farmer education is needed to eliminate outrage on all levels. They are under pressure from industry leaders to adopt practices that they are unfamiliar with daily. As technology increases, it seems out yields are decreasing with small farmers. These are growing concerns at all supply chain levels. With a bit of education and vision, local rural communities can become sustainable and feel confortable with their practices.

All educational material should be presented in layman terms steering clear of confusing 'high-tech' dialect, while clearly defining what directly pertains their operation. It is unnecessary to provide farmers and/or community members with information that will cause further confusion or concern. The importance of the educational sessions will be to eliminate panic. For this reason, "An Educational Guide for Hydroponic Greenhouse Production" incorporating food safety, food traceability and food defense is needed. This educational guide should offer guidance incorporating all food protection components into a single Standard Operating Procedure (SOP's) was developed. We need to ACT – not REACT.

Rationale for Small Farmer Intervention of Food Safety Modernization Act

At some level, there is always reasonable rationale for policy intervention within the agricultural sector. The government makes the best decisions base on the greatest population at risk in public health protection efforts. We have to always remember, if the system is working, the government will not take the time to fix it. No one person is aware of all factors that lead to certain policies, regulations and standards. Factors that can play a role may be related to the development of new technologies, infrastructure development, the correction of market failures, economy, price stabilization, food security, public health alerts related to agriculture, and the list goes on. Food supply demands are continuously changing worldwide, therefore regulations are likely to continue to change. The adoption of intervention often results in an intervention of an intervention.

Type of Intervention	Examples
Process Standards	• Specify how products are produced (i.e., inputs)
Mandatory Disclosure	• Specify self determination of acceptable risks (ORM for food defense)
Providing information to the public	• Informing consumers of how to avoid risks at home; Subsidizing

	hydroponic production showing support of safe, quality products while meeting consumer demand for food protection. • Government support
Providing information to the farmers	• Informing farmers that they have a choice in production systems and the resources to compete. • Government support
Education	• Providing information to the community members and farmers ensuring they understand the challenges and the fact that GAP alone does not guarantee safe food. • Ensuring that farmers are provided through education and comprehend the information given to them.

Tools and Guidance Made Available by the U.S. Government

1. Guidance for Industry (FDA & USDA)
2. GAP/GHP (FDA)
3. HACCP (seafood, meat, fruit juice currently) (FDA & USDA)
4. Food Defense Mitigations Strategies Database (FDA)
5. Food Vulnerability Assessment Tool (FDA)

Guidance for Industry

The Guidance for Industry are industry specific recommended guidelines complied by the FDA and USDA. These guides are intended to be use as a starting point for the development of food safety plans. In response to a produce safety initiative by President Clinton in 1997, the FDA and USDA issued the *Guidance for Industry: Guide to Minimize Microbial Food Safety Hazards for Fresh Fruits and Vegetables*. This guidance is common to the growing, harvesting, washing, sorting, packing, and transporting of most fruits and vegetables. It is considered science-based guidance, and is currently not regulated.

In 2009 the FDA released and additional draft version for the *Guidance of Industry: Guide to Minimize Microbial Food Safety Hazards of Leafy Greens*. This guidance is to be utilized in the same fashion and also is not currently regulated. It is recommended that all producers become familiar with these *Guidance of Industry* documents, as they are the basis of the recommended tools throughout the food industry.

Evaluation of Implementing GAP/GHP at a Small Farm Level

Good Agricultural Practices and Good Handling Practices (GAP/GHP) were developed in an effort to minimize foodborne pathogens in our food supply. The developers of the GAP Certification Program were clearly mindful of traditional crop growing, without considering or recommending alternative crop production systems, nor sustainable solutions for small farmers in implementing these standards.

Public health concerns have been priority, as it is with small farmers in the production of quality health food. Inputs that are currently being used in our supply chain (pesticides, fungicides, etc.) have made our soils sick. We need to focus our attention toward healthy soils, as we continue to address public health concerns maintaining abundant food supplies. We can no longer produce the desirable yields under current practices.

The prevention of microbial contamination, if in the forefront, will allow for greater local marketability of hydroponically produced vegetables meeting consumer demands.

SWOT Analysis: Food Safety + Awareness

A SWOT analysis was performed highlighting possible concerns of small farmer's as they consider the implementation of GAP.

