

INTRODUCTION

Farming has been part of our lives for as long as there has been civilization. It has been the most essential embodiment of life for thousands of years. Unfortunately farming has lost its basics/roots to the modern era and its advancements. But the time has come back where due to the shortage of income and few modern overseers, farming is making a comeback. This definitely does not imply to the conventional farming rather than to a form of farming which had been abandoned for centuries known as "Aquaponics".

First reaction to the name of Aquaponics is people who have some knowledge jump to the conclusion of fish farming and the latter half has lost expressions on their faces. Aquaponics is a closed loop system where the fish waste water is used in the system to grow fruits and vegetables all year round in a control environment. The fish waste with the help of bacteria, is broken down to its basics of nutrients, nitrates, etc. which the roots absorb as a natural fertilizer hence leaving the water clean for the fish. One of the advantages of this system is that the amount of water used in conventional farming, only 5% of that water is required in Aquaponics system.

Is this type of farming new? This is the number one question asked by everyone that I or my company has promoted to. The answer is right in the middle of "Yes" and "No". It is hard to believe but nothing can be far from the truth. Even though this type of farming has been used recently from the last 10-12 years but the matter of fact is that it is long lost farming which has been revived or brought back to life. Oldest records of Aquaponics can be found in the records of Aztecs. Aztecs farmed in a system of agricultural islands known as Chimampas in their lakes.

All the way from Mexico to Asian rice paddies, this type of farming is shown in our history. In South China and Thailand, thousands of year's rice has been grown at the same time and place as fish. In Indonesia, modern day farmers are

making huge profits by converting to Minapadi/Minapati (Fish Rice Farming) system.

Functionality of Aquaponics has graduated too many levels and in my belief it is the next best solution for end of global famine. Why Aquaponics is the next best solution? Well the answer is as simple as its question. Aquaponics closed loop system makes it the best water conservative system available. Aquaponics does not require a lot of usage of electricity or biofuel generators to pull water from underground. For example in an acre of Aquaponics system, a seven horse power solar power system is more than sufficient. Fruits and vegetables today have been organized in two forms of organic and inorganic. The truth about this forms in my opinion is that how does the end user know who is telling the truth. From underdeveloped to developed markets consumers are cheated in the name of organic. This is where Aquaponics has a major role, as in the entire system no fertilizer, no pesticide or any form of chemicals are added. Aquaponics is also a fast pace growing system. According to many studies and researches it has been seen that due to its controlled environment and 24/7 nutrition provided, the growth is phenomenal. For example growth of lettuces is almost in a month, cucumber, tomato, bell peppers, zucchini are available in every two months. Another benefit of Aquaponics is that the yield produced is extremely high. Best example will be a company in New York that has converted 40 feet container to an Aquaponics farm that produces equivalent to five acres of green leafy vegetables. Even though Aquaponics is very economical for a farmer.

It is unfortunate to see or hear that there is a great shortage of water and food to go with it. Rich is getting richer and the poor are getting poorer, this philosophy has sunk deep within our mindset. Only few are able to breakthrough this mindset and succeed. Farming is becoming a big corporate machine that is only farming certain products that benefit them the most. Side effect of this is the usage of the soil nutrients, which is almost diminished, with alternate use of chemically induced fertilizers and pesticides, which in turn is harmful for humans. Children are getting weaker; their immune system is almost on the verge of collapsing. The children of

today have a higher rate of cancer and other serious diseases due to these fertilizers and pesticides. This does not imply in any way that we as adults are not facing the same issues.

As stated above even though farming has been the most valuable form of providing for the population, it has had certain side effects to our world's environment. To name some of these side effects have been deforestation, pollution, climate change, pollution, soil degradation, irrigation issues and general environmental degradation. To face some of these issues, and I repeat some, enhanced fertilizers and pesticides have been used in trying to go around irrigation and soil degradation issues. One of the major side effects that no one at the current moment is concerned over is this, "Loss of nutrient rich soil not only reduces productivity, but also results in silting of water bodies and streams and induces the release of soil carbon from particulate organic material, which contributes to global warming. Leaching of nitrates (NPK fertilizers) may cause ground-water pollution."

This quotation is from an Indian website that provides coaching to becoming the top government employees of India. Evidently we can easily say that Indians are not able to follow their own written words. Compared to the world's developing countries, India has the highest rejection rate of goods due to its toxicity. Latest reject was from Nepal, where the countries government had stopped entire import payload to be inspected from India and not to be cleared unless certificate of low levels of pesticides and harmful fertilizers is present, is not given to the farmers.

"Products such as mangoes, table grapes, okra, peanuts, curry leaves, chilies, shrimps, prawns, and tamarind have faced rejections and even bans in markets such as the US, Vietnam, EU, Saudi Arabia, Japan and Bhutan due to issues such as presence of higher than approved levels of chemical residues, and pest and bacterial infestation. In the short run, such rejections and bans can lead to financial losses while in the long run, exporters and farmers can lose market share to exporters from other countries that are able to meet the food safety and health standards of importing countries." [74]

This is just the example of one country that has a global impact, but even with their researchers and scientists providing them with guidance which is just simply being ignored by the government. Nonetheless we have to face facts that farming is the only way to sustain the growing population with farmers ready to quit and look for other ways of earning income. Hence Aquaponics where less water, space, and energy is required without having any serious or major side effects to the earth or its environment, comes into face value to solve most of the issues we face today.

In Aquaponics due to its various types of farming getting high yield and quality is not out of a normal farmers reach. In this system any person even without a farmer's background can also begin. In the recent years due to the high rise in urban farming, aquaponics hobbyists have also taken rise. It is all due to them that we can see the elimination of what can be grown in the system. Recently, rice has been successfully grown in aquaponics systems.

Roots of the aquaponics systems were laid out around 1000 A.D., by the Aztec people, living in the current Mexico area. Due to the mountainous region, farming required a little more out of the box thinking, which they successfully did, by starting aquaponics. Necessity is the mother of all inventions and so it was proven again this special point by our ancestors. Their location of forests and marshes made them innovate farming or that they had to face their own demise. Aztecs revolutionized farming as it has come to be known, without any machinery or fertilizers or pesticides. It was their innovation in farming that is one of the shining lights in the shortage of food, in the current times.

Little is known of the fact that the introduction of fish in this system was contributed by the South Chinese and Thailand people. Aztecs made the rafts for the shallow waters, but South Chinese and Thailand introduced the fish. Like everything farming was revolutionized again. Dedicated researchers from the New Alchemy Institute and North Carolina state are the reason behind the comeback of aquaponics. Again the need to produce more food with less land and minimum water was the reason for bringing back aquaponics by mixing the two, aquaculture with hydroponics. Major change in the aquaponics was to make it more sustainable

and for recycling itself, was the shift to large ponds. Both New Alchemy Institute and North Carolina State were able to set the pace and starting point for the aquaponics from the seventies.

During the research one of the major issues that arose was that of the accumulated fish waste. To resolve these issue bio-filters from plants to mechanical bio-filters for commercial use were implemented. University of the Virgin Islands has a research that is completely based on to make the aquaponics system more efficient for the public. Due to the shortage of land and natural resources, ways are being researched for making aquaponics, the farming of the future. Even though it is good, the researchers are considering this to end the food security in the world.

Even today, the population is confused between conventional farming and aquaponics. Compared to conventional farming, aquaponics has only three basic concepts that need to be had, plants, fish and bacteria.

If not understood, the basic function or need of aquaponics is to grow plants for consumption, while looking at the factors of reducing food shortages or to be able to make countries self-sustainable. Plants play an active role in the system by cleaning the water for the fish, without any technology involved. Plants are considered to be the natural filter that helps to keep the fish healthy and growing. The waste that was accumulated in the bottom, is toxic for the fish if not cleaned, that is where the plant takes little more crucial roots in the system. They help regulate the entire system.

The plants are inside a small net cup with substrates such as clay pellets and can be placed in any of the three systems. Once the plants have grown, the net pots can be removed and planted with new seedlings. From seeds to seedlings, they have to be grown separately, enough for them to have roots, which can absorb nitrates from the water and grow further. It is important to know that as long as the net pots are net style, as they allow the maximum water for the ample growth of the plant. Now the plants can be vegetables or fruits, it does not matter.

Fish is the aquaculture part of the aquaponics system. There is no other farming like aquaponics as a farmer is able to grow plants and also be able to farm fish. But the fish will only be able to properly survive if the plants are taken care of as well. It is the waste of the fish that actually starts the entire aquaponics system by providing the nutrients which will be absorbed by the plants. Now this is where information varies from place to place is that the number of fish in the tank. Usually it is said that for every pound of fish approx. two gallons of water is required but in actual practicing farmers it is said that for every pound five to six gallons of water is required.

A prospective farmer has to calculate how much will the fish end up weighing the time they want to dispose of it or sell it. Every fish has its own weight, like tilapia will grow 1-1.5 pounds, trout usually around a pound, etc. When the seedlings are bought, they usually are around 10-20 grams, so the amount of seedlings you have will be able to tell the amount of water needed. For e.g. trout will end up weighing around a pound when it is good to sell, so calculating for the future. If the tank is 1000 gallons, and the two gallon per pound is taken into consideration then you can add around 500 fish seedlings. Best is to have lower than what can fit just to be on the safe side. Tilapia is farmed most often due to the fact they are easy going and can live in high density population wise.

This is where almost every aquaponics beginner makes a mistake and loses their setup or the farm. Everyone just looks at the basics that plants and fish are all that is needed except the PVC pipes and other setup. But third part roll is the bacteria that are needed. Even though bacteria are everywhere but to settle down in the system takes time. For a normal setup without any external intervention it would take around 4-6 weeks, with the system running, before any fish or plants are placed. Bacteria are right in the middle of fish and plants. It is the bacteria's work that converts the fish waste into nutrients for the plants, which is known as nitrification.

Definition of nitrification is as follows:

“Nitrification is the process in which nitrogenous organic compounds are converted into nitrites and nitrates. The first step is the conversion of ammonia to nitrite. This is done by Nitrospira (in soil) and Nitrosococcus (in aquatic environments). The ammonia is oxidized by these bacteria into nitrites, which then flows to the second group of bacteria. Nitrobacteria (in soil) and Nitrococcus (in aquatic environments) further oxidize the nitrites into nitrates. Once converted into nitrates, the compounds are in a form that can be absorbed by the plants.”

Best place the bacteria will set hold and grow is the bio-filter that is in place. They will be present in the entire system, as the bacteria are in the air.

What is known in the system as secondary components are aerator, pipes, grow beds, lights and pumps. Every system requires the secondary components so the aquaponics system can work.

It is very unfortunate that the farmers of aquaponics and hydroponics have not been embraced by the society and even other organic soil farmers. USDA's organic seal has even been placed on certain items of the hydroponics produce, but the organic soil farmers are not welcoming the competition. Simple reason for that is both aquaponics and hydroponics are able to produce more in faster time, less space with better quality.

Many firms and Non-profits have already waged war on the soil less system growers. Such as the Center for Food and Safety, who have the tendency to take everyone to court, has already filed a 22 page petition to remove the current USDA approved hydroponics products and to place restrictions on further approvals permanently. Food safety is using the only tool they have in stock which is the soil part. Hydroponics and aquaponics do not require soil to grow vegetation and fruits, so they are not able to produce any soil samples for testing compliance. They are just pointing out one fact that Organics Food Production Act of 1990, states the soil samples to be provided and tested regularly by the agents of USDA by the regulations of OFPA.

Growers are being offered to get the organic certification only to provide soil samples. Regulations are being made and run by old school buffoons who consider

themselves the final say to our food security problem. The National Organic Standard Board (NOSB), which is the USDA's advisory board even, recommended that all soil less farmed products to be banned from organic product label. USDA's Agricultural Marketing Service is taking steps to resolve issues for organic certification for the soil less farmers.

Companies such as the CFS have made this an issue for debate for the last decade or so. It seems that they are just interested in promoting farmers that produce chemically enhanced farming products. It is of no shock as most of the agricultural industry is run by these soil farmers. CFS just simply wants a ban on organic products from the soil less farmers and to discredit them. According to CFS, soil less farmers is violating organic farming terms by not using or providing soil samples. “Mislabeling mega-hydroponics operations as ‘organic’ is contrary to the text and basic principles of the organic standards. Right now there is a pitched battle for the future of organic, and we stand with organic farmers and consumers who believe the label must retain its integrity” [29].

According to the petitioner, consumer pays extra for the label "Organic"; that it is healthy and environmentally friendly. It is a joke, as they are contradicting themselves but soil fewer farmers are a small part of this huge soil farming system.

This Certified Organic Label was started over 20 years ago and no changes have been made in the label. With this label the industry has grown over \$60 Billion and now the battle between MNC is being wage with the soil less environmental friendly farmers.

It is to everyone's surprise that USDA is still allowing soil less farmers to continue even though their own advisory is against them. Countries such as Canada and Mexico have already banned the soil less farmers as organics and Europe took away their certification by 2018.

“Corporate agribusiness lobbyists have been working to water down the organic standards for decades,” said Mark Kastel, executive director for the Cornucopia Institute. “In this case, the careful stewardship of soil fertility is not only a philosophical precept, but it’s also codified in federal law.”

Even though CFS has been successful in many of its worthless endeavors, their current petition will not go as far as they think it would. Few of the comments by USDA Director, on the petition against soil less farmers. "A settled issue. "Last year we issued an Organic Insider (email newsletter) that indicated that hydroponics had been allowed since the beginning of the program and that (they) are still allowed," Tucker said. "We consider that a settled issue." The Packer, the produce industry publication, reported Tucker's comments to the 2019 Global Organic Produce Expo. "There are some certifiers that certify hydroponics, and there are some that do not; they are all bound by a common set of regulations" [28].

Competition is not the only thing that is worrying the current soil farmers but also the loss of business, soil less farming causes to MNCs. Fertilizers and pesticides company will practically go bankrupt is soil less farming is ever made organic. The damage that is being caused by these MNCs is what world is not willing to see because they all are worried about reaching their minimum food quota for their populations.

In the beginning, in a conventional farming throughout the world we are faced with the problem of limitation from the land. As one of the major problems was the land was not able to provide enough for the population. Reason being the land needs to replenish its nutrients that are used during the farming season. To avoid such problems bi-farming was started where at first season one type of crop was produced and the second season of the year another crop was produced. For example, in India first rice was being farmed in first half by farmers and the other half sugarcane. From area to area or region to region the crop that was being produced was changed. It is just unfortunate that even today a so called developed country such as India is still stuck in this system.

As the entire Aquaponics system is in a controlled environment, it can be beneficial to many countries where weather conditions can become harsh. Desert either a cold harsh environments, with controlled environment government can cater to its population. In today's world food produced is frozen for future use to be

sold more expensively. Aquaponics system eliminates this bridge. If any basic farmers set up their farms for this system the turnaround including expansion of the farm can be at a fast rate. For example If we only consider fish as to consider the profit then in an acre, around eight big tanks are setup for fish which cater to 500 fishes each. The total of fish at the moment is 4000. If we take the female fishes by the minimal fish's number of 500 only, which are capable of 2000 eggs each in six month? We are looking at around 10, 00,000 fish eggs, which during a period of six month will gain weight of up to a kilogram and up. Let's presume that about half of the hatchlings have died during the six months of incubation period but even with five million fish are able to survive. Even with half of the fish surviving and sold to the market for the mere Rs.60 according to government rate, a farmer is still able to make Rs 3,00,00,000. The amount gains are still not close to the investment made for the entire acre of farming by only one third. At this point the profit from the vegetables and fruits is still not being considered. In a day for 1000 sq. ft. one person's effort needed is only about 15 minutes per day.

I am from India and it is well known for its doctors, engineers and IT personnel. But is it possible that India be known for something else. The least known fact about India is that even in the modern time over 40% of the country's income is from farming but did you also know or aware of that Indian farmed goods are banned in most countries due to their high usage of chemicals and pesticides.

Nevertheless Indian government has done absolutely nothing to educate or inform or train farmers for anything else. Last year Indian government forgave Rs 150 crores (Approx. \$ 24 Million), of agricultural loans, even though the farmer or big farmers per say are still in major profit. Just for votes for getting reelected, current and even the past governments, made life far more easy for the big farmers who are nothing short of being anything but crooks. It is not their fault as corruption in India is at its peak. Meanwhile the farmer that actually needs help that is provided by the government.

Nonstop you hear that our leader shouting about how they are looking for ways to help the farmers. How they can make farming more available for the youth? But as a person who has faced or dealt with the government, the words are just pathetic. Countries like India even though we show a face of advancement we are far from it. Government data is not only flawed but worth absolutely nothing. We are that far back in farming that hydroponics is still in the infant stages. Why we are showing a façade to the world is a joke.

In the records we are supposed to be the world's largest farm goods producers. That also goes for fish farming section, according to the World Fisheries Department, India is supposed to be the largest fish farmers in the world but to be honest we are nowhere near the top. We are actually at the bottom at the moment. The same government that wants to do some good is actually the ones stopping everyone from doing anything.

Even though hydroponics and aquaponics are almost the same, the difference is the fish farming that it invokes. Main part of plant growth is from the nutrients and nitrates which the hydroponics is adding separately in the water. How can food grown with the help of chemicals be organic? So called organic chemicals are made in the lab inside a factory. This is organic, private companies are making a fool of consumer and we are doing nothing about it.