SWOT Analysis + Awareness: GAP/GHP		
	Positive	Negative
	Strengths: • The government is the driving force. • Extension officers are available to assist in transitioning. • Standardization • Meets consumer demand for quality, safe product. • Branding opportunities	**Weaknesses:** • General lack of knowledge and understanding on the concepts of GAP and the objectives. • Farmer's are unable to visualize the benefits of implementing GAP due to cost restraints (audits, improvements, etc.). • Farmer's cannot understand the economic benefits such as meeting consumer demands • Farmer's cannot accept that there are no guarantees in price premiums. • The documenting and paper trails seem overwhelming. • Small farmer's are dependent on the middleman and are unaware of

<table>
<tr><td></td><td></td><td>direct marketing opportunities.
• Challenges for direct marketing include farm location and logistics.
• Farmer's find it challenging to change their mindset from Eco-diversity.
• Slow certification process
• Audit
• Small farmers are not conscious of the consumer awareness of GAP standards.
• Confusion on the demands of the Food Safety Modernization Act (FSMA)</td></tr>
<tr><td></td><td>Opportunities:

• GAP is already in place
• Outsourcing testing, laboratories, auditing and certification.
• Creation of Associations to assist in the process.
• Improvement of quality and productivity (in some cases with knowledge of inputs and rebuilding soil health)
• Absence of incentives or price premiums on certified products.
• Consumers willingness to pay for quality, safe products
• Food Protection (intentional contamination through food defense)</td><td>Threats:

• Higher energy costs
• Absence of incentives or price premiums.
• Shortage of auditors and meeting deadlines.

AWARENESS
• Auditing
• Documentation Simplified
• Increasing Consumer Demand
• Cost vs. Benefits
• Education
• ACT – don't REACT</td></tr>
</table>

HACCP as a Standards Based Approach

The utilization of the Hazard Analysis and Critical Control Points (HACCP) will enable the small-scale hydroponic greenhouse producer to demonstrate their commitment to food safety and customer satisfaction. It is time to integrate the realities of a changing world.

HACCP is already widely recognized in the food industry as an effective approach to establishing good production, good sanitation, and manufacturing practices, which should be maintained. Through focusing on the hazards that affect food safety and microbial contamination, HACCP systematically identifies these hazards by setting up critical control limits at critical points throughout production. HACCP is built around the following seven principles:

1. Analysis of food hazards including biological, chemical or physical;
2. Identification of critical control points such as seed, nutrients, sanitization, storage, recordkeeping, and distribution.
3. Establishment of critical control limits and preventive measures: for example, harvest to distribution storage.
4. Monitoring of these critical control points;
5. Establishment of corrective actions;
6. Keeping records; and
7. Systematic and regular auditing of the system in place by independent third party certification bodies.

SWOT Analysis: Food Safety/Defense

SWOT Analysis: HACCP Evaluating the Use of HACCP in Small-Scale Hydroponic Greenhouse Production		
	Positive	Negative
	Strengths: • Utilization as a regulatory tool • Can be applied to control any stage of the food system • Widely recognized • Relies on prevention and identification of	**Weaknesses:** • Cost of Implementation • Esurience that all CCP's have been identified.

	CCP's • Verification of system processes • Dual Use	
	Opportunities: • Ability to demonstrate commitment to food safety. • Improves reliability. • Increased demand.	**Threats:** • Misuse – Not designed to replace management decision making relative to choice of inputs, product marketing. • Having to choose between regulatory compliance and managerial decision for product success. • Allows some flexibility for management choice

Recommendations:

HACCP is already a familiar tool used within the food industry. It is highly recommended for use within small-scale production, especially hydroponic greenhouse production in reducing the risks of microbial contamination. Management must use precautions in evaluating risks versus costs for mitigation. It is recommended that more than one person perform a HACCP evaluation and compare results of identified risks and mitigation strategies.