In India people are asking for organic food only to be cheated by its own government and private companies. For e.g. Is of one of the Indian wholesale markets, potato from many regular farms but the wholesalers do is take half of the potatoes, clean them polish them and sell to the consumer in the name of organic. Worst of all consumers look at the packaging and pay double the amount. This battle to prove if the food is organic is impossible to know but nonetheless we care to the matter of zero about it.

We are growing sicker by the day only to prolong our lives with the help of medicines. There was a time In Indian history that there were no enhanced fertilizers or pesticides. Our great grandparents ate foods that in today's times are considered highly unhealthy because of its potency and drank homemade liquor

and still were healthy as an ox. We as their dependents in the name of advancements are as weak from the inside as can be. All the foods that are considered unhealthy were still there in old times, so what have changed.

The so called quality, which nowadays is considered to be the best as pointless as they can be. The oil used was supposedly of poor quality and definitely unhygienic but our ancestors were still healthy. We all see it but what are we doing. Let me inform everyone that nothing important only thing we have done is increase the demand of organic food. Like always demand is great but the supply is missing. This philosophy also implies to the northern countries where cold exists for six or more months.

Farming on the ground is done once or twice a year, this type of farming around the world known as conventional farming. Aquaponics is the solution as the entire farming is done in conventional farming. There are many places and people that have showed distaste or just pushed off the theory of aquaponics. Again I come back to India, where educated people have told is how wrong is to use the fish waste to make vegetables or fruits. At one point a person showed disgust as I had grown sacred plant Tulsi in the system.

Why the concept of using fish waste is so unthinkable but what is actually fertilizer? Not even 20-25 years back, fertilizer was the waste of animals, but in current times it is considered disgusting. In movie, Martian, a lone astronaut using his own waste and his crew to grow vegetables on another planet. Mindset of many Indians is as low as big as their bank accounts. For every successful business is an idea. All over the world aquaponics has been accepted to improve our world. Making a small farmer to a successful organic farmer. Unfortunately the Indian mind set needs to be changed to take something great, economical and environmentally friendly. Hopefully the coming generation will have a clear and open mind. This might be the technology that might bring the youth back into farming.

In the world today, there are massive food shortages that are being filled by inorganic materials hence making our health worse than ever. Today the ratio for a

person to have cancer is three to one. Which in terms of a la man is that out of three people, we all have 30% chances of anyone of us getting it? Still the governments are not taking action against fertilizer and other inorganic compound manufacturers.

Many steps can be taken to solve the food shortages in the world today but it is not profitable to the government or for the major investors. If in a 40 ft. container an individual can make over 5 acres of green leaves so you can imagine if the and he has off an acre.

It is no doubt that even today we are struggling with the food production, the methods used to food and the restrictions laid out by countries government. The food produced today in majority of the countries is not only harmful with loaded pesticides and unnatural fertilizers and chemicals. Many countries' governments have taken zero steps to solve this issue due to which the consequences faced by the world's different authorities are to ban their food products from being imported to their countries.

In modern day of Aquaponics farming everything grown is organic, economical, fast pace, high yielding and water conservative. Due to Aquaponics system being in a controlled environment almost any type of fruits and vegetables can be grown all year round. With so many benefits it is not hard to imagine that Aquaponics farming system will be the future.

The main aim of the thesis is to be able to create and manage a farm according to the external conditions of any country. Basically as long as the internal environment of an aquaponics system is controlled all that has to be checked is the external environment. In this paper, I will be discussing how to improve or start the self-sustainability of a farm. One of the best parts about an aquaponics farm it is not only easy to manage but also for an amateur to start an aquaponics farm successfully.

In this thesis, it will also be shown how to design, building and testing the system that will successfully run and later be self-sustainability.

CHAPTER 1
THEORETICAL AND METHODOLOGICAL FOUNDATIONS FOR
MANAGING DEVELOPMENT AND ENSURING THE COUNTRY'S FOOD
SECURITY

1.1. Food security of the country as a part of its economic policy

Before anything else, let us start from the basics. "Food security (Fig. 1. 1), as defined by the United Nations' Committee on World Food Security, means that all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their food preferences and dietary needs for an active and healthy life" [4].

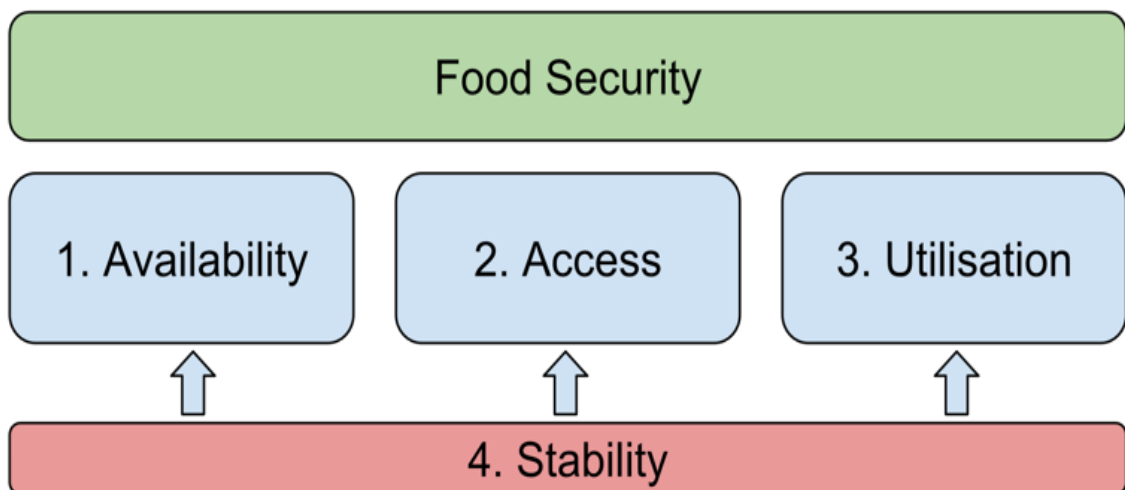


Fig. 1.1. The four components of food security

During the last century, the world has gone through major chaos that has rattled the every thread of life in this world. Multiple World Wars, rapid increase in population, major environmental issues (famine, climate change etc.) are naming the few in considerations of the stress on our food security. The rise of the issue of food security just didn't arise overnight. There was a lot of rejection by our leaders and their mismanagement that now we are on the verge of a serious problem with the world's food security. Serious thoughts, analysis and actions are needed to get

things under control like essential monitoring of the water issues, the manner in which land is being utilized, and food with its production, trade and prices control.

Food Security is not just a simple factor that now every country in the world is facing but properly initialized it can bring stability or utter chaos. There are certain factors or pillars or components that are essential for the stability that can be provided by the food security. They are:

Availability of Food. For us as humans to survive, certain amount of daily nutrition is required for our consumption. This Availability of food is vulnerable to production of what is grown? How much is grown? Where is it kept? Availability is also affected by the distribution, of where the food is? How will it be available? Where it will be available? Availability is also affected by the manner of exchange that is available? The amount of food that is available and which form, barter, trade, purchase or loans. In a state of emergency food security has to be able to have a great method of exchange for the population;

Accessibility of Food. Population of the world should be able to get the nutrition they need as well as the resources to be able to grow food for themselves and the community. Accessibility of food is vulnerable to affordability, as the population during crisis should be able to or have the ability to afford food, other requirements to be able to produce food. In the current times, underdeveloped countries and their governments have taken advantage of the food security and sold to the highest bidder and not to the starving population. Accessibility is also affected by the allocation of the food security by the governments and their local partners, to the population on how and in what terms. For e.g. In the matter of emergency, food can be allocated according to the populations household age or gender. Accessibility is also affected by the preference of what food will be consumed by the population. For e.g. if there is only meat available then vegetarians and their preferences will make them go hungry;

Utilization of Food. Population should be able to get the nutrition that they are able to consume in variety or different available types to be able to sustain themselves to be able to get back on their feet. If they are not able to get back on

their feet, like vitamins, nutrients etc., then even through diversity they will not be able to get over the limited food security available. Utilization is vulnerable to the health scenarios of the population. Certain population might need more nutrients due to their illness which will cause strain for others, such cases as diarrhea, cancer, pregnancy, etc. These considerations have to be taken accountable for as it has the ability to create a major chaos later. If the resources (wood, gas, water etc.) are not readily available or not even considered for a food security then there will be an issue for the preparing and consumption of the food. Food security or its safety can save the population in need or can destroy the made system entirely. The food should be monitored for no toxicity now or after packaging, the stored food should not be able to destroy itself like expiration, or other food borne diseases like salmonella;

Stability. During a crisis, food security and water will be the most essential thing after safety. So monitoring should be available on how to provide food to the population so they can maximize the rations available to them. So according to times patterns of distribution has to be changed, so other products can also be utilized.

The cultural adaptability or acceptability is an important factor to be considered in the food security. To be able to say that the security system is aware of the certain groups that have certain needs of its population, that is just not based on the nutritional values but also their cultural values, such as kosher, Hindu or Muslim meals. Even though this type of system in my opinion is not going to be effective or worth creating because in the time of crisis, food security should be able to give everyone the same to sustain themselves until things or scenarios are back in order.

For food security to be able to be assessed there are certain methods or ways that need to be checked. First one is the levels and its types. The scenario of food security is varied in different levels, not only regionally but also globally. Even if there is food security available regional or global level, it does not imply that the same will be available for individually or household wise. It also implies in vice

versa situation. Even with government having food security for its population, it does not imply that the entire population will be secured. There will always be factions that are insecure (Fig. 1. 2).

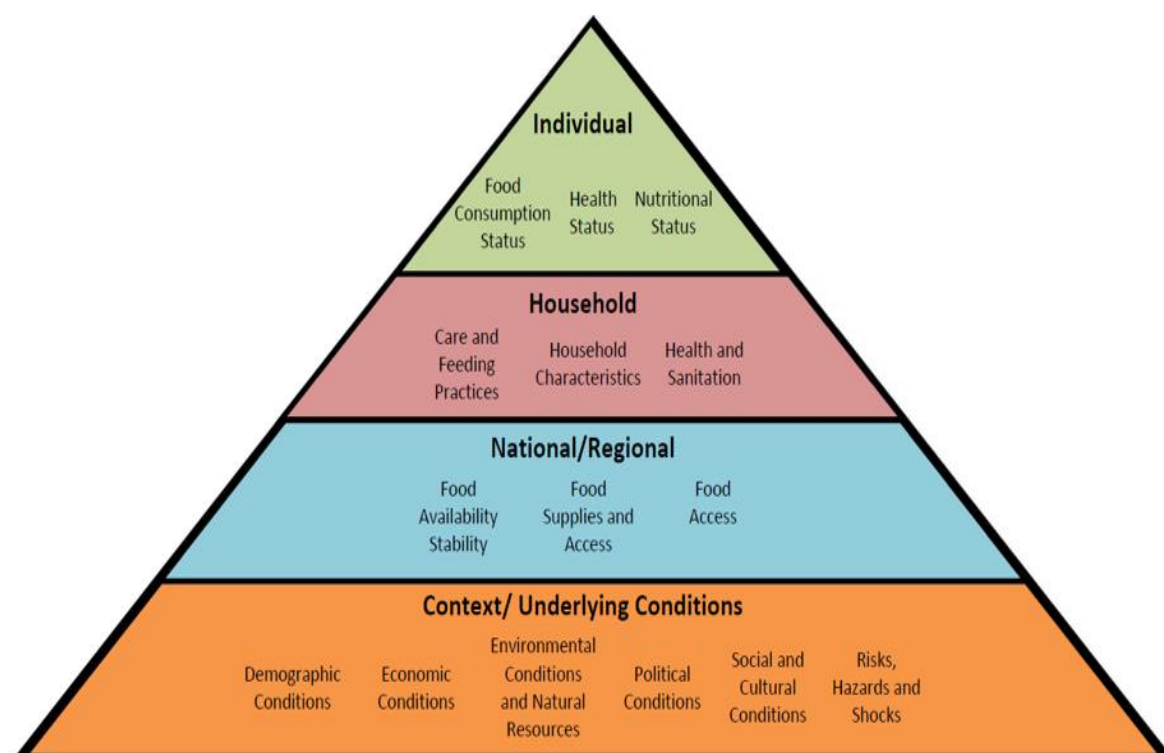


Fig. 1. 2. Levels and types of food security

There are three types of food insecurity which are available according to their time and manner. They are:

Chronic food insecurity. The cause of this suffering is not even meeting the minimum availability of food over a long period of time, which can be six months and over;

Transitory food insecurity. A sudden drop of the availability of food or being able to produce to fulfill the nutritional needs of the population is transitory food insecurity. It is based out of short term;

Seasonal Food Security. Just like as the season ends so does the fruits and vegetables that come along with them, it's basically a cyclic insecurity that population goes through every season.

Till today there is not even a single form or method that has been formulated to calculate all the dimensions of the insecurity. Nevertheless a single formula is

available by the FAO's Food Insecurity Experience Scale, which are based upon certain 8 questions. They are as follows with Fig. 1. 3:



Fig. 1. 3. A scale to measure food insecurity based on the Food Insecurity Experience Scale. Adapted from FAO [34].

"During the last 12 months, was there a time when, because of lack of money or other resources:

1. You were worried you would not have enough food to eat?
2. You were unable to eat healthy and nutritious food?
3. You ate only a few kinds of foods?
4. You had to skip a meal?
5. You ate less than you thought you should?
6. Your household ran out of food?
7. You were hungry but did not eat?
8. You went without eating for a whole day?

These questions compose a scale that covers a range of severity of food insecurity from mild to severe.

The Food and Agricultural Organization (FAO), is able to define food security as: "When all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life." In the world today, it is unfortunate to even say that out of every seven people one is suffering from malnutrition. One factor has to be taken that the reports done do not actually show the worst just enough to make it not look bad. Another fact that will shake to one's core is that according to the data that FAO has, there is plenty of food for everyone.

Countries where the population is getting ridiculously high, it is but obvious so does the demand of food for them to be sustained. Countries like India and China, where the population is at alarming levels of high, they have decided to poison their own population. India has implemented extreme dosages of chemically induced fertilizers and pesticides, while China has opted to make fake food productions, such as, plastic rice, chemically made cabbage, bacon made out of cardboard to fake eggs. All of their fake products are famously available to see online on YouTube and other media. It is estimated by FAO that by the year 2050, the food consumption compared to today will be doubled. Still no innovative procedures are being made to handle the scenario that will be the future end of the civilizations (Fig. 1. 4).

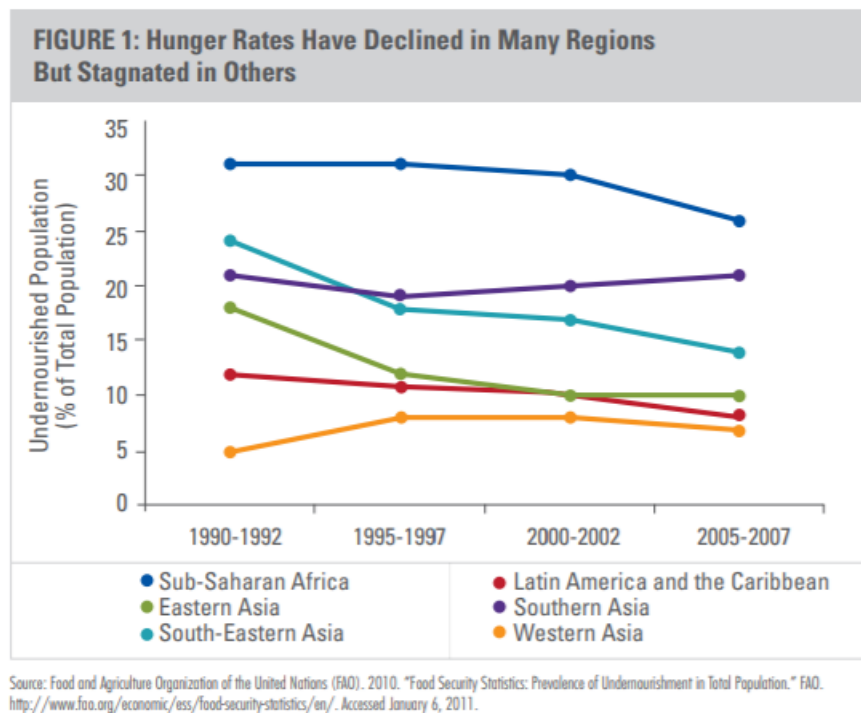


Fig.1. 4. Hunger Rates in the World

When the numbers of 1 person in 7 is considered it doesn't look big but the actual figures of 1 billion makes a nice ring to one's ears. It's not hard to imagine that which countries are having the worst food securities or malnourished issues, they are, Bangladesh, China, India, Pakistan, Ethiopia, Indonesia and the Republic of Congo. They are top seven contenders that contribute to the world's two thirds malnourished population. The sudden change in climate and environmental

conditions has caused the rise of food security and at the same time in other regions the adverse effects. The bad environmental issues with climate changes seem to be having the worst in Asia and Africa.

The countries that are leaning towards the food security unfortunately also have the highest rate of population growth. With the projections from 2050 that the sub Saharan African population will be doubled even if the fertility rate drops by then. Even now the 1 out of 4 people in this area are malnourished. To make matters worse due to their climate conditions, farming is becoming as scarce as it can be.

World has to come together and face this Food Security head on, with new policies and aggressive moves. Hard hit nations with highest risk of food security are needed to be addressed first while steps to stop any food security in other countries as well. Investment to the rural sector has declined so that needs to be revived and at the same time bringing brand new methods to resolve the future food security problem. Innovative methods are needed to be research and the current ones like aquaponics to be given wider bandwidth in the current drastic food security times.

Internal and external factors, domestic and international policies, make it impossible to maintain the current policies that are being used for the food security. Any sudden changes to the policy by the government can do serious damage to the food security for the citizens.

Since the middle of 1970's, the underdeveloped countries have faced the worst part in sustaining food security. Due to which all the budgets and accounts that had been setup, have had major imbalances. As there was regular instability in the international market in oil prices, most of the underdeveloped countries just borrowed from the international community to correct their imbalances. All the governments were in the thoughts that their economies would be able to take the shocks and correct the imbalances that were their automatically. Governments that were able to change their policy structures were able to bear the brunt of the instability and the countries that did not do any changes went into further debts and

instability of all securities. Imbalances are thought to be caused by macroeconomic shocks or by the delusional domestic policies that the government is not able to gain a perfect balance of full employment and price stability. The governments that are not able to make the balance usually end of running high budget deficits. What these governments not tend to realize is that all the major economic shocks are sourced both internally and externally. For the past few decades, many of the under developed countries have been facing structural imbalances of one form or the other.

No doubt that these poor countries trading patterns have been disturbed by the influence of external macroeconomic shocks. In the mid 1970's, the entire world's economy had shifted due to the high rise of petrol prices. Economic growth and the countries market functions were severely disrupted due to the domestic shocks as well. In many countries in the world factors like, drought was able to further destroy poor economies, Civil unrest or wars were able to cause major refugees flux, greed in the politicians was even able to help change the rich entrepreneurs to take advantage of imports rather than working on the countries own resources. This has been the cause bureaucracies to flourish, leaving the rich to richer and poor to poorest.

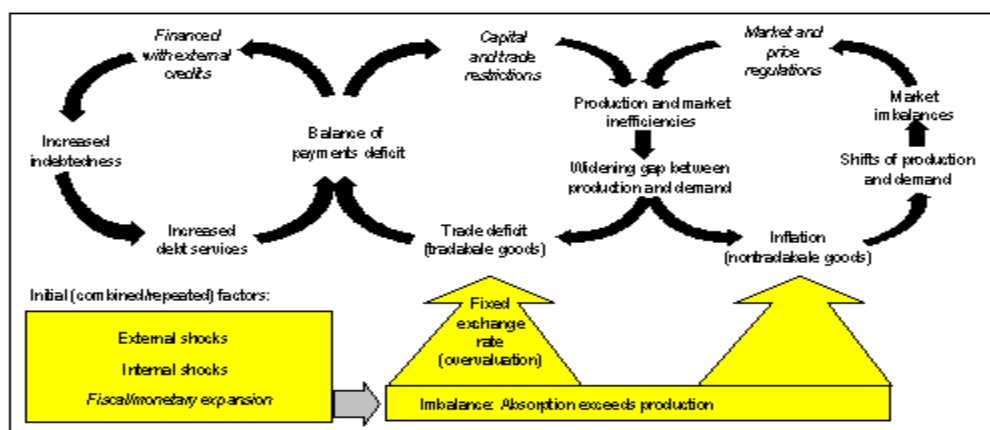


Fig. 1.5. Countries Inner Workings leading to loss in Food Security.

In the path of incorrect policies, both the internal and external shocks and imbalances in foreigner trade, has been able to expose the developing countries to

worst case scenario of cyclone of growing internal and external macroeconomic disequilibrium.

It is not that, the governments of the underdeveloped countries did not do anything to work around the problem. Many products, market and prices regulating measures were taken, such as the currency exchange, restrictions on trading, consumer or its input prices, marketing channels were monitored etc. Production and market inefficiency were compounded due to these policies and also resulting in further structural imbalances from the production side. This growing structural imbalance can be shown the figure below as when set to motion (Tabl. 1.1).

Tabl. 1.1

Different Countries National and International Level Debt

	Total external debt as a percentage of GNP			Total debt service as a percentage of exports of goods and services		
	1970	1980	1990	1970	1980	1990
Low- and middle income economies	12.5	26.6	40.2	10.3	20.5	19.4
Sub-Saharan-Africa	12.5	28.5	109.4	5.3	10.9	19.3
East Asia	15.0	16.8	26.9	5.9	13.5	14.6
South Asia	14.3	17.3	30.7	18.1	12.2	25.9
Europe, M. East, & N. Africa	13.6	31.1	52.6	10.2	16.4	24.4
Latin America & Caribbean	10.5	35.2	41.6	13.1	37.3	25.0
Severely indebted	10.2	34.4	46.4	12.0	35.1	25.3

Source: World Bank, World Development Report, various issues.

Due to the structural downfalls in many of the countries in the world, food security policies were put on hold or just ignored in the mist of imbalances and self-preservation. As the economies of these countries are stabilizing, they have been able to realize the lack food security policy to the next pending doom of food and water shortages that we will be facing

1.2. Managing the development of the country's food security

In the earlier times or to be exact 19th century and before, the population of a country was based on certain three factors, which were war, famine and epidemics that in turn was direct indications to the food production. It is well known fact that until the 20th century farming had been the main source of food not only for developing countries but also for the under developed countries. As long as history recalls, food security has always been the major form of stability for the population and the governments that had control over the population.

In 1974, the first ever World Food Conference, was held to address the new issue that the entire humans were about to face in the near future, food security. Food security was not limited to just plain old underdeveloped countries, its actual fires would take the developed countries first. Reason was no other then that their complete dependence to under developed countries and their resources that they were stealing or manipulating. To officially address this issue for the world in 1975 the World Food Security Company (FSC) was created.

To address this issue, most of the governments had set up a food security departments that were supposed to handle this issue for the present and future. As we all can see the underdeveloped countries were being ripped off by their own politicians leaving their population starving and exporting most of the goods. An example for this is no better than India, a global fiasco that everyone considers developed. The national surveys, stocks, supply all that are mentioned are false and flawed. Unfortunately this does not just include India as an underdeveloped country. Major developed countries had their corporations that were going for only the profitable foods, leaving the local farmers to take up the slack. High end up making them use chemically induced pesticides and fertilizers for the growing population.

Due to the economic conditions, most of the underdeveloped countries also had their priorities in different directions. Greed was a major factor in misusing the food securities that were setup for the countries welfare end up going to their own. Monitoring systems were made by the FSC to control the distribution and control of the food supplies for the food security. Grain is the international FSC currency

as it is able to feed people. Throughout the years there has been a disturbing decline in the grain supplies in the world, which in turn again has reduced the aid to other countries that require immediate assistance from the international food security.

If the numbers of farmers in the world is to be seen then from 1990's till now we have lost one third of them. Even though the decline of farmers is still there from 1269 million to 1134 million, the number is estimated to keep on declining. There have been major developments worldwide as well as the satellites to scale up rain fed nations and their vegetation's to be sold to international markets for vast profits rather than to nations with food security. Even with globalization of technologies, food security systems have been upgraded and with food security now under observance is coming back into the limelight thanks to the technologies such as the Internet, fax, satellite telephone, etc. and management (computers) systems.

As the population of the world has increased immensely, with natural selection of other species are coming to an end. World leaders are coming to the point where they are realizing the fact that humans actually are in need of saving. Food security over the last few years have become as big as global warming for that they all came together to start the "FIVIMS initiative", the secretariat of which is based at FAO. The aim of the FIVIMS is to improve information on food-insecure and vulnerable people at national and international levels.

"There are many advantages of the FIVIMS system which are:

it is in keeping with the globalization of information;

it is integrated into the monitoring framework of the World Food Summit;

it capitalizes on twenty years of worldwide experience by international specialists, national managers and development partners in the development of a simple instrument, suited to changing contexts, able to give an objective view of the evolving food security situation in a country and provide a simple means of analyzing this evolution;

it can supply the major global information networks (GIEWS, RESAL, FEWS, VAM, etc.) with the information they need; in particular, it enables international organizations to monitor the changing numbers and characteristics of undernourished groups more closely, and to target aid and international assistance regarding food security more accurately;

It is involved in the major humanitarian initiatives coordinated by the United Nations: the fight against poverty and inequality, better governance, disaster limitation, etc.;

It has a fundamental role to play in the gradual move away from direct funding for the national information systems set up by donors in the 1980s to meet their information needs regarding humanitarian intervention;

Above all, it enables both national and regional officers to take direct action regarding their food security and to meet the demand expressed by government representatives, as well as CSOs and the private sector" [59].

Due to the modern technologies that the food industry has made during these years has made it less reliant on those three factors. But that does not imply that any other factors that have not arisen threatening the food security now not only of the country but the world itself.

Rather than what people in the world might think but economy has an effect on the workings of Food Security. Food security in the world is affected in two ways, first, is the loss of land which directly connects with loss of food production and the second, is the loss or decline of personal income, which evidently affects the food demand.

IFPRI issued an article on the World Food Day, which is October 16, that to be able to have sustainable economic growth for any country in the world, food security has to be present. In the absence of food security, economic growth will have to face further hassles, increased costs etc. For the underdeveloped countries to be able to achieve sustainable growth in their economy, they are being faced with high levels of malnutrition and poverty. Underdeveloped countries governments are forced to invest their resources for short term to bring down the

high levels of poverty, malnutrition and inequality. According to United Nations FAO, malnutrition can lead to a loss in GDP of a country by 4-5 percent, which for an underdeveloped country can be as good as 25% loss.

Substantial benefits are there for a country's population but also foundation for obtaining sustainable economic growth, with the presence of food security. It is the single most important issue that this sector not be included with others but to be considered as a single entity in the government. All the government sectors should be able to contribute and coordinate to stabilize the food security sector, such as the agricultural sector, finance sector, infrastructure sectors, just naming a few.

Even though economic growth plays an important role in economic growth, it does not solve the age old problem of malnutrition. In the latest publications of a leading scientific journal in the field of global health and nutrition, The Lancet, "We learn that a 10 percent increase in economic growth reduces chronic malnutrition by only 6 percent. This asymmetry illustrates that economic growth by itself won't resolve the problem of chronic malnutrition, which is a key variable in any food security strategy."

For every action there is an equal or opposite reaction, and economic growth is no different, as it does have negative effects as well. According to The Lancet, "For example, a 10 percent increase in economic growth is correlated with a 7 percent increase in obesity among women. This shows the critical nature of targeting tax and fiscal instruments to optimize the consumption of nutritious foods and minimize the use of foods that cause obesity, another common form of malnutrition." These findings are not just taken from somewhere; these are findings from years of research in different countries. They also prove that drastic measures to change our policies on economic growth which seem to be obsolete and to sincerely strategize food security.

Serious effects of not being able to attain stability and food security in a country can cause the government to have an increase in public spending, which in turn will raise the government's fiscal costs. Another effect will be the long term disabled government and economic growth. Therefore, it shows that the long and

short term growth in economy is an integral part and it should be able to set itself in the government as an independent sector, with all the other sectors giving a helping hand.

1.3. Innovative approaches to ensuring the food security of the country

“Aquaponics (ækwəpɒnɪks) refers to any system that combines conventional aquaculture (raising aquatic animals such as snails, fish, crayfish or prawns in tanks) with hydroponics (cultivating plants in water) in a symbiotic environment. In normal aquaculture, excretions from the animals being raised can accumulate in the water, increasing toxicity. In an aquaponics system, water from an aquaculture system is fed to a hydroponic system where the by-products are broken down by nitrifying bacteria initially into nitrites and subsequently into nitrates that are utilized by the plants as nutrients. Then, the water is recirculated back to the aquaculture system” [13].

In simple way it can be described also a closed loop system which is soil less, using fish water in a circulatory manner, where the roots take the nutrients and nitrates from the water and returning it to the fish tank clean. Figure in Appendix 1 shows basic explanation of this system.

Aquaponics is in my point of view the solution to all the food problems that we and the farmers are facing today. Even though we are producing over float beds or using clay pebbles it still copies the entire essential parts of conventional farming minus the negative effects.

Aquaponics main role is carried out by the fish and the food that is provided to them. It is a well-known fact in the fish farming industry that 50% of the fish waste is taken out by the fish through their gills in the form of ammonia. The other 50% is excreted in the form of hard waste which once sent to the filter with bacteria breaks down the ammonia to nutrients and nitrates. The filter is there with bacteria to convert ammonia otherwise high contents of ammonia will not only kill the fish but also the plants as ammonia is considered very toxic.

In the filter and eventually all around the tanks the bacteria forms and is an integral clog in the machine as its sole job at that point is to break down ammonia. Better the breakdown of ammonia it is better for the plants as the roots take in the nutrients and nitrates for growth. This bacteria is considered good for the aquaponics system and will naturally grow as soon as the ammonia is there in the system.

As it is a closed loop system, not only plants are to be taken care of but also the fish and the bacteria. They all rely on each other to survive, so maintenance and monitoring of the aquaponics system is very important. Eventually the system gets a kick start and mostly the fish and plants will be left to be monitored in a perfect system. As the system is in a loop 24/7, plants are able to get nutrients and nitrates nonstop as well, leading it to grow faster and healthier. Due to the fact that we are not using soil or synthetic fertilizer and no pesticide as it is in closed environment, the crop produced is completely organic and healthy for any age.

Throughout the recent decades, Industrial farming in major countries has been the primary form of farming. Industrial farming as defined by Wikipedia is:

"Intensive animal farming or industrial livestock production, also known as factory farming, is a production approach towards farm animals in order to maximize production output, while minimizing production costs. Intensive farming refers to animal husbandry, the keeping of livestock such as cattle, poultry, and fish at higher stocking densities than is usually the case with other forms of animal agriculture—a practice typical in industrial farming by agribusinesses. The main products of this industry are meat, milk and eggs for human consumption. There are issues regarding whether factory farming is sustainable or ethical."

In simple words it is just mass production of any consumer products without concerning about the ramifications of the soil, environmentally, socially or any factors, year after year. Today everything is concerned or connected with a corporation and all their concerns is to gain profitably at any cost. These industrial farmers to keep up with their profit margins have or are using great amounts of fertilizers, pesticides, which are enhanced with the help of chemicals, resulting in

the destruction of all the three nature elements, earth, air, water resulting in change in our climate.

Advocates to the farmers and their corporations have given defenses that due to their way of farming there has been increase in food production and disease control, while their rival advocates have made claims that it is not only major health risk but also falling in the category of animal cruelty, plus other risks. This is where sustainable farming comes in place to help both sides.

"Sustainable agriculture" is farming in sustainable ways (meeting society's food and textile needs in the present without compromising the ability of future generations to meet their own needs) based on an understanding of ecosystem services, the study of relationships between organisms and their environment. It is a long-term methodological structure that incorporates profit, environmental stewardship, fairness, health, business and familial aspects on a farm setting. It is defined by 3 integral aspects which are: economic profit, environmental stewardship and social responsibility. Sustainability focuses on the business process and practice of a farm in general, rather than a specific agricultural product. The integrated economic, environmental, and social principles are incorporated into a "triple bottom line" (TBL); when the general impacts of the farm are assessed. Unlike a traditional approach where the profit-margin is the single major factor; Agriculture sustainability is also involved with the social and environmental factors"[13].

It just seems that our ancestors around the world were just too smart who were able to understand that working with nature yields the best result and in time we have lost not only our ways but due to making high profits lost the ways of sustainability. Our planet is in dire need of help because of our certain ways that has not only destroyed the planet but also its environment. So we have to care about our planet where it can also help in sustainability but also provide good organic food and financially viable. Some of the major concerns around the world are possible with the help of aquaponics

More than 70% of the world is covered with water but the least known fact is that only 2.5% of it is freshwater and out of even that only 1% of it is accessible. Even in the future is not seeable that today itself water is reaching the point of scarcity. Soon there will be the time when water's value be as good as gold. In over 130 major countries, 70% of the freshwater is consumed by the farmers, leaving one fifth of the world's population with inadequate water to even drink according to United Nations report. If we take away the water from farmers then we have no food for the population. What makes matters worse is that out of the 70% water used by the farmers, 60% of it is wasted via runoff into waterways or evapotranspiration.

As aquaponics farming is a closed looped soil less system, it is a great water conservative farming. Concerning with the traditional farming, aquaponics farming only requires 90% of the water used. It is just imaginable how much water wastage can be stopped by adopting this type of farming.

Urban agriculture can be simply defined as someone raising plants or animals in the cities. Urban agriculture is not something that is from the ancient times, nor has it been brought by the rural immigrants. It has been there as long as the urban cities have existed and has been an important clog to the urban system. Lately it can be seen that the urban farming has increased due to the increase in health and food quality concerns.

Urbanization has been increasing for the last couple of decades with it also increase in urban farming. It is estimated that by the year 2020, 75% of the world's population would be known as the urban dwellers, in the second and third world countries in Africa, Asia and Latin America. It is also estimated that 85% of the poor from Latin America and 40%-45% will be living around or in the cities. Turning the already packed cities into mega cities, leaving the agricultural land into waste land, as there will be no usage.