The Food Defense Mitigation Strategies Database (FDA)

Introduction

The Food Defense Mitigations Strategies Database tool was developed by the FDA to provide guidance in protecting our food from intentional contamination. However, it is focuses mainly on food processing facilities. The database works by the user inputting certain 'nodes' pertaining to their business. However this is very limited and is up to the user to identify potential vulnerabilities. This tool produces the same information as the FDA's Vulnerability Assessment Tool as described below. For the purpose of evaluation, specific 'node' inputs for the evaluation of the tool are illustrated below:

Input Node #1: Materials/Water

1. Secure all water treatment supplies (filters, minerals, chemicals)
2. Restrict maintenance and water treatment system access to authorized employees.
3. Secure all water system cleaning supplies
4. For non-public potable water sources, restrict access to wellhead, spring, cistern, as well as pumping, filtering, storage and piping systems

5. Fence off appropriate area around the wellhead/spring to minimize possible intentional surface contamination (minimum area 50 ft. radius)
6. Protect pumping system controls with swipe cards, cipher pads or biometric controls
7. For all potable water systems, restrict access to pumping, storage, piping and treatment systems (to include filtering) as well as air sources for pressurization
8. Ensure that any water system modifications maintain backflow protection
9. Design or modify water system to minimize obscure access points (e.g. unused valves, tees, and nipples)
10. Protect treatment system controls with swipe cards, cipher pads, or biometric devices
11. Secure all plans/drawings/schematics of the water system
12. Establish a chemical and biological baseline water profile
13. Whether sourced publicly or privately, frequently test and record water attributes to ensure adherence to safety standards and compare regularly with baseline profile
14. Limit access to system and controls and supplies to authorized employees
15. Ensure that contractors for water system cleaning and maintenance have a security plan in place
16. Develop a protocol to deal with "suspect" water
17. Utilize peer monitoring for employees authorized to clean or undertake system maintenance
18. Install surveillance cameras to monitor remote components of the water supply system
19. Verify/audit contractor security plans

Node #2: General Information/Management

Security Policies and Procedures
Objective: Implement/augment company security efforts to minimize vulnerabilities to intentional acts of contamination.

1. Develop a written security plan for each company-owned facility and include an assessment of possible security risks including food handling/processing procedures and operations. Establish appropriate actions to address those risks.
2. Communicate and distribute copies of the security plan, or portions of the plan, to company employees who are assigned responsibility for implementation .
3. Take precautionary steps to safeguard company's security plan from unauthorized disclosure.
4. Mark sensitive security information (SSI) and keep in a secure location.
5. Eliminate sensitive information from your company web site.
6. Take appropriate measures to prevent unauthorized access to corporate computer systems.
7. Establish communication policies for reporting and responding to suspicious behavior or events, including which employees should be contacted to immediately report threats and incidents.
8. Establish an emergency procedure plan including identifying, segregating, and securing affected products and distribute to the appropriate individuals including emergency response personnel.
9. Establish a policy regarding employee personal items on the premises e.g. prescription drugs, foods etc. (outside designated eating areas).
10. Establish a policy regarding entry and storage of employee belongings
11. Establish procedures to ensure the safety of incoming mail and packages, including courier deliveries.
12. Establish a policy to ensure adequate and active employee oversight, to include cleaning and maintenance staff, contract workers, data entry and IT support staff and especially new employees
13. Establish an emergency evacuation plan and include actions to prevent security breaches during evacuation.
14. Make appropriate personnel aware of 24-hour contact information for local, State, and

Federal police/fire/rescue/health/homeland security agencies.

15. Ensure that staff is aware of who to contact about potential security problems (24-hour contacts).
16. Communicate and distribute copies of your company's security plan to appropriate staff, law enforcement, and emergency responders.
17. Collect and dispose of outdated copies of the company security plan to ensure that it does not remain in use and can not be reconstructed.
18. Keep current on industry news and security issues
19. Develop security actions to be implemented during raised threat levels. (e.g., post the threat level in an area where employees can see it or notify employees of an increased threat.)
20. Ensure that suppliers are legitimate prior to accepting materials.
21. Use only known suppliers and contractors that have adopted adequate security measures in their operations.
22. Request company and product information from potential new suppliers.
23. Involve suppliers, as appropriate, in your risk reduction program.
24. Implement an inventory control system.
25. Establish guidelines for investigating production interruptions.
26. Verify the use of anti-tampering devices such as tamper-resistant cable locks or seals on vehicles, containers, and railcars that supply your facilities.
27. Have an internal communication system to inform and update staff about relevant security issues.
28. Establish a strategy for communicating with the public (for example, identifying a media spokesperson, preparing generic press statements and background information, and coordinating press statements with appropriate authorities).
29. Establish and implement a policy regarding the storage and use of poisonous and toxic chemicals, including laboratory reagents.
30. Inventory and limit dangerous chemicals and reagents in the facility to only those necessary for the operations and maintenance. Ensure they are properly secured and assign custody to responsible individuals.
31. Store and secure poisonous and toxic substances and reagents as far away from food processing, handling and storage as is practical.
32. Use pesticides in accordance with the Federal Insecticide and Rodenticide Act
33. Investigate poison, toxic chemical and lab reagent stocks for irregularities and report unresolved discrepancies to law enforcement and public health authorities
34. Conduct self test of security measures
35. Establish a check-in/check-out policy for employees, vendors, contractors and visitors
36. Revise your company's security plan as necessary to reflect changing circumstances.
37. Have a third party review your security plan to conduct a food defense audit including exercises or penetration audits.
38. Immediately report all suspicious information to your local FBI office or local law enforcement officials as specified in your company security plan.