Government and many other organizations are supporting urban farming as there are various benefits, such as:

Contributions to urban food security and nutrition. Urban farming is the most valuable asset urban cities have in hand. Urban farming is due to the lack of food availability or accessibility, high priced food products etc. Today many of the urban farmers are doing this due to save basic costs in food as well as growth as a hobby. According to the World Bank, over 50% of the poor will be residing in the cities and UNDP 1996 & FAO 1999, also estimates that 200 million city dwellers contribute to the local markets, as well as that around 800 million city dwellers are initiated in one form or another of farming;

Economic Impact. In under developed countries growing your own food is a major source for saving household income and to be able to meet the basic nutritional value. Poor people usually spend 50-70% of their income for food, so growing their own saves them funds for other uses. Urban agriculture stimulates the growth and development of micro enterprises. Many of the household made items such as jam, yoghurt to milk, chicken to eggs, etc. are easily sold at the local shop or farmers market. The local municipality and the other forms of governments need to help these local farmers and help them allocate with the help of places to sell their products such as farmers markets. In South America, Ecuador, has taken initiative to help urban growers with places where they can sell their produce. Whatever is left or not sold is collected by a local women's group who are able to compost them and reuse them at their own farms;

Social Impacts. One of the urban farming functions can be to improve poverty and social integration in the cities. Urban farming also promotes the females contribution in the community. There are many institutions and NGOs who are there to support women organizations, poor, elderly people, orphans, to help them integrate them into society. Urban farming helps not only the citizens but also can be used for education for the youth;

Contributions to Urban Ecology. In the urban cities, disposal of waste that is created as the cities grow from time to time is hard to dispose of. Urban farming can utilize these waste resources for their own benefits, reducing the carbon print in the world. In many countries there cities have government organizations, which

collect the organic waste to be converted to animal feed but can also be used for farmers who utilize organic waste. Quality waste compost has been in good demand as the price it brings is good and at the same time farmers prefer this waste as it allows them room to use less of chemically induced fertilizers, which in turn also allows for less contamination of underground water. Organic compost is another form of income for the poor.

Waste water is also a good source for farmers for nutrients when there is scarcity or the cost is high. It does not imply that the usage of waste water can be useful 100%, as it does need proper guidance and supervision otherwise it can lead to health and environmental problems. Government needs to teach the farmers to use the waste water properly with varieties of classes and seminars. There are various technologies such as hydroponics, organoponics, drip irrigation, etc. that reduces the use of water and great for urban farmers where the size of location matters.

Another major advantage of urban farming is the benefits that are the most needed in the cities. Due to the farming the green culture increases which can help bring down the pollution and CO₂ levels in the cities. Free land has been converted for the use for dumping wastes that government ignores to collect. Second and third world countries this is one of the major problems causing immense diseases, especially in India where black plague still exists.

CHAPTER 2

RESEARCH AND ASSESSMENT OF THE REAL STATE OF MANAGEMENT OF FOOD SECURITY IN INDIA

2.1. Analysis of the state of food security in India

When the population is able to avail the availability, accessibility and affordability of food is known as Food Security. This does not imply to the fact that they only get two square meals. Factors that are dependent on food security are: the Public Distribution System. The government acts at times when this security is threatened. Mainly, India's food security is known as the Public Distribution System (PDS). It is not just recently created department but known as the green revolution, which was initiated in the 1960's, that was aimed to transform the food security of India. In spite the well-known fact that India's population has doubled from the time of initiation of the program. India has been able to increase the grain productions by 300%, and according to the government data over 50% of the food insecurity and poverty has been reduced, which a fine achievement is shown in the government data. But only as a citizen of India am I aware of the real situation of our country. It is even said in the reports that India has achieved the phenomenon task of self-sufficiency at the macro level.

PDS was created under the joint venture of the government of India under the supervision of the Ministry of Consumer Affairs, Food, and Public Distribution and under the management of the state governments jointly. Their job is to provide subsidies to the food and non-food items to the poor. This program was launched right after the independence from the British in 1947, with food and commodities such as grain, wheat, rice , sugar and kerosene, through a chain of semi-private shops across India. Till this date, the same PDS system has been maintained by the government, literally the same as 1947 since its conception.

In a country like India where one third of the population is under the poverty line and over half of all the children are malnourished in some form or the other,

food security is still to be taken seriously. In the last few decades in India, there have been issues in the rise for the food security.

"They are: economic liberalization in the 1990s and its impact on agriculture and food security; establishment of WTO: particularly the Agreement on Agriculture (AoA) under it; challenges of climate change; crisis of the three Fs, viz., food prices, fuel prices, and financial crisis; the phenomenon of hunger amidst plenty, i.e., accumulation of stocks in the early years of this decade and in 2008-09 along with high levels of poverty; introduction of targeting in the Public Distribution System (PDS) for the first time in the 1990s; right to Food' campaign for improving food security in the country and the Supreme Court Orders on mid-day meal schemes; proposal for National Food Security Law (Right to Food); and monitorable targets under the Tenth and Eleventh Five Year Plans similar to the Millennium Development Goals (MDGs) on poverty and women and child nutrition" [9].

AS it has been read so far that food security is a worldwide issue and so far many countries have an established food security system only few are actually managing it. Just during the past two years alone, we have seen, mother earth creating havoc over India with epic floods. Many in the world are not even aware that a couple of years back, severe weather conditions and earthquakes entire mountain cities have vanished in areas of Uttarakhand. Countless lives have been lost and till today no real numbers of dead bodies have been revealed. In these situations is where food security of the country comes to the rescue of the population involved. India told the international community that India does not require help from them and they are able to manage, it was all a lie.

When the government is known corrupt culprits either be it BJP or the Congress, food security will only show up in the books. Earlier, it had come over the news that people are dying of hunger but the Congress government did not take any actions, even though we had overfill. Then why did the population did not get any help, the grain was exported for profits and the rest to the alcohol barons who need grains to make their product. Kerala floods were the worst in the history of

India and still the central government now BJP offered no help. The state chief minister was literally begging everywhere to give donations to help the population. If there was actually food security as they so claim since 1947, then Kerala and now again Uttarakhand populations would not die of malnutrition.

Concept in food security that a person needs to understand is that, food is just part of the food security. It also involves many different sectors such as finance, which is also essential in rebuilding. Programs are said to be implemented but hardly anyone see them, as we are not part of the so called government. If there were any securities in place then the population would not suffer or the economy growth. It is just sad to even think that people, who we actually vote to protect us for their own greed, will take us for a ride. Nevertheless I will be providing details about the India's food security, as per the government written facts.

In the current times, India is now considered a developed country, with a strong food security system, at least at the macro level. Indian population today is suffering from three different ways of malnutrition, and national and international surveys with many studies have pointed out to this very issue. This issue seems to be from time to time has been ignored but reports come out as if they have been. There is an example, which is based on the National Family Health Survey (2005-06), one third of the married women population in India, BMI(Body Mass Index), is less than normal and the same is also to be said from 28% of the men.

As discussed earlier, malnutrition is due to multiple factors in the economic growth, in which food security lies right in the middle of it. Food security in India refers itself to the national security and fulfillment of individual needs. Even though individual needs are considered in food security, major concentration and concern is for the wellbeing of the household.

Beginning of the National Food Security Mission (NFSM) is considered to be the best thing that has happened to them. NFSM has laid foundation to the growth of the production of cereals and pulses, which have been able to show with support the increase that is needed. But none has taken into consideration how they have been able to achieve it. Widespread usage of chemically induced fertilizers and

pesticides, has definitely given the boost needed to supply and cover the food security but at what cost. This production is nothing less than poison to the population, since the 1970's there have been a decrease in the health of the population and increase in deadly diseases such as cancer. Being the reason why, Indian agro products are banned in most of the world.

To ensure that the food security is running smoothly, one of the major integral parts of maintaining this is the Minimum Support Price/Procurement Price(MSP). Example of MSP is provided in Appendix B.

“Minimum Support Price is the price at which the government purchases crops from the farmers, whatever may be the price for the crops. Minimum Support Price is an important part of India's agricultural price policy" [11].

Government of India, answer to food security was MSP, which was to protect farmers internally, so no sharp prices downfall would affect them. The prices set by the government were guaranteed, but in the years after hardly any major farmers used it until recently when government prices were marked higher than the private market. There were two types of prices that were monitored by the government: minimum Support Prices; procurement Prices.

MSP was to assure and insure the farmers that they will get the set price for the farm products. Procurement prices were their so the private and public agencies could buy the farm products like FCI, through PDS. There were always two types which came to known as government prices and the other private prices. Farmers were obviously more interested in private as they gain more and when they couldn't get, they would create hassles for the government to do so. Since the middle of 1970's, this is the way of the food security of India.

MSP system basically provides massive incentives to the farmers who are able to go higher than the set production levels. Evidently the incentives to be able to mass produce for the farmers is known to be very good as long as they are following the programme which is set by the PDS and other relative programmes.

Objectives have been set for MSP, that are:

To be able to provide a stable price for the farmers, who in turn will try to produce more for better incentives;

Best availability of the food to its population;

To be able to change or evolve the production, so that it is in line with the economy.

Just after the independence, in 1965, MSP was used to meet the objectives of the Indian agricultural Price policy. Since then it has been used to monitor and maintain those objectives relate to the agricultural policy.

With the recommendations of the Commission for Agricultural Cost and Prices (CACP), The Cabinet Committees on Economic Affairs (CCEA), Government of India, is able to MSP for the different types of agricultural products. Many factors are taken into consideration for attaining the minimum prices for the commission.

"The following factors are: cost of production; changes in input prices; input-output price parity; trends in market prices; demand and supply; inter-crop price parity; effect on industrial cost structure; effect on cost of living; effect on general price level; international price situation; parity between prices paid and prices received by the farmers; effect on issue prices and implications for subsidy.

The Commission makes use of both micro-level data and aggregates at the level of district, state and the country. The information/data used by the Commission, inter-alia include the following : cost of cultivation per hectare and structure of costs in various regions of the country and changes there in; cost of production per quintal in various regions of the country and changes therein; prices of various inputs and changes therein; market prices of products and changes therein; prices of commodities sold by the farmers and of those purchased by them and changes therein; supply related information - area, yield and production, imports, exports and domestic availability and stocks with the Government/public agencies or industry; demand related information - total and per capita consumption, trends and capacity of the processing industry; prices in the international market and changes therein, demand and supply situation in the world

market; prices of the derivatives of the farm products such as sugar, jaggery, jute goods, edible/non-edible oils and cotton yarn and changes therein; cost of processing of agricultural products and changes therein; cost of marketing - storage, transportation, processing, marketing services, taxes/fees and margins retained by market functionaries; and macro-economic variables such as general level of prices, consumer price indices and those reflecting monetary and fiscal factors. Government has announced its historic decision to fix MSP at a level of at least 150 per cent of the cost of production for kharif crops 2018-2019 [12].

Unlike procurement prices, MSP's, only protects the mandated crops and fair and remunerative price (FRP) for sugarcane.

“The mandated crops are 14 crops of the kharif season, 6 rabi crops and two other commercial crops. In addition, the MSPs of toria and de-husked coconut are fixed on the basis of the MSPs of rapeseed/mustard and copra, respectively. The list of crops are as follows: cereals (7) - paddy, wheat, barley, jowar, bajra, maize and ragi; pulses (5) - gram, arhar/tur, moong, urad and lentil; oilseeds (8) - groundnut, rapeseed/mustard, toria, soyabean, sunflower seed, sesamum, safflower seed and nigerseed; raw cotton; raw jute; copra; de-husked coconut; sugarcane (Fair and remunerative price); virginia flu cured (VFC) tobacco" [12].

Appendix B for Minimum Support Price for 2019-2020 MSP of Kharif Crops for 2018-19 Season applicable is applicable from 1 September 2019. The Fair and Remunerative Price payable by sugar mills for 2019-20 sugar season has been fixed at Rs.275 per quintal for a basic recovery rate of 10%; providing a premium of Rs. 2.75/qtl for each 0.1 % increase in recovery over and above 10%. The cost of production of sugarcane for sugar season is Rs. 155 per quintal.

The FRP so approved shall be applicable for purchase of sugarcane from the farmers in the sugar season 2019-20 (starting w.e.f. 1st October, 2019) by the sugar mills.

The Procurement Prices are the prices at which the government purchases the production straight from the manufacturers, so that can be used for keeping and maintaining the reserves or the public distribution system (PDS). With the

assistance of the Commission of Agricultural costs and Prices, the government set up prices before the harvest even begins. The prices that are set are usually higher than the MSP but lower than private market prices or the prevailing market prices.

Procurement prices are set before the season or seeding is done. In turn, the procurement price will become the base price by which the government will purchase all the production offered for sale by the manufacturers. Another side of the coin is that the procurement prices become the MSP, due to the fact that government is bound as well as obligated to buy all the production offered by the manufacturers.

Basis of Procurement Prices is that:

under the supervision of Price Support, the procurement prices is mainly to ensure that the farmers get the best price for their produce, which in turn promises better incentives for mass productions;

This process not only adds to the food security of the country but also maintains the prices under check so no individual or corporation can take advantage;

Many factors and costs of different varieties of agricultural products are taken into consideration, so they are able to provide farmers with sufficient pricing.

2.2. Features of food security management as part of the economic policy of India

Since the mid 1970's, many major nutritional programs have been initiated, in the name of food security. They are:

- 1) Integrated Child Development Services Scheme (ICDS)
- 2) Mid-day meal Programs (MDM)
- 3) Special Nutrition Programs (SNP)
- 4) Wheat Based Nutrition Programs (WNP)
- 5) Applied Nutrition Programs (ANP)

6) Balwadi Nutrition Programs (BNP)

7) National Nutritional Anaemia Prophylaxis Program (NNAPP)

8) National Program for the Prevention of Blindness due to Vitamin A Deficiency

9) National Goiter Control Program (NGCP).

Out of them all, Integrated Child Development Services Scheme (ICDS), Mid-day meal Programs (MDM)/(MDMS), are the oldest and the most powerful programs that are in place. ICDS was initiated in 1975, to help the children under the age of 6, mothers to be and nursing mothers but a special focus is given to children under the age of 2. only until recently has polio in India brought under control, but even today many children are dying of malnutrition and believe it or not Dengue(the Black Plague). Through ICDS, any mother either rich or poor can avail their services with no questions asked.

Mothers or expectant mothers can literally walk in with or without their baby and get the Medicare they are needed to almost little to no cost. "This program has six different services that are available for them: health check-ups, immunization, referral services, supplementary feeding, non-formal preschool education, and advice on health and nutrition." since its inception, it has been over three decades and still not a major dent has been made for the rights of the children. Even today they are shown to have every possible attention from all forms of government but nothing actually true has been seen from their behalf.

The MDM scheme was launched in 1995 and its sole purpose is to provide free cooked meal to any government run or aided schools in India. I saw this implemented but not until 2010-11, even since then cases of impurities in the food have been filed, let alone the fact of no food provided.

This program is run by individual states but they are all assisted by the central government. From 1995, food grains were provided for the state but the state government bore the costs of cooking. Evidently, due to the so called inadequate funds, state government just forwarded the grains, instead of cooking.

There are so many programs that have been implemented by the government of India for the food security and they have been successful for the most part of it. As we know due to the huge population mark their always e hurdles that these programs have to go through. The flaw has always been in the implementation of all these programs.

SNP is to be able to distribute nutritional and medical services to preschool children, current and mothers to be, plus with the adequate supply of Vitamin A, iron and folic acid tablets. This program is available to the poor population in the urban and tribal areas.

The ANP, works hard to provide almost the same services as SNP but also to educate people to seek their daily nutritional needs. In the WNP programs, maintains itself by working in the high infant mortality places such as the slums and rural backward areas. The BNP programs main purpose is to provide calorie and half of the proteins requirements to school children in the age of 3-5 years, so that they can improve the nutritional status.

The NNAPP provide benefits to the children in the age of 1-5, pregnant and lactating mothers. The NGCP motives were that they should be able to provide salt to the entire country of India by 1992 (due to the high rates of goiter).

Innovative strategies for the highly populated second and third world countries such as India, need to state thinking outside of the box and secure their food security for the population. Major integration of the poor, under privileged, pro woman methods for sustainable agriculture and development needs to be implemented. It is known that different factors affect food security so the methods or strategies need to be flexible as well. Countries like India, China and Brazil, have taken different ways to achieve the common goals for sustainability in agriculture and at the same time lowering the rural poverty and risk to food security in the ever changing environment. It is unfortunate that India due to its increasing population has to suffer through various ways affecting food security and they need to have greater focus on them as well.

It was already calculated that by the year 2017 India would already have a deficit of 14 million metric tons of food grains shortage. According to the experts, advances in plant biotechnology and innovations can not only provide relief for the farmers but also increase the yield. Usage of chemically induced fertilizers, pesticides and wastage of water has already been tested and tried and the result has been India's farm products started to get banned and India's population getting sicker. It is also thought that India's move towards innovation and technologies such as the high roof greenhouse, mobile apps for farming, organic means of farming, and farm management software and training, can change the face of its farming.

India is working with other countries to improve its farming but with South Africa they are especially concentrated on working with qualitative seeds.

They are working on the seeds section as both countries suffer from the need of qualitative seeds for their farming process. In my opinion and many others, not only both these countries but others as well need to take steps or learn from Israel. Why Israel? Reason is as simple as the answer, Israel has very little rain, even in these harsh conditions they are able to produce most of their own food and also export of about \$2 billion worth. They are facing the same or similar conditions as India but the results of their output are just amazing.

2.3. Characteristics of innovative technologies for the production of products that are used to develop and ensure food security in India

What defines Global Food Security? That all over the world including the poor areas such as the rural areas is secured with the availability of food on a regular basis, leading to healthy lives. No matter if the countries all over the world are developed or underdeveloped; they should adopt the food security for their population. As earlier stated, that food security is affected by various factors, such as education, the country's stability, financing, etc. This is the area where technology can play an important role in food security.

Technology can affect food security in different forms and the technology required is also specific to every country. Methods and forms used by developing countries are always different from the methods used by the developed countries. For e.g. India's agriculture industry is using highly modified seeds for accommodating ever increasing population. Implementing technology is used only to ensure the yielding of high quality foods, whereas the low quality will lead in rise of malnourished population. Social economic wellbeing of the population is needed to overall affected, creating a burden on the society as well.

Many things are to be taken into consideration when the issue of quality is to be taken regarding the staple crops, post-harvest practices, and processing and packaging of finished products for the safe consumption. To be able to ensure that food security is global, use of large number of professionals with wide varieties of expertise are required. Research and innovation is based on the fact that training will be required, otherwise adequately said and dynamic businesses will not be developed to provide the needed sustained output of knowledge, skills and products.

It is not unknown that India has the second largest population, which is constantly growing at a steady pace, but the unknown fact is that how much the growing population has on its economy and its growth. Now as even the government of India has been able to realize is that the growing population needs to be kept fed and steps need to be taken soon before something disastrous happens. All over the world countries are working on achieving their Millennium Development Goals (MDG) for the food security. Following their steps India also passed a bill in 2013, which assures every citizen of India with the right to quality of food.

Currently the greatest challenge for the world is to feed the ever increase in population and to be able to increase 40% in food production from the limited resources they have such as land water. To be able to cope with increase in demand for food, farmers are opting to use the chemically induced fertilizers and pesticides as well as rapid steroid filled shots to make the current produce overnight its

double the size of fruits and vegetables. Evidently scientists are working on various forms of fertilizers and pesticides that are also organic. It is now time that government and farmers work together to achieve the requirements for the increasing population. With the help of technology reduction of losses can be achieved.

Some of the technological advancement essential to secure food security are:

Biotechnology. “Biotechnology is a systematic science which utilizes the benefits of micro-organisms or components produced by microorganisms, in agricultural or industrial process. There are evidences from history for usage of microorganisms in food preparation preservation and transformation of raw agricultural commodities into edible products for human consumption. Biotechnology is a combination of diverse technologies that can be applied in different food and agriculture sectors. It includes technologies such as gene modification (manipulation) and transfer to achieve desired characteristics in plants, development of recombinant vaccines and DNA-based methods of disease characterization/diagnosis. Biotechnology can be utilized in reproductive techniques like in-vitro vegetative propagation, embryo transfer etc for increased production. The science and art of biotechnology can be utilized in plant and animal origin food products to achieve higher yields. This area requires relatively more focused research to achieve the goal of food security in developing countries. There are cases of development of transgenic plants with commercially useful traits such as resistance to herbicides, insects and viruses” [15].

Nanotechnology. “Nanotechnology is a new subset of science, dealing with nano particles which are of the tenth magnitude. Nanotechnology is not yet widely exploited to achieve food security. However, it is progressing rapidly by usage of interdisciplinary research. Nanotechnology is the science which helps scientists to understand the structure at molecular level and relate the same to microscopic level. This technology has the potential to improve the efficiency of crop production, improve food processing and food safety, minimize environmental impact of crop production and food products and increase storage and distribution

capabilities (Norman and Chen, 2003). Nanotechnology can be applied in agricultural food system for reproductive methods for conversion of agricultural and food wastes to energy and other useful by-products using enzymatic nanobioprocessing, disease prevention and health protection of plants and animals (Norman and Chen 2003). The combination of nanotechnology with available technology like genomic and microelectronics can be utilized in development diagnostic kits to detect and monitor the spread of plant and animal diseases. Nanotechnology can be utilized in the area of packaging and storage to increase the shelf life. However, it is equally important to establish the safety aspect while exploiting any of these technologies. Some of the plastic wraps can be developed to prevent food from spoiling by inhibiting the growth of bacteria and even edible coating can be developed using nanotechnology application (Kasturi, 2009)” [15].

Information Technology. “IT can be utilized as a strategic tool for agricultural development and welfare especially in rural India. The potential of IT can be explored for direct contribution to agricultural productivity by empowering farmers to take relevant information and timely quality decision which will have positive impact on the agriculture and allied activities. Precision farming extensively uses IT to make a direct contribution to agricultural productivity. Other techniques such as remote sensing using satellite technologies, GIS and agronomy, soil science help to increase the agricultural output. These techniques provide useful information where large scale agriculture production is practiced. With the advent of corporate in agricultural retail sector these technologies are explored to the benefits of retailers. Agricultural production in India is primarily at small scale farms owned by small farmers generally less than 1 acre. Mobile enable information sharing will be useful for India as it provides timely and reliable sources of information for decisions making to individual farm owners. At present, the farmer depends on trickling down of decision inputs from conventional sources which are slow and unreliable. The changing environment faced by Indians farmers makes information not only useful, but necessary to remain competitive. Consideration must be given to generating investment in IT and communications in the developing countries

including India and parts of African countries so farmers can gain the benefits of communication and technology” [15].

Metrological Advancement. “The biggest threat to food security comes from the current imbalances caused by climate change. With every 1°C increase in temperature, there is an estimated decrease in crop production by 5%. Technology, including computers, advanced radars and weather satellites, are keys to collecting data needed for weather forecasting for decision making. The correct weather forecasting helps the farmers to sow the seeds and harvest the plants at the right time and locations” [15].

As it has been stated earlier that food security is not just based out of shortage of food, in countries like India, one of the causes is also that the food never reaches its destination. Due to the lack of proper distribution system, food crisis in India is at a rise all the way to the national level. as there is a damage to the food grains in the storage level, Food Corporation of India is making sure that the Department of Food and Public Distribution is using all the advanced technologies available to minimize this risk and maximize the distribution. FCI has so far started the use of e-payments, websites, tender placements online, anything that is accessible by its citizens for a fair trade out.

"The solution is aimed at providing three key functions to the FCI. A transaction data system would enable the FCI to share information between depots and district level officers. Information compiled using the Management Information Software would form the second function of the solution. The third function was forecasting supply and demand. The solution is an intranet-based web interface, allows all other related departments to work on same database. The data and reports are generated periodically without any delay. There is an interlinking of modules information sharing for improved coordination. Government of India has implemented a new policy ‘National Policy on Handling, Storage and Transportation of Food Grains’ in June 2000 to minimize storage and transit loses. This policy provides provision for creation of integrated bulk handling, storage and transportation facilities to the tune of 5.5 lakh MTs at identified locations in

producing and consuming areas by involving private sector participation through 'Build-Own-Operate'. FCI moves around 250 lakh tons food grains over an average distance of 1500 kilometers. An average of 12,000,000 1bags (50 kilogram) of food grains are transported every day from the producing states to the consuming areas, by rail, road, inland waterways etc. This can be achieved by effective planning and management of the transport system. The preservation of food grain starts, the minute it arrives in the warehouses. The bags are transported on wooden crates/poly pallets to avoid contact with moisture from the floor. The stocks are fumigated to prevent infestation at a frequency of around 15 days with Malathion and once in three months with deltamathrinetc. Curative treatment is done with aluminum phosphide on traces of infestation. The quality of the food grains is impacted, if the technology is not appropriately utilized" [15].

The most recent successful is the GAYA PDS, which is integrated in India all the way to central, state and districts. Using the modern technology all the warehouses are computerized including the weighing bay, so the corruption in the system can be minimized. With the help of GPS systems, food grains are tracked from pickup to drop off points. Every data is available in real time. This entire Gaya PDS system is under the jurisdiction of the District Magistrate and managed by the District Supply Officer.

CHAPTER 3

IMPROVING THE EFFICIENCY OF ENSURING FOOD SECURITY OF THE COUNTRY

3.1. Development and implementation of aquaponics as an innovative production technology of products in the country

Just like regular farming there are various methods or configurations to work with except for two facts in aquaponics, which are the fish and soil less plant bed. Further the variables for aquaponics can be the specific design filtration, aeration system, piping involved and regulation of the water flowing in the system. It is considered that systems that have the bio filter system have a far better success rate than the systems without the bio filter system. Bio filters main function is to remove the solid waste, which if properly removed can be used to place on land to produce fertility. To help in the system there is also the growth of bacteria which helps to break down the solids.

Over the years there have been various configurations tried for the systems but overall there are only three different types that can be seen. They are as follows:

Raft System. Float, deep channel, deep flow are various names that the Raft system is known as. It is based on polystyrene boards that are used to float on water. Mostly this system is separate from the fish tank but there have been cases where fish are integrated in the same system. In this system, water is continuously flowing from one point to another with proper aeration system placed in gaps. This system from point to point is connected by the piping system going through the filtration system. The water gap or the extra water in the system is provided as a buffer for the fish so they are not to be stressed and the filtration system by the roots is of the best quality.

This system is also known to be the most successful for beginners but professionals or experienced farmers prefer the other two systems. It is also good

for the best utilization of the area and is perfect for leafy green vegetables. The rafts can be reseeded and used over again and again;

Nutrient Film Technique (NFT). In this system, plants are grown in long pvc pipes. From one point of the pipe to the other end of the pipe, a small layer of water is constantly moving, providing the roots with constant water. In the NFT system plants are grown in the nursery and after the roots have come to a certain size, they are placed in the NFT system to complete their growth cycle. In this system a separate bio-filter are required otherwise outlets can be clogged and there isn't much space for bacteria to grow, as the water layer is thin. The bio filter houses most of the bacteria needed to break down the solids.

NFT system is used in two different configurations, which is the vertical and horizontal. NFT system has shown loads of potential but till today it is still the least used system;

Media-Filled Bed. This system is based on a tank that is filled with substrate which can be from gravel to clay pellets. In the system plumbing can be used in various configurations such as the siphon filter or overflow filter. Worms also play a vital role in this system as bio-filter is not required. As the solids are deposited directly in the system worms break it with the help of bacteria, so the roots get the nutrients that are required. It is one of the simplest forms of system and can be easily maintained. The production value in this system is lower than the other two systems but as it is the easiest hobbyist usually work on more than the others.

Due to the high demand of fresh and organic produce, aquaponics systems have had a massive increase in usage. As it is able to bring two produced from fish and plants in lesser amount of time, and water, it sure seems to be the next farming boom in the world. Even though this form of farming has been available since centuries but western society has just started the use of it. Even before you decide on what method of aquaponics you will choose, you have to make a calculated choice in the fish for your system. Variables to choose the fish vary from the taste, its way with the roots and its sizes. A detailed study is needed to be done before

purchasing the first lot. Will the fish live in tanks or muddy ground, how resilient are the fish to disease? Is the fish in demand?

Few of the fish listed below are the ones tested by producers:

Tilapia. Around the world tilapia is most used fish in aquaponics. It is known to be called the chicken of the sea. They are extremely easy to breed which is a major plus as they are ready to breed by 4-5 months and are able to gain decent weight for resale. They are very resilient to high and low temperatures but best when they are in warm waters, which make them easier to breed. They are omnivorous, so they eat everything from algae to insects, leaving the tank clean. All over the world from the tilapia family, Nile Tilapia is farmed the most, but recently in India certain types of tilapia have been banned;

Trout. Trout compared to tilapia is completely different as it requires to be in fresh and cold waters. India currently is trying to breed Himachal Trout but have noticed breeding is not possible unless fresh water is not available. They are carnivorous, so require only fish based food for their survival. Biggest advantage of trout is their growth rate and also their food conversion ratio, in other words the amount of feed you give the fish is less compared to the fish meat;

Carp. Over the past centuries carp was the most farmed fish in the world and its popularity still exists around Eastern Europe and Asia. Like Tilapia, carp is also omnivorous and can survive in variable of temperatures and with an incredible reproductive rate. With the help of Aquaponics this breed of fish is making a comeback in farming. Recently with certain types of Tilapia being banned in India, rise in carp farming has increased. Mostly because of its fast turnaround time and can be easily bred;

Catfish. Compared to the other fishes in the list, catfish is the only one without scales, so in other words, this fish needs to be skinned. This is one type of fish whose food conversion ratio is the best, after the skinning process. They are also considered best for aquaponics as they also have the widest range of diet that they can take, from plants, insects to other fish. They are also considered for their high nutritional value;

Koi. No doubt the most beautiful fish to have for hobbies and also for the aquaponics. Especially for people who are vegan, as koi has a long life span, and do not wish to deal with fish part of the business. As they are related to carp, they also have a wide range of diet, meaning omnivorous. In India, many are vegetarians, so our company is installing instead of tanks, natural ponds, so it enhances the beauty and at the same time, works as an engine for the aquaponics;

Perch. Out of all the fish in the list; perch in to be the healthiest of them all. They are widely known to help the cognitive functions of the human body, as they have good amounts of Omega-3 in their system. Perch has many different varieties out of which jade perch are the most sought after. Again, another fish that is omnivorous helps in bringing down the feed cost due to their wide diets. Their growth rate is excellent and plus they require warm water so indoor Aquaponics system is just plain perfect for them. Silver perch, a distant cousin, takes around twelve to eighteen months before you can harvest them;

Bass. Bass relatively is the most sought after fish in the fishing hobby. So it's no doubt that its largemouth bass is considered for large aquaponics systems. While they are young their diets vary from insects to crustaceans but as they grow older they can eat from a snake to small mammals. As full grown they are not good for the system as there feeding cost rises. As they have been a favorite in the fishing hobby, their taste is considered normal;

Crustaceans. Only recently crustaceans have been started to use in the aquaponics systems and sometimes different varieties are also being utilized in the aquaponics systems. In India, freshwater prawns, mussels and crayfish, have already been started as fish farming and their demand is extremely high. They are well known to be bottom feeders, so in a aquaponics tank they can be placed to keep the water clean.

In aquaponics, fish has an integral role and does its counterpart the plants. They both rely on each other for its basic survival. In aquaponics system practically anything can be grown, but here only certain plants will be discussed. Every plant that is placed in the system requires certain temperature of water as

well as the pH levels. Types of systems also play a vital role, as the leafy crop and herbs are better grown in small systems unlike the fruits require heavy duty system where waste produced is more. Plants are divided into four different types, which are Leafy greens, Herbs, fruits, & Vegetables

So far aquaponics has proven that it is able to grow any type of plants, by using the right method for growing. Even then there are certain types of plants (fruits and vegetables) which have the easiest and fastest growth making them in high demand around the world. Aquaponics makes it easy to choose what exactly you are looking for. Best example would be to grow tomatoes in winter if the demand and price of tomatoes is high, or grow which is always in high demand. This is one system where limit has no bounds as long as you are able to grow in proper methods.

Vegetables:

Tomatoes. This simple vegetable has the highest success rate in this system. Even with the spectrum lights, their growth has been good. Only side effect is that the tomatoes plants usually attract pests;

Lettuce. They are good in the system because of their long roots that settle themselves in the layer of water in aquaponics. Roots are so densely in the bottom that they are able to absorb all waste as their food, cleaning the water in the process. This is one of the reasons why mostly leafy vegetables have the highest rate of success. The growth rate is extremely fast, as their turnaround time is a month or less than that;

Peppers. Regular method of farming has shown little success in growing of the peppers, as they require ample water for their roots and sun. Aquaponics system water is constantly moving, providing the roots with the water they require and spectrum lights can be provided to the plants 24/7. As the heat from the spectrum lights is increased it provides hotter peppers. They are best grown in media based system with bell siphon;

Cucumbers. Another one of the best growing plants in the system is the cucumbers as the plant itself is water based and also has large roots. Only issue is

that the roots are so long they tend to clog the pipes. If in the system there are different plants then it is bad because they will take most of the nitrogen for themselves. Best would be, if you are operating with only one system is to place the cucumbers in the end, so others also get the nitrogen they need;

Cauliflower. Another water based plant that is a loved one for all vegans. Also making to the top five in aquaponics systems. This plant requires the least amount of time and hardly any maintenance required. Being resilient to almost all of the bugs and diseases, it is also the best choice for beginners in the aquaponics. In this system in about every 3 months you can harvest, compared to the six months required in conventional farming. As it is not fond of too much sun or cold, covered area or in a polyhouse, best for its growth.