SWOT Analysis: Food Defense

SWOT Analysis: Food Defense Mitigation Strategies Database (FDA)		
	Positive	**Negative**
	Strengths: • Contains a range of preventative	**Weaknesses:** • Only Windows compatible • Limited 'nodes' (approx.. 55

	measures for manufacturers, processors, distributors & retail to consider. • Searchable by users	production steps. • Repetitive to Guidance for Industry Guides; FDA compiled mitigations from these Guidance Documents, which were complied form Industry Inputs. • Key 'search words' were not obvious.
	Opportunities: • Additional focus from seed to distribution.	**Threats:** • Does not walk user through the entire food chain supply. • Not comprehensive and should be utilized as a starting point only. Users must be made aware of this fact.

Recommendations:

In general, the Food Defense Mitigation Strategies Database provides guidance for food defense mitigation measures specifically for manufacturers, processors, distributors & retail, therefore is not useful in evaluating pre-distribution (seed to distribution) defense practices. It is recommended for the intended food industry sectors only. The same guidance can be found in "Industry for Guidance" documents compiled by the FDA and USDA.

FDA's Vulnerability Assessment Tool

Introduction

There is a growing recognition of the importance of accessing vulnerabilities within our food supply chain, however challenging for small conventional farmers. For this reason, the Food and Drug Administration has developed a software tool to assist in identifying vulnerable areas within a food system. Specifically, the tool was utilized in accessing possible vulnerabilities in greenhouse hydroponic production.

The CARVER + Shock methodology was chosen by the FDA to incorporate into the software. The CARVER + Shock method was originally a face-to-face assessment that was consider classified for use by the U.S. military. The methodology was released for public use in 2007.

The methodology includes breaking down the food system into nodes from 'farm to table' continuum. The user chooses the most applicable 'node' and answers a list of questions pertaining to that specific 'node'. The software assesses each 'node' and prioritizes the most vulnerable (see Figure 1). The software then provides the user with suggested mitigation strategies.

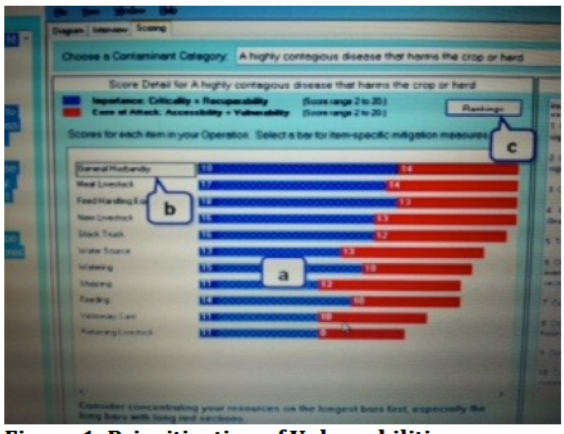

Figure 1: Prioritization of Vulnerabilities

SWOT Analysis: Food Defense

SWOT Analysis: FDA Vulnerability Assessment Tool		
	Positive	**Negative**
	Strengths: • Utilization of CARVER + Shock Methodology • Real-time mapping capability. • Non-technical thought processes • Enhances identification of unacceptable risks • Potentially overrides management decision determining the value of the risk. •	**Weaknesses:** • Very little variation in vulnerability scale with different inputs. • Decisions could vary from person-to-person. • Not intended for small-scale production • Not MAC compatible • Technological Skills • Unreliability
	Opportunities: • Available free of charge on FDA.gov • May provide guidance through thought processes • Increased demand for vulnerability	**Threats:** • Not specific for hydroponic greenhouse production, therefore may lead to oversight. • Change in Government policy

	assessment tool improvements • New distribution channels (small-scale)	