Fruits:

Strawberries. The most farmed fruit in aquaponics is the strawberries, for not only there fast growth but also for the exceptional taste compared to the conventionally farmed products. They are mostly farmed in the vertical towers rather than the horizontal one due to the space it saves. Another preference is because they are commercially in high demand, due to the fact that easy to grow with minimum funding;

Pomegranate. This is one of the most sought after fruit in the world, not only for their taste but also for their health nutritional value. They are highly rich in vitamins and dietary fibers. In the loss of blood or many cases of pregnancy, its juice is highly recommended for the mother. Their international popularity has been there since the ancient civilizations. In aquaponics farming, their size are known to be larger than the conventional farming and just like strawberries are easy to grow;

Bananas. No matter who it is? when They first hear about bananas in an aquaponics system, confusion arises. As everyone has seen bananas on top of trees, but in aquaponics they can be easily grown on media beds. This is another fruit that is highly successful in the system and already one of the tastiest and highly demanded fruits. Also grows faster in an aquaponics system, making it one of the

most popular fruits among aquaponics lovers. The only part that is a side effect of growing bananas is that their roots are extremely powerful and are known to destroy the growing beds;

Dwarf 3-1 Citrus Trees. Also known as Citrus Fruit Cocktail Tree, this unique tree's specialty is that it produces three fruits at the same time, lemons, oranges and tangerines, in one tree. One of the easiest plants to grow, as it requires only water and sunlight. After the plant is sowed, the first fruits start to yield in from 12-15 months. Aquaponics system helps the plant grown successfully; grower does not need to bother that the plant will yield one fruit more than the other;

Watermelon. Another fruit that is fast grower and unusual because of its size. To grow watermelon, extremely strong support system is required. It grows as a vine type plant, and grown through the system, it produces extreme red, sweet and juicy. Their size is also bigger. This is not a crop for beginners as it requires it a lot of attention, as well as loads of sunlight.

It has been proven that in any aquaponics system, any type of plants can be grown. Above only few vegetables and fruits have been stated. Most recently using the Minapadi system, rice has been successfully grown in the NFT aquaponics system. In second and third world countries where rice is highly consumed and exported, aquaponics has made the rice also organic. In the aquaponics system they are able to grow stronger and faster, which is what the world needs at the time to provide nutritional food to its population.

3.2. Management of the introduction of aquaponics: the process and provision

Aquaponics is a perfect natural integration between hydroponics and aqua farming in a system. Fruits and vegetables are the most obvious production of the aquaponics system but the management of the entire system is very important which consists of important features of fish, plants, and bacteria. Below will be a

description of how to manage these features in perfect harmony to achieve the best possible results in from start to finish product in a complete season.

Basic steps are going to be stated for the completion of a new system and also for the management of a current system. The entire aquaponics system needs to be stable meaning all the features on the system must be coordinated properly. Fish needs to be fed proper feed which can provide nutrients through its waste to the plants. The plants absorb the nutrients which end up cleaning the water for the fish. The bio filter has to be large enough to sustain the number of fish that are in the system and with enough water to be circulating in the entire system. To be able to achieve perfection in the aquaponics system, a manager should be able to calculate, what is needed? When is needed? And how it is needed?

How much fish needs to be in the system to be able to provide for certain square footage of the plant growth? Everything has to be calculated; otherwise the system will fail one way or the other. For e.g. One of the most common mistakes is calculating the amount of water in the system, less water than the fish are dead and overflow plants are dead. It also depends on what is being grown, leafy vegetables only require one third of the nutrients that are required by other vegetables and fruits. Feed for the fish also plays an important role, as plants require 13 types of nutrients to be able to grow and normal fish feed only provides 10-11 types. Those gaps to be calculated and bridged to get the best results (Tabl. 3.1).

Tabl. 3.1

Daily Fish Feedby Plant Type

Leafy green plants	Fruiting Vegetablts
40 to 50 of fish feed per square meter	50 to 80 of fish feed per square meter

In research by FAO this has been calculated to be optimal for the growth of the plant. Meaning that the plants will have the nutrients to be able to grow. If you plant more than required then there will be a shortage of nutrients for other plants and in other way if not proper amount of filter has been placed then filtration will not be enough for the fish. All of the data provided by the research of FAO is only

an estimate and can change with different variables. So always check all the conditions internal or external that would be able to affect the system (Tabl. 3.2).

Tabl. 3.2

Planting Density by Plant Type

Leafy green plants	Fruiting Vegetables
20 to 25 g of fish feed per square meter	4 plants per square meter

It can be assumed that the fish are over 50grams and are eating 1-2% of body weight daily. Younger fish eat more than the older fish (Tabl. 3.3).

Tabl. 3.3

Fish Feeding Rate

Fish feeding rate
1 to 2 percent of total body weight per day

It is recommended that for every 1000 liters of water approximately 20Kg of fish should be in the system. Now it has to be taken into consideration that the fish in the system will end up growing to the weight that is recommended. so it is necessary to calculate with looking at future in mind. Higher amounts of fish can be kept in the system but better filtration and aeration systems are then required to be able to manage the solid waste (Tabl. 3.4).

Tabl. 3.4

Fish Stocking Rate

Fish stoking density
10 to 20 kg of fish per 1000 litre of woter

In the table 3. 5, a basic guideline has been provided for small scale aquaponics systems with media bed, NFT and DWC. Again it is being mentioned that the measurements can change with the factors like environmental or the

amount of electricity available etc. Certain points have to be taken into consideration, which are:

The fish level has been recommended to 20Kgs for 1000 liters. Level of fish in the system can be done but with better filtration and aeration in the system;

The recommended feeding rate is 1-2% of the body fat of the fish. Feeding ratio for leafy greens is 40-50 grams and for fruity vegetables 50-80 grams per meter square;

Recommended bio filter should be 10-30% of the fish tank volume. It is highly recommended to have bio filter for the NFT and DWC systems;

Most important fact that needs to be taken is that the figures are based on the fact that bacteria are in optimal working condition. During winter time, extra filtration system will be required;

Figures that have been provided for the leafy greens is more than what is required for the fruity vegetables which is less.

Tabl. 3.5

Practical System Design guide for small units

Table 5: Practical system design guide for small scale units

Fish tank volume (Litre)	Max. fish biomass (kg)	Feed rate (g/day)	Pump flow rate (litre/h)	Filter volume (litre)	Min. volume of biofilter media (litre)		Plant growing area (m ²)
					Volcanic Tuff	Bioballs	
200	5	50	800	20	50	25	1
500	10	100	1 200	20-50	100	50	2
1 000	20	200	2 000	100-200	200	100	4
1 500	30	300	2 500	200-300	300	150	6
2 000	40	400	3 200	300-400	400	200	8
3 000	60	600	4 500	400-500	600	300	12

Source: FAO 2015

Daily monitoring of the health of the fish and plants is required to keep monitoring the balance in the system. Most of the major side effects such as death, nutritional deficiencies, death are all because of the imbalance in the system. Daily numerous times the water quality has to be checked to see if the Ph levels are

stable. If the bio filter is not working properly than there will be an increase in high ammonia and nitrates. In the other sense if there is a low nitrate level which implies that there are more plants and not enough fish. Even though increasing nitrates increases nutrients in the system but when the level of nitrates is greater than 150mg over liter then the water needed to be changed.

Bacteria is the most integral part in the aquaponics system, it is able to bridge the gap between the fish and the plants. The nitrifying bacterium, Nitrosomonas, is able to break the waste of the fish into ammonia, into nitrate which is the fertilizer for the plants. Nitrifying bacteria, Nitrosomonas and Nitrobacter, are the two bacteria that in two different processes, so the colony of bacteria in the system is crucial (as shown in Fig. 3. 1).

When the first time the aquaponics system is started, system cycling at first is the process of the bacteria starting in it. Time has to be given to the aquaponics system to start and settle a colony. Bacteria are already in the air, in the atmosphere, so for it to settle down in a system, it requires at least four to six weeks. It is a slow process but it is well worth waiting to start with fish or plants. With the bio filter in the system, bacteria's colonies will get nonstop supply of ammonia or their food source from the fish. Decent nitrate test kits will be able to tell the levels of nitrogen in the system but nowadays there are decent electronic systems available but expensive still.

Figure 1. The nitrification process in aquaponics

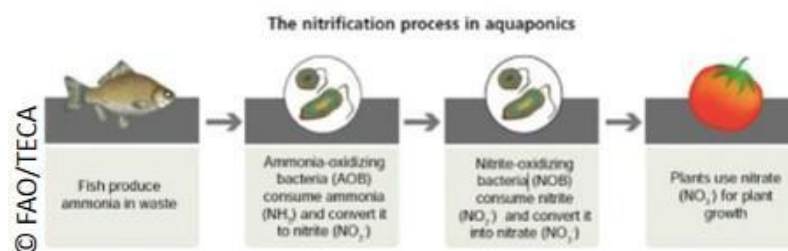


Fig. 3.1. Nitrification Process in Aquaponics

As the system is completely started, the fish solid waste is the food source for the ammonia-oxidizing bacteria, AOB, which are naturally occurring. These

bacteria, once the system is started, it begins to integrate itself within five to seven days in the system. Addition of ammonia in the system has to be done gradually, meaning too much in the beginning can turn toxic for the plants. Another five to seven days, the nitrate levels in the system will start to rise, which in turn will attract NOB, nitrate-oxidizing bacteria in the system. As the NOB levels will increase the nitrate levels in the system will also start declining as they are being oxidized into nitrates for the plants. The system cycling process is considered at the end when nitrite level is at 0mg per liter and ammonia level is below 1 mg per liter. This perfect system cycling takes around 20-40 days but in cooler temperature it might take a few more days from two to three months. Before the end of the system bacteria has already started to take hold and started to convert ammonia into nitrate.

The rate of growth of nitrifying bacteria is extremely slow, and is the reason due to which the initial process is long. Even when a new system is being setup then it is advisable to connect the new bio filter with the old one to speed up the process. This helps in reducing the system cycling process significantly. So it is always recommended to start another two to three bio filters in advance, before they are setup in the system. Nowadays many companies are selling nitrifying bacteria to kick start a system, but unfortunately it has to be seen that it does not harm the fish.

Plants in a system can be planted as soon as the levels of nitrates are visible but the growth is not that fast as the levels are still rising. That is one of the reasons why the first crop in an aquaponics system is slow and not that good compared to the crops after. After the research was done it was recommended to wait at least three to four weeks for the system to have the nutrients accumulated for the plants to be placed. It is also seen that for the first crop it is a slow process compared to the soil based or hydroponics farming. But as the months pass and the system have bacteria colonies formed, then the plants growth is two-three times faster compared to soil based and hydroponics farming (Fig. 3.2).

Figure 2. Levels of ammonia, nitrite and nitrate during the first few weeks in a recirculating aquaculture system

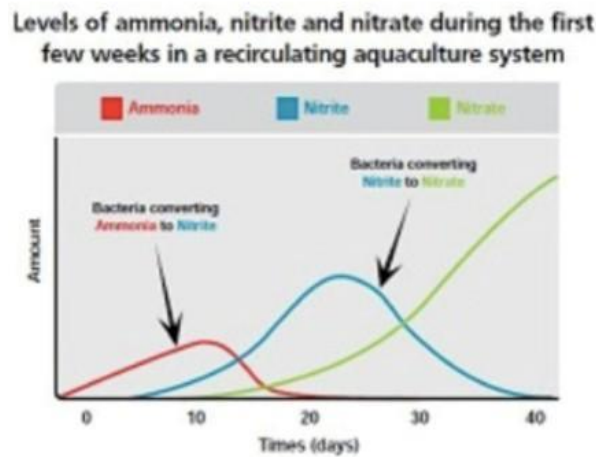


Fig. 3.2. Levels of Ammonia, nitrate and nitrite during first few weeks in a recirculating aquaculture system

As it is seen that in a small aquaponics system plants show the best output so it is also important that the best seedlings are placed in the system. It has to be taken into consideration as the plants also face the transplant shock. For this reason it is advisable to have a small nursery setup with your aquaponics system to have readily supply of plants, as waiting to plants for production can cause major delays.

Recommended by the FAO organization is that to have a small table constructed for the seedlings that will be planted and to water them daily at least half an hour (which can be controlled by a timer), which is to be absorbed by the media. The water is in time drained to a tank below, which helps in conserving water. Draining the water regularly in this method not only helps in controlling the fungal issues for the seedlings but also water logging. Nowadays in the market polystyrene propagation trays are easily available, with the use inert media such as rock wool, coco peat or fiber, vermiculite, perlite or potting mix, are just a few of the growing media. Many forms of trays can be used as well such as the recycled egg trays, but the propagation trays provides enough space for each seedling with ample light from the sun.

Seeds can directly be placed in the media beds with siphon filter or the flood and drain system. But it is recommended that to close the siphon system until the

seed blooms. Reason is that the sudden pull of water due to vacuum can move the seeds around.

It is highly forbidden to transplanting seedlings from the soil, it is only to be done under extreme conditions. If needed to be transplanted then the plant has to be thoroughly cleaned due to them carrying plant pathogens which are a disaster for the system. As they are being transplanted and thoroughly cleaned, seedlings do come under stress and can die but if they survive there growth will be stunned for a couple of days until the roots acclimatize themselves with the system. As explained before the use of inert media will reduce the shock, if transplanting is needed.

This transplanting method is not limited to just the seedlings; large plants can also be done with the point that the soil is removed. It has been seen that it is not recommended to transplant plants during the day because the plant roots are extremely sensitive to the sun light and can face water stress due to the change in growing conditions. Therefore it is advisable to plant the seedlings to new condition overnight for minimal shock.

A new aquaponics system should always start with the minimal nutrient hungry plants, such as the leafy greens. Reason is to provide the system with ample space for nutrients and bacteria to grow. Leafy greens can regularly grow in an aquaponics system every month, so in my recommendation will be to let the cycle grow two to three times. So the system cycle can take a strong grip.

Another advantage of aquaponics is the minimum space required. Seedlings can be densely planted together unlike the soil based system, as the seedlings are not competing for water and nutrients. Even then the seedlings when they grow up they would need ample space, so they do not fight for the sunlight. Lack of sunlight will bring down the quality of the plants. As seedlings they can be in the tray available but in the aquaponics system it is recommended to half a gap of half a foot, which is still less than what is required by the soil based farming.

Organic or inorganic supplements that are sold in the market cannot be integrated into the aquaponics system. In the early stages of the aquaponics system,

shortage of iron is in the system, to make matters worse fish feed lack in iron as well. In this case chelated iron or powder form that will dissolve in water is to be added. Recommended is 1-2g per liter is to be added, only for the first two to three months. If in the future there is a shortage of iron in the system, chelated iron can be bought but also from aquaponics safe organic fertilizers such as compost or seaweed tea, as iron is abundant in both.

After the first two months, the first set of leafy plants will be ready for harvest and with another two harvest, nutrients base will be strong and the system ready for larger plants to be planted. Few of the extra points that need to be considered after the first harvest are:

As the first harvest is ready, it is always recommended in the aquaponics system to take time in harvesting the plants because it can be the cause of declining nutrients that creates nutritional problems for the plants, causing spike after the harvest, finally stressing the fish. Creating havoc for the entire system;

While harvesting plants, it is to be made sure that the entire roots are taken out with the gravel (if that is used as a substrate). The gravel needs to be cleaned out from the plants and is said to be placed back into the system. In the NFT and DWC systems, the roots need to be cleaned out after harvesting to contain any blockages that can occur. The roots need to be discarded into a recycle bin for to be converted as compost for other soil based farmers. Plants and roots left in the system overtime will cause for the rise in any form of plant diseases. Harvest plants need to be cleaned, placed in a bag and placed in cold storage place.

Managing Plants in Maturing Plants:

Stabilizing Ph Levels. The biggest blunder any aquaponics beginner or farmer even has done is not managing the Ph level. As stated earlier that if the Ph levels are high (above 7) or low (below 6), both plants and fish are affected leading to their demise. According to FAO's research 6 Ph level is said to be the optimal but farmers practicing aquaponics farming have stated that 6.5 Ph level is the optimal. If the Ph levels are not balanced then rain water can be added to correct it. Many Ph levels checking equipment are available from cheap to expensive;

Plant Nutrition. Perfect aquaponics systems are those that are balanced. Entire system is started from the feed that is given to the fish that is used to balance to the plant growing area, which in turn is measured by the feed per square meter of plant growing space. "The feed rate ratio for leafy vegetables is 20 to 50 g per m² daily; fruiting vegetables require 50 to 80 g per m² daily" [24].

Organic Fertilizers. It is a known fact that if there is a shortage of nutrients, external factors are required to fill the gaps. Lately Aquaponics friendly compost and liquids are available to help bridge the missing gaps in nutrients. Compost tea and seaweed tea are the most highly recommended. Deficiencies in an aquaponics system usually occur when the plant to fish ratio is high or during the winter times when the feeding is slowed down. As this is an aquaponics system, before adding these supplements, it has to be checked separately for the Ph level so there is no nutrient lockout;

Pests and Diseases. FAO recommends that using of IPPM (Integrated Production and Pest Management) techniques like using poly houses, crop rotation etc. If the pest's problems persist then other mechanical solutions should be implemented before using sprays. It is said in the commercial market that organic pesticides are available but there viability is still to be assessed. Aquaponics friendly solutions are only to be applied such as plant extracts, biological insecticides (*Bacillus thuringiensis* and *Beauveria bassiana*), soft soaps, ash, plant oils or extracts of essential oils, chromatic/attractant traps, and external attractant plants treated with insecticides. No matter what is used, strict precautions have to be taken, to keep it from mixing in water;

Follow seasonal planting advice. If the aquaponics system is inside a greenhouse or poly house then seasonal planting can be changed to the current market demands. If there is no greenhouse then the use of seasonal planting is highly advised.

FAO recommends that the best for the plants is to wait for cycling process in the system is completely and the bacteria has taken roots in the bio filter and the system, before the fish is integrated in the system. Even with the advice, people

tend to get eager in starting the farm, so small amount of fish can be placed in the system. This can actually cause the fish stress for which constant monitoring and water changes.

There are many different types of fish that can be integrated in the aquaponics system, giving them excellent growths. They are tilapia, common carp, silver carp, grass carp, barramundi, jade perch, catfish, trout, salmon, Murray cod, and largemouth bass. One fact that needs to be in the mind, when starting a farm is that the local governing policies have to be taken into consideration. For e.g., lately in India certain types of tilapia have been banned due to their effect on the ecosystem. Local government sections should be consulted with which invasive species not to choose and which is suitable for farming. Many of these fish are invasive in the sense that they produce rapidly and can endanger the local fish population, destroying the local ecosystem.

Whenever new fish is introduced to the system, it has to be acclimatized first or the water shock will kill most or they will just end up being sick for a long time. Even when just acclimatization of fish is complicated and stressful process for them and being transported from one place to another is just not helpful. Factors that are known to stress out the fish the most during acclimatization are the Ph level between the original water they are in and the water they will move into and the other is the changes in the temperature of the water. If the difference in the Ph levels in the water is more than 0.5, the time for the fish needed to adjust is around 24 hours. In this case, fish i to be kept in a container with the original water with new water gradually being added to the tank over the course of a couple of hours.

Even a slight differentiation in the ph level of the water, fish still needs time to adjust. Another of the most used method is that allow the bags of fish to float on top of the new water, that allows the temperature of bag to adjust to the water in the tank. Minimum time this process requires is around 15-20 minutes. After this the new water from the tank should be allowed to mix with the closed bag water, for the minimum shock for the fish.

The entire aquaponics system kick starts with the feeding process, which balances many of the aquaponics aspects such as to calculate planting area, fish feed, and fish biomass. For each fish the feed rate is different as their growth rate varies:

When the system is initiated the fish feed rate is 1 to 2 percent of their body weight per day. Calculating the basic density of 20kg for 1000 liters, 200g feed can be given;

If the fish farmed is tilapia then for the first two to three months fingerlings weight is usually less than 50 g, and eats only two to three percent of their body weight. So in the case of 40 fingerlings weighing 50 g each will have 2000 g of fish weight? Their two to three percent will be 60 g of feed every day;

Eventually after two to three months fish will grow to be around 80 to 100 grams, making total weight from 3200-4000 g, increasing their food load to 80g to 100g.

After three to fourth month the food has to be given around twice a day but for the young fingerlings have to be provided by three times a day. By giving them the food in breaks is not just helpful and healthy for fish but also for the plants, by evenly providing nutrients throughout the day. Floating feed is best and spreading over the entire service allows all the fish to eat and not hit each other or on the sides. For the first couple of days a person has to monitor the tanks and watch over the fish while feeding. Food that is still floating after 30 minutes should be removed and the next feed to be calculated accordingly.

Eating behavior of the fish is to be monitored as their healthy appetite can be seen. If after sometime the food is leftover or they stop eating food all together then the fish health needs to be checked or the unit is at risk. For the tropical fish, they need to be monitored, as during the winter they eat less.

Fish health can easily be seen from their behavior. The person maintains the aquaponics system should be able to monitor the fish's behavior, if they are in stress, disease or parasites. It is said that feeding time is the best way to check their behavior. Once before eating and after eating, how much food is left?

Healthy fish Behavior are:

"Fins are extended, tails are straight.

Swimming in normal, graceful patterns. No lethargy. However, catfish often sleep on the bottom until they wake up and begin feeding.

Strong appetite and not shying away at the presence of the feeder.

No marks along the body.

No discolored blotches, streaks or lines.

No rubbing or scraping on the sides of the tank.

No breathing air from the surface.

Clear sharp shiny eyes"[68].

Bacteria, fungi and parasites are the three known diseases that can kill the fish. These diseases can easily enter the aquaponics system just by water change or being activated by being already in the system, and as they are also available in our environment. To be able to prevent these scenarios in time is better than changing the complete aquaculture. As stated above as well that monitoring the fish daily will help prevent any diseases to manifest itself in the system.

In an aquaculture one or two fish can easily be spotted as they are ignored by the group but when significant amount of fish are showing signs of being infected, it can be taken into consideration that environmental factors are causing the stress. In cases such as these, water temperature, the nitrates levels, nutrients level, ph level, ammonia level, all should be checked individually and steps to be taken to lower the stress of fish. If only a couple of fish are showing signs of diseases they should be quarantined before the infection spreads.

One of the tried and successful cures for most of the common bacteria and parasites is the salt bath. The infected fish can be taken out of the group and given a salt bath, which is toxic for the diseases but not harmful to the fish. The formula for the salt bath is that for every 100 liters 1 kg of salt is required. For the first 20-30 minutes the infected fish should be placed into the salty water and after that transferred into another tank for five to seven days, where the salt ratio is 1 -2

grams per liter. If the water is heated, it will make the salt's work more effective in eradicating the diseases.

After the cure, the fish should be individually placed back into the aquaculture tank without the salt water as it would have an adverse effect on the plants.

A constant supply of fish waste is good for the plants as they are being provided nutrients and to keep this system running successfully, it is highly advisable to work with the stocking method. Stocking method implies that three different age levels are working in the same tank. In other words every three months approx. 500 grams of fish is harvested and new fingerlings (50 grams each) are placed in the system as their replacements. With this system all the fish are not harvested in one time but gradually, allowing the fish waste to be constant in the system.

If the fish fingerlings are not easily available then higher density can be kept for random harvesting, which still allows for constant waste for the system. One point to be considered is that the fingerlings are going to be mixed as it is impossible to find out the sex of the fish at that age, to be removed as soon as they hit maturity for mating by 5 months. If the fish in the tank started to breed then the whole lot will be stressed out with cohort. It is good to eventually separate the males and females in time. As if the fingerlings are at shortage then on side a separate tank can be maintained for the fish to breed so constant supply of fingerlings are available. This way of self-breeding will also make the farm self-reliant.

Adult fish like tilapia, catfish and trout will eat their fingerlings, if they are not harvested as soon as they turn adults. There is a technique to keep the fingerlings safe by placing them in floating frame, until the adults are harvested. But I have seen fish like tilapia and carp have the tendency of jumping, and it is the same for the fingerlings. This frame can be constructed as a cube with the pvc pipes and a dense mesh in the middle so bigger fish cannot enter from the bottom or the sides. Each of the different weight size should be kept in their own set of

floating frame to be on the safe side. As the fish grow and are safe the float rack can be removed. In this method it is possible to have three different ages in one system, just to be made sure that feed is of size for all to eat.

Just like regular farming there are various methods or configurations to work with except for two facts in aquaponics, which are the fish and soil less plant bed. Further the variables for aquaponics can be the specific design filtration, aeration system, piping involved and regulation of the water flowing in the system. It is considered that systems that have the bio filter system has a far better success rate than the systems without the bio filter system. Bio filters main function is to remove the solid waste, which if properly removed can be used to place on land to produce fertility. To help in the system there is also the growth of bacteria which helps to break down the solids.

Over the years there have been various configurations tried for the systems but overall there are only three different types that can be seen. They are as follows:

Raft System. Float, deep channel, deep flow are various names that the Raft system is known as. It is based on polystyrene boards that are used to float on water. Mostly this system is separate from the fish tank but there have been cases where fish are integrated in the same system. In this system, water is continuously flowing from one point to another with proper aeration system placed in gaps. This system from point to point is connected by the piping system going through the filtration system. The water gap or the extra water in the system is provided as a buffer for the fish so they are not to be stressed and the filtration system by the roots is of the best quality. This system is also known to be the most successful for beginners but professionals or experienced farmers prefer the other two systems. It is also good for the best utilization of the area and is perfect for leafy green vegetables. The rafts can be reseeded and used over again and again;

Nutrient Film Technique (NFT). In this system, plants are grown in long pvc pipes. From one point of the pipe to the other end of the pipe, a small layer of water is constantly moving, providing the roots with constant water. in the NFT

system plants are grown in the nursery and after the roots have come to a certain size, they are placed in the NFT system to complete their growth cycle. In this system a separate bio-filter are required otherwise outlets can be clogged and there isn't much space for bacteria to grow, as the water layer is thin. The bio filter houses most of the bacteria needed to break down the solids. NFT system is used in two different configurations, which is the vertical and horizontal. NFT system has shown loads of potential but till today it is still the least used system;

Media-Filled Bed. This system is based on a tank that is filled with substrate which can be from gravel to clay pellets. In the system plumbing can be used in various configurations such as the siphon filter or overflow filter. Worms also play a vital role in this system as bio-filter is not required. As the solids are deposited directly in the system worms break it with the help of bacteria, so the roots get the nutrients that are required. It is one of the simplest forms of system and can be easily maintained. The production value in this system is lower than the other two systems but as it is the easiest hobbyist usually work on more than the others.

Due to the high demand of fresh and organic produce, aquaponics systems have had a massive increase in usage. As it is able to bring two produced from fish and plants in lesser amount of time, and water, it sure seems to be the next farming boom in the world. Even though this form of farming has been available since centuries but western society has just started the use of it. Even before you decide on what method of aquaponics you will choose, you have to make a calculated choice in the fish for your system. Variables to choose the fish vary from the taste, its way with the roots and its sizes. A detailed study is needed to be done before purchasing the first lot. Will the fish live in tanks or muddy ground, how resilient are the fish to disease?, Is the fish in demand?

Routine Management. Daily Activities: to be able to check the water, air pumps; to be able to check the water is flowing in the system and to clear any obstructions in the system; to be able to check and correct the water level; to be able to check for leaks; to have a system to be able to check ph, nutrients, nitrates, ammonia, temperature levels; to be able to feed and monitor fish, also to remove

uneaten food and adjust feed; to be able to remove dead fish and plants; to be able to clear the filters; checking plants for pests and clearing them.

Weekly Activities: to have a system to be able to check ph, nutrients, nitrates, ammonia, temperature levels; to be able to check plants with deficiencies; to be able to clean tank bottoms and filters for solid wastes; harvest and plant new seedlings; harvest fish, if required; to be able to check and remove and obstructions.

Monthly Activities: to have new tanks for new fingerlings; to be able to clear filters; take a sample of fish and check for any disease or pathogens.

According to FAO and their research it is noted that aquaponics farming is Women Friendly, as the technology is easy to use, all the resources used with efficiency in a ecosystems with the three major groups, fish, plants and bacteria, and finally that it is very pro-poor environment friendly.

3.3. The advantages and effectiveness of aquaponics as an innovative technology for the production of products in order to ensure food security in the country

In the last decade, soil less farming especially aquaponics farming has become extremely popular. If sustainable farming is considered then aquaponics takes the highest place or rank. Obviously, aquaponics systems do require maintenance and feeding to be monitored. Aquaponics increase in popularity has been so high due to its sustainability but also for it being environmentally friendly.

Being healthy is now the current trend and population of the world daily is getting aware of being environmental friendly. Already steps are taken by the population to teach our future generations of farming that is sustainable and profitable as well. Using only few resources, aquaponics farms are able to grow various types of fruits and vegetables and at the same time also have bountiful of fish for sale. As only few electric machines are required, the power usage is at minimal which can also be replaced with solar power.

The water in the system is in a loop system, so there's no wastage except for the evaporation, which still is minimal compared to regular wastage of farmer of soil farming. There is no soil so the soil forms of diseases are not present. The usage of pesticides is also not present, which is important for good health.

When the aquaponics system is started, the only requirement is to feed the fish and have the daily monitoring of the system is required. Nowadays, automatic electronic monitors are starting to be available in the market. With the optimal running of the system, the outputs of the plants are 4-5 times faster and the yield as well which is said to have been almost ten times more than the regular farming.

The fact that pleases or attracts most beginners or farmers aquaponics farming is poly-culture. While farming for leafy vegetables, fruity plants can also be done side by side. From one system, fish and plants both are harvested.

Waste Utilisation and Nutrient Utilization. The basic rationale of aquaponics is the use of fish waste as the main source of nutrients for the plants. Plants alone are not the only form that uses the waste, bio filters are there for the waste management and the bacteria for the breaking down of the waste that is collected. Plants are the final step in the system in clearing the water. According to the research done by the College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa, the conversion of fish feed to waste to plant usage of nutrients falls around 40-50%, which without waste is still sustainable use of resources.

Energy Use. Aquaponics system require minimum of the power usage compared to soil farming, which can run mostly run with a solar system.

Dependency of External Factors. In certain countries like in pacific which are surrounded by water, are dependent on imports and exports for the system requirements, such as seeds, kits, pumps and even fish. But in normal countries, even third world countries, it is not uncommon to find or use substitutes to make the system.

Fish. In certain countries the fish like tilapia is considered an exotic as it has to be imported. Fish like tilapia still in certain countries are imported because they

are considered the best fish choice for the aquaponics system. Another reason being that in some countries have ban to tilapia as they are known to be very invasive species and not good for the ecosystem of the locality.

Water. In many countries such as Africa and India, water levels are to the down low and aquaponics is able to encourage farmers for fish farming and vegetables at the same time, having them with daily nutritional values.

Weakness of Aquaponics. As the aquaponics is still in the early stages, so aquaponics being acceptable by many farmers is still in the consideration process. Studies have been done in the current times, to see if aquaponics system is viable for now but the studies have not been able to show great results that would favor it. In many areas aquaponics shows great promise but as everything goes according to the economies until its parts or products do not become cheaper it will still remain in the lower levels for beginners. In pacific countries it has turned out to be risky, expensive, and compared to hydroponics due to high importing of its parts. Right now it is being taken similar to hydroponics even though aquaponics has zero additives and has fish farming as well.

Below are some of the data compared to other farming (Fig. 3.6 – 3.8).

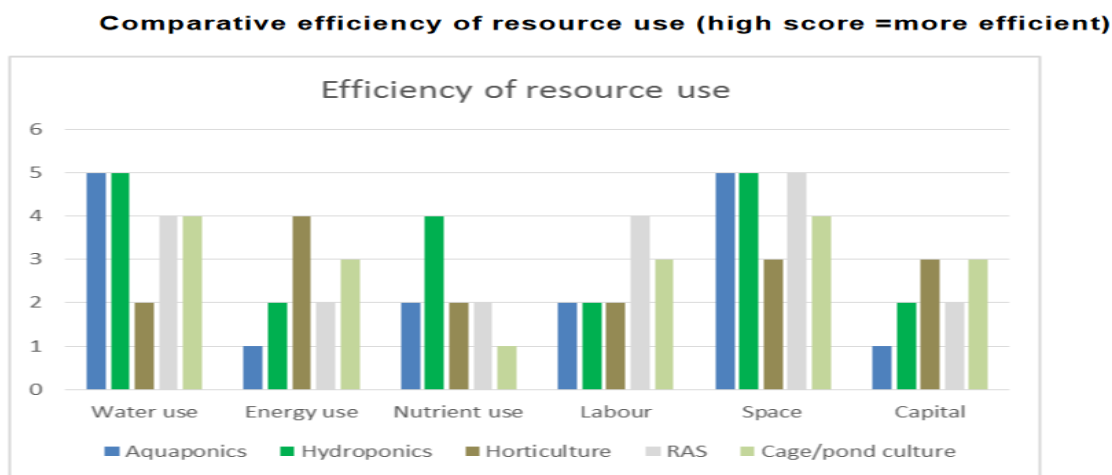


Fig. 3.6. Comparative Efficiency of Resource Use

Demands in terms of knowledge, skills, commitment.

High score = relatively more demanding

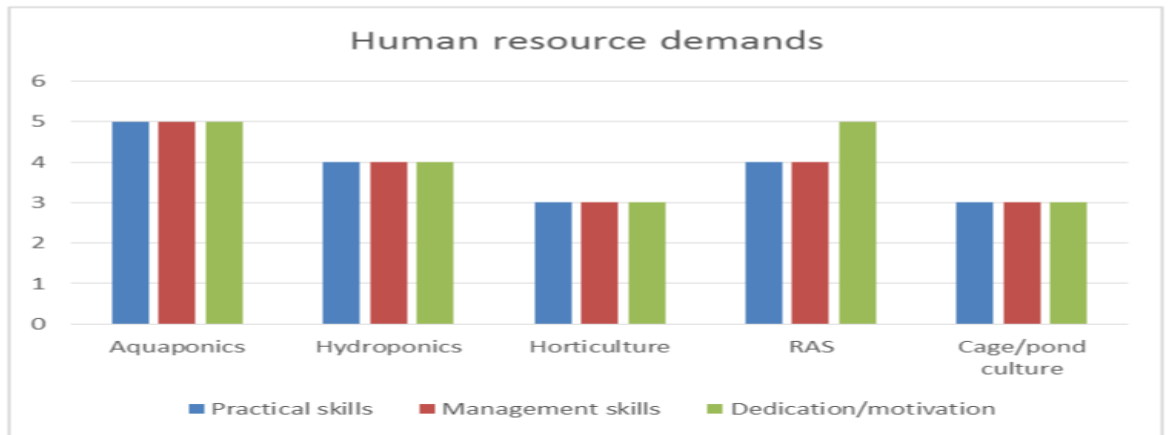


Fig. 3.7. Demands in terms of knowledge, skills, commitment.