User Challenges Identified

1. Implement Hydroponic production into the tool.
2. Eliminate the repetitiveness of the user questions.
3. Insert "not applicable" as an answer to the user questions, which will then re-route to applicable questionnaire.
4. Define small, medium or large operations allowing for user input eliminating repetitive or unnecessary questions.
5. Improve 'dropbox' format, which is inoperable. For example, the question 'Where do you get water for your operation? (Check all that apply) provided a dropdown list that did not offer options, as well as the user being instructed to check all answers that apply to their operation.
6. Aquaculture was chosen from the "Icon List" as the most comparable production method to hydroponic production. It was interesting that 'Aquaculture water source was listed under material sources for conventional farming, while there seemed to be no vulnerability concern in the hypothetical development model addressing water sources when Aquaculture specifically was evaluation.
7. The verbiage does not change based on the inputs, although a user is allowed to 'rename' their icon. This becomes confusing for the user as the results verbiage does not change.

Recommendations:

The results of the evaluation suggest that this tool could tolerate improvement with a deeper understanding of the hypothesized model used in development. The utilization of the CARVER + Shock method in accessing vulnerabilities is the most valuable implementation to the model. The tool appears to be industry specific however asks the same questions repetitively and is not specific to chosen category. It is clear that the software is designed for commercial production, as well as imports and exports providing little guidance on a small-scale production level.

Although the concept of the software is simply described, it would be time consuming for someone with very little computer skills to utilize the tool. Keeping the small-scale farmer in mind, the ease of use in comparison to Food Defense Mitigation Strategies Database is absent. However, the mitigation strategies are basically the same for both tools although they are intended for different levels within the food supply chain.

It is recommended that the FDA's Vulnerability Assessment Tool be utilized by small-scale hydroponic greenhouse production to assist in the recognition of vulnerabilities. The 'thought process' in which the software takes the user through could be beneficial in recognizing threats in a variety of crop production techniques, however hydroponic production was not considered in model development.

Proposed GHAP Standards for Greenhouse Hydroponic Production

Here I propose an integrative GHAP model to:

- To integrate the most important existing terms associated with agricultural practices into greenhouse hydroponic production.
- To demonstrate how GHAP could be used as a tool in accomplishing sustainable rural development.
- Identify the benefits of a controlled environment in reducing microbial risks.
- Identify how the U.S. Government can reevaluate subsidies in rural communities supporting diversity while maintaining food safety.
- Integrate food safety and food defense into Standard Operating Procedures for ease of understanding.
- Demonstrate the need for education and guidance.

A SWOT analysis was performed providing a comparison mechanism of GHAP to standard GAP.

SWOT Analysis of 100% Diversified Farming Practices Incorporating Proposed GHAP		
	Positive	Negative
	Strengths: • Optimal Marketing Value (locally grown, environmentally responsible, low-mileage distribution, quality product) • High Yields • Low Inputs • Diversified Profits • Commercial production has been identified as	**Weaknesses:** • Viewed as "high-tech" and "non-organic" • High initial costs • Lack of government subsidies • Lack of knowledge

	profitable • Less labor intensive • Optimal growth environment • Elimination of animal introduced pathogens	
	Opportunities: • Consumers willingness to pay for quality, safe products • Potential for Agri-tourism • Supply of high-value niche markets • Branding Opportunities • Development of Regional Cuisine • Increase of Farm Direct Sales • Educating rural communities on making healthy eating choices • Potential to Market as "Organic" • Potential for government to subsidized energy costs and/or provide alternative energy sources • Easily adaptable to changing patterns of food consumption • No technological obsolescence • Rebuild soil fertility • Food Protection (intentional contamination through food defense)	**Threats:** • Higher energy costs • Lack of governmental support • Sustainable development costs • Consumer views • Media

GAP vs. GHAP

The integration of GAP into a hydroponic greenhouse production system involves the integration of three major provisions:

1. Food Safety
2. Social Responsibility
3. Sustainability (economic and environmental)

There are four primary components of GAP focusing on production and processing; 1) Soil; 2) Water; 3) Hands; and 4) Surfaces. The elimination of soil, water treated with reverse osmosis (RO), the implementation of employee hygiene practices, and sanitation practices in hydroponic greenhouse production all entail controllable risks and should viable, subsidized alternative to field production.

The USDA states that 'it is not a requirement to perform a separate audit for every separate commodity grown on the farm, however operations may choose to do so if they so desire'. The USDA further states that the 'USDA AMS policy allows diversified farming operations to cover all the commodities grown on the farm under the same audit subject to the following conditions', however they will be subject to unannounced visits due to the fact that the crops have different seasons:

The Key to GAP is to develop an overall process based on Hazard Analysis Control Points (HACCP) from seed to consumer. All necessary guidance and compliance should be maintained for the protection of public health. Modifications for small farmers may include the incorporation of the most vulnerable, high-risk prevention method as described below in the proposed Good Hydroponic Agricultural Practices (GHAP) certification.

Audit Process for GAP vs. GHAP	
GAP	GHAP
Food Safety - Production (Seed to Harvest)	
Food Safety Plan	✔ Considered a necessity
Traceability of the produce from seed to the specific field grown	✔ From seed to consumer
Recordkeeping	✔ Sources for seed, equipment, nutrients, packaging materials, etc.)
Site History and Management	✔ Not as Crucial
Crop Protection from Environment	✔ Most Secure
Harvesting	✔ No risk of soil pathogens or runoff

Recall Program	✔ For all commodities
Worker Health and Hygiene	✔ Microbial Contamination
Pesticide and Chemical Use	NA - Biocontrol and environmental control utilized within the greenhouse
Water Use (Irrigation, post-harvest, etc.)	✔ Reverse Osmosis (RO) Utilized, No need for post-harvest was due to soilless media.
Water Quality Risk Assessment	✔ Tester Pre-RO and Post-RO Bi-annually
Soil Amendments	NA
Animals/Wildlife/Livestock	NA All fruit and vegetables grown indoors
Land Use & Land Use History	NA – Indoor Productions of Fruits and Vegetables
Food Safety - Harvest and Packing Activities	
Field Harvest and Field Packing	NA – Sanitation practices and employee Hygiene only
Harvesting Containers & Equipment	✔ All containers and equipment are stored inside and if any tools are needed (rarely) they are sanitized
Transportation of Produce	✔ Distribution straight to consumer
House Packing Facility	NA – Packing can take place in designated area within greenhouse
Emergency clean up Procedures	✔ Nutrient spill will be diluted; Minor CCP under HACCP
Water Use in Packing Facility	✔ If applicable depending on crop; RO utilized
Treatment of Processing Water	NA – Always monitored through entire process – (Seed to Consumer)
Sanitation Program/General Housekeeping	✔ Integrated into daily SOP's
Worker Health and Hygiene	✔ Microbial/Pathogen Contamination Elimination Procedures Daily
Pest Control	✔ Sticky Cards, Covered Trashcans; proper disposal and sanitation practices
Containers	✔ Multiple Container use is eliminated – Soil contamination eliminated on crop and containers.
Food Protection	
Food Safety Plan	✔ Incorporation of Food Defense into SOP's
Food Defense Plan	✔ Incorporation of Food Defense into SOP's
Characteristics	
Regulatory Guidance	Possible Regulatory Guidance

Immediate term intention (not sustainable)	Future, long term aims
Experience based	Experience and Vision Based
Aimed to Standardization (Should definitely apply to imported foods and commercial producers)	Individualized supporting the implementation of best solution farm-wide
Bases for Incentives (government subsidies, etc.)	Possible bases for Incentives, but maintains base for awards (safe, local, sustainable)
Fixed Regulations	Living documents, standards, etc.
Targeted to particular segments of product chain	Meets the demands of rural development, and local supply chains.
Self Audits /Guidance/Tools	
Standard Operating Procedure	Standard Operating Procedure incorporating GAP/GHAP
HACCP Recommended	HACCP Highly Recommended
Self-Audit	Quarterly Review of SOP's Testing Procedures
	SWOT Analysis (specialty niche crops, crop evaluations, meeting consumer demands, diversity or addition of new product, daily procedures, etc.)
	Community Education Sessions

Conclusion

Food is being increasingly imported from developing countries where production and surveillance standards are lower than those for growers in the United States. We have retailers that claim they are supporters of local agriculture, however maintain product that contain U.S. "Certified Organic Labeling" and in small print contains the words "A Product of China". The point being, we do not know if our food is safe. The government has raised concerns that they are not staffed to maintain all boarder protocols and maintain safety countrywide. It seems senseless to spend funds that we do not have in order to protect our boarders, when we should be protecting our small farmers. The solution to this is to act on a community level.

Produce is exposed to naturally occurring, biological hazards in the soil, water, and air. The potential risk for contamination is increased by production practices using manure for fertilizer and human handling (pre-harvest and post-harvest) of field products. Incorporating hydroponic production for leafy greens, considering they are the most vulnerable, especially will minimize these contamination concerns through protected cropping in an optimal growing environment utilizing proper sanitization methods.

We need to move faster in the development of tools on a small-scale production level in fighting pathogen reduction from animal waste to produce, environmental factors and contamination concerns. Decontamination of produce remains a challenge and will continue to remain a challenge. Demanding GAP Standards Alone will put small farmers out of business and does not guarantee safety of our food. At a minimum, a combination of HACCP and GHAP into a Standard Operating Procedure should be required for small-scale production of any kind. Through the information presented, the government can lead in supporting small farmers, especially in rural communities, throughout the U.S.

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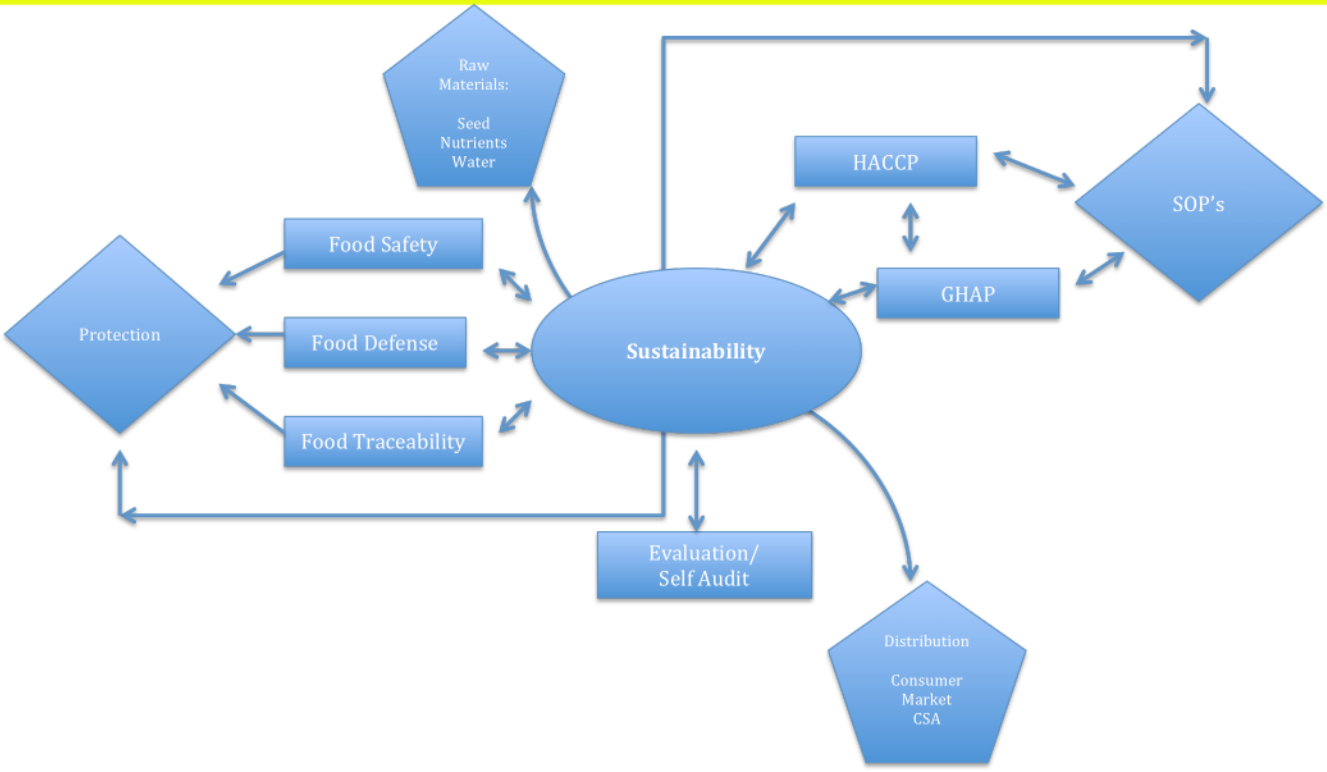
Small-Scale Hydroponic Greenhouse Production

Good Hydroponic Agricultural Practices (GHAP) Survival Model



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