Exposure to a range of risk factors - high score = greater exposure

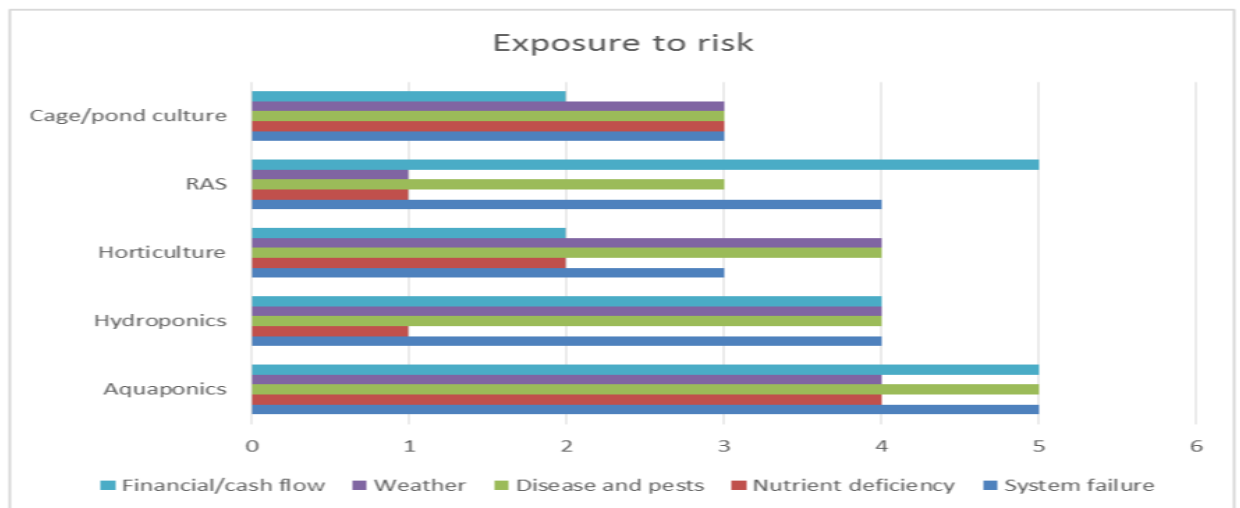


Fig. 3.8. Exposure to a range of risk factors – high score=greater exposure

India 1 Acre Farming Example – Gujarat (Fig. 3.9.).

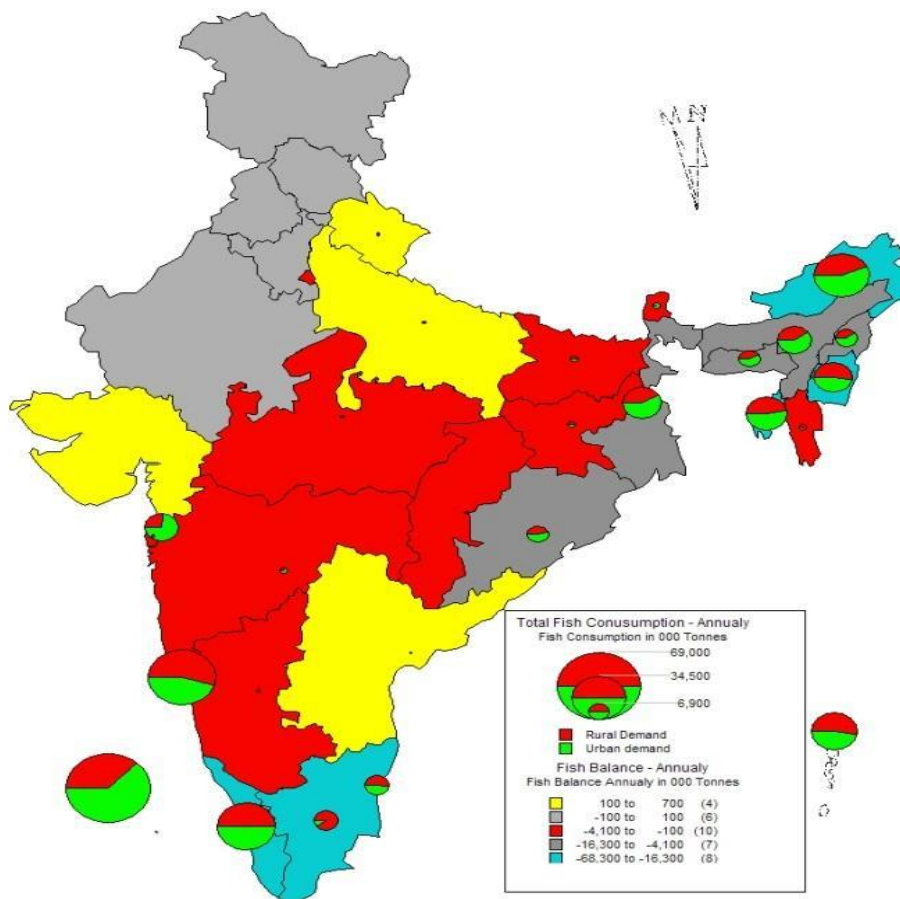


Fig. 3.9. Total Fish Consumption in India

Gujarat has varying topographic features though a major part of the state was dominated by parched and dry region. The distinctive features of agro-climatic zones are briefly presented in Table below. The average rainfall in the state varies widely from 250 mm to 1500 mm across various zones. Out of 8 agro-climatic zones, five are arid to semi-arid in nature, while remaining three are dry sub-humid in nature. Deep black to medium black soils dominate the soil types in the state. Based on soil characterization, rainfall and temperature, eight agro climatic zones in Gujarat have been identified as under (Tabl. 3.6).

Major Agricultural produce of the state include cotton, groundnut (peanuts), dates, and sugar cane, milk & milk products. Gujarat is the dominant producer of tobacco, cotton, and groundnuts in India. Other major crops produced in state are rice, wheat, jowar, bajra, maize, pigeon pea and gram. Castor, Groundnut and Mustard are the important oilseed s crops of the state. The state has notable

achievement in production and productivity scenario in cotton, castor and groundnut. Cotton is an important crop of the state which covers 27.97 lakh ha. Area under cultivation and produced 98.72 lakh bales during 2014-15(as per fourth advance estimate of 2014-15) which is approximately 1/3 production of the country. State has recognition for highest area, production and productivity of castor in India. State produced 84% of total castor production of the country with area of 6.83 lakh ha. And 12.98 lakh MT production. State has a 30% share in country for production of Groundnut with 20.37 lakh MT production through area coverage of 14.02 lakh ha.

Tabl. 3.6

Data on amount of Rain in india's different regions

Agro climatic zone Type of soil Rain fall (in mm)	Agro climatic zone Type of soil Rain fall (in mm)	Agro climatic zone Type of soil Rain fall (in mm)
South Gujarat (Heavy Rain Area)	Deep black with few patches of coastal alluvial, laterite and medium black	1500 and more
South Gujarat	Deep black clayey	1000-1500
Middle Gujarat	Deep black, medium black to loamy sand	800-1000
North Gujarat	Sandy loam to sandy	625-875
Bhal & Coastal Area	Medium black, poorly drained and saline	625-1000
South Saurashtra	Shallow medium black calcareous	625-750
North Saurashtra	Shallow medium black	400-700
North West Zone	Sandy and saline	250-500

Horticulture production scenario gives the shining of increment. Area under cultivation of horticulture crops and production are continuously increasing in the state. “Gir Kesar Mango” and

“Kutchi Date” have unique identity in the country. State is known for Cumin, Fennel and Isabgul production and productivity. State contributes more than 90% production of the country in Fennel. Farmers’ efforts make Gujarat proud in productivity of the onion and potato.

State has highest productivity in country for onion (25 MT/ha.) and potato (28.81 MT/ha.). Farmer of the state has notable achievement in potato productivity i.e. 87 MT/ha., which is the highest in the world. Gujarat state is 1st in the production of Cumin, Fennel and Date palm, 2nd in production of Banana, Papaya and lime. Productivity of Onion and Potato is highest in the country where productivity of Banana, pomegranate and sapota is 2nd highest in the country. State enjoys monopoly in processing of Istanbul. The crop specific Centers of Excellence for the crops like Vegetables, Mango and Date palm have been planned and shall be established with the support of world best technologies with a view to increase productivity and quality by capacity building of the farmers. Couple of good integrated pack houses, air cargo complex and Gamma irradiation projects has been established by Gujarat Agro Industries Corporation. Onion dehydration industry of the state is the biggest in the country.

Animal husbandry and dairying sector has played a vital role in socioeconomic development of Gujarat state. Animal husbandry provides employment to every class of society and is also an important source of income for poor families of Gujarat. Gujarat is rich with various indigenous pure breeds including Gir and Kankarej breed of cow; Mahesani, Surti, Jaffrabadi and Bunni breed of Buffalo; Marwari and Patanvadi breed of sheep; Sirohi, Surti, Mehsani, Kuchchhi, Gohilwadi and Zalawadi breed of goat; Kutchi and Kharai breed of camel, Kathiyavadi breed of Horse etc. Gujarat possesses 19 registered breeds (13%) out of total 151 registered breeds of the country. As per Livestock Census-2012, Gujarat possess 2, 71, 28,200 Livestock contributing 5.30% to total 51, 20, 57,000 livestock population of India. Gujarat has been a leader in milk production. In 2014-15, Gujarat stood at 3rd position in India with milk production of 116.91 Lakhs metric tons. Gujarat has attained notable 7.33% average growth rate in milk production during the last decade.

Of the 173 landing centers situated along the Gujarat coastline, only 18 have any permanent landing facilities such as harbors or jetties. Of the ports visited, Veraval, Mangrol and Porbandar appeared to be the most developed and between

them handle about 72% (157 000 t-1984) of the state catch as well as possessing 68% (741 t/day) of the state's ice production capacity and 90% (1 820 t) of the frozen storage capacity. Of the state's total, 2 113 mechanized boats (61%) operate from these ports with just over half of these being trawlers. About 96% of the existing ice making capacity is in private hands and ice is competitively priced at around Rupees (Rs) 0.20/kg. Ice appeared to be plentiful in Veraval and is transported from there and the other production centers to the more remote landing areas to suit requirements.

Even where landing facilities exist, they do not appear to be used as effectively as they might. There are several likely reasons for this. In Veraval, although the new landing centre (World Bank financed) is convenient for the shrimp processors, it is located well away from the traditional and established area for fresh fish marketing.

Many of the fresh fish merchants (and hence their suppliers) are reluctant to change, leading to a situation where the landing facilities are used almost exclusively by the trawler fleet for landing shrimp and by-catch, while fish destined for fresh distribution is landed both at the beach to the north of the town (Zaleshwar) and at the congested main jetty immediately adjacent to the town. Additionally, although both the landing facilities at Veraval and Mangrol include auction halls with stalls for storage and wholesale of fresh fish on ice, the auction system appears to be little developed here. Most fish is disposed of through prearranged contracts with merchants and boat owners, many of whom act as creditors to fishermen and are repaid with a portion of the catch. In these circumstances, much of this handling, marketing and iced storage capacity remains underutilized.

In other important fishing centers such as Jafarabad and Rajpara where large quantities of Bombay duck are landed and processed (likely quantities are 35 000/75 000 t/year), the landing facilities are sparse with most of the fish being landed directly onto the beach. This is, in general, symptomatic of the fact that the greatest investment in infrastructure has been made in the fishing centers which

specialize in higher value produce such as shrimp and frozen fish, rather than, for example, cured fish.

Aquaponics is the future of farming in India or globally we would say. The pilot projects will prove the worth. The idea behind taking 1 acre of land at different heights is that farmer wants to display all aspects of Aquaponics. Certain Population is totally committed for its operations in India & will set up projects in each & every part of India to educate farmers about this technique & how this can change their lifestyle as well as income.

This little support from the Govt. can actually start a new Green Revolution in the country. From Appendix Page__ to Page __, have provided calculations to a farm of One Acre for a year.

Like any other activity some side effects are always present, no matter what the situation is, and as for beginners it has a learning curve. Most of the beginners and enthusiasts lose interest, due to minor mistakes which end up destroying or killing the plants or fish.

Following are some of the challenges faced by an aquaponics farmer:

The Bug Problem. The first most common challenge in farming is the bug problem that eat and destroy the plant life. Using pesticides is the foremost answer but in the current times, farmers are looking for alternative ways to kill the bugs. Many of the pesticides companies are researching now for these so called organic pesticides. Alternative method can be using net traps to catch the bugs which can be fed to the fish as feed.

Too Many fish in Tank. No matter how many times it can be emphasized that proper research has to be done for how many fish can be placed in a tank. Many beginners calculate wrong and cause the death of many fish in the system. The efficiency of the aquaponics system depends on the right calculation of how many fish in a tank.

Too much density in the fish tank can have the larger fish eating the smaller ones but another side effect of too many fish is the waste produced will be too

much for the bio filter too handle or convert. Throughout the net it is said the rule of thumb to be 5-6 gallons or approximately 20 liters.

System not checked Daily for ammonia. Ammonia is produced by the fish respiratory system and discharged through their gills. Ammonia is toxic for the fish and it builds up in the tank which will eventually be fatal for the fish. This fatal issue can be resolved by checking the tank water every day, ammonia has to be removed from the tank diluted or converted.

Bringing down Ph level too Fast. It is shown that plants grown in the ph level between 6-7, other studies have shown from 5.8-6 also. By adding acid to water to bring down the ph level but it can prove to be counterproductive. As it can kill the fish it is always advised not to add any acid to an aquaponics system. It is preferred and known that doing nothing to the water will automatically bring down the ph levels due to nitrification process which is safer for the fish.

Not stirring Hydroton. To prevent dead zones in an aquaponics system, every few months hydroton has to be stirred so there are no dead zones. Hydroton does not settle down, as the nitrifying bacteria has an exponential growth but still ignoring hydroton can be fatal for the plants.

Restricting access to Fish Tanks. It is never considered a good idea to restrict the fish tanks as it will make doing daily rounds difficult, such as water changes or removing dead fish, or accessing fish.

Tank water too hot. Only certain types of fish can survive the tropical temperatures in the water which also tends to be fatal for the fish. For any fish that is intended to be farmed, detailed research has to be done. Not all fish can be like tilapia which can survive in tropical temperatures and lower as well. Extreme heat or direct sunlight is bad for the fish, as the oxygen level is depleted.

Myth that aquaponics is simple. It is wide spread mistake that aquaponics is just combining fish and plants. The process of starting and maintaining an aquaponics system is far more complicated than that. It is a complicated system, where any mistake can lead to the death of plants or fish or even both. Many other variables including these ones need to be considered for the system to work or fail.

Disregarding Algae Growth. One of the biggest reasons for the Ph levels in an aquaponics fluctuates is due to the algae. People ignore the algae growth even though they have to be monitored regularly in the system so it is in good condition. Even though algae is the result of sunlight and nutrient rich water, it is still fatal for the entire aquaponics system.

Feeding Fish once a day. Even though ignorance and laziness is the cause for not feeding the fish but it is extremely important that the feeding has to be done a couple of times in a day and monitored.

Tap Water Usage. It is not recommended for the use of tap water due to its high concentration of chlorine. For the use of chlorine water, it has to be left alone for a couple of days with plenty of aeration to off-gas the chlorine. Rain water is the best water for the aquaponics system which can be stored but the rules and regulations for the storage of rainwater has to be checked as it is illegal in some places due to the scarcity of water.

Energy Deficient Plants. As plants have to be monitored daily and if the signs of deficiency is ignored that will be costly for the system. Plants are the perfect and natural barometer for the aquaponics system. If the plants are not doing well then that is an indication that the system is not functioning properly. Best place to start is with the nutrient levels.

Varying Water Temperatures. Water temperature has various effects such as on the ph level, the amount fish will eat, activity level of the nitrifying bacteria and plant growth. Temperatures with difference of 40 or more is never good for the aquaponics system.

Fish waste is not Sufficient. A strong belief is that the fish waste alone is sufficient for the growth of the plants. It is to the contrary that fish feed given has only 10 out of 13 nutrients needed for the plants, so the waste alone cannot be sufficient. One time or another supplements need to be added in the system to fill the deficiency.

Aquaponics is the face of modern and sustainable method of farming. It is also the most promising and emerging soil less form of farming technologies of the

future. The major issues that are being faced by the governments of the world are that is this organic farming and secondly, in which department does it belong to. In countries like India, the government and their employees have almost zero knowledge about this type of farming, so obviously confusion does arise. Department of agriculture argues that aquaponics belongs in there category and same thing is argued by Department of Fishing. They fail to understand it belongs to both, making it difficult for the farmers to participate. Euro government has been able to peacefully realize that both Common Agriculture Policy and Common Fisheries Policy.

CONCLUSION

It is just unfortunate that this great innovation has been lost in the modern day technologies but it is always said, better late than never. Now we should consider the fact that is we late? Or we are just going to postpone the inevitable. To now seek betterment is not bad, but losing it in times progresses there is no bigger mistake than that. Aquaponics is for the future, because it mimics nature at its best, without any side effects. We are not hurting the soil, we are not adding any chemicals to the soil, those chemicals are not destroying our underground water supplies, and water is being saved.

Aquaponics farming can be just picked up and installed in the middle of the desert, and it will start working with the power of solar. It is hard to conceive that farming can be done in the middle of desert but impossible has been achieved in recent years through aquaponics. Company called Sundrop Farms has successfully started a farm in the desert of South Australia, producing around 17000 tons of tomatoes a year using only solar and sea water. Same can be said in one of the deadliest deserts in the world in Oman, where aquaponics farm is also running successfully.

Times are changing and so are the technology but due to certain factions farming are stuck in the past. With limited resources that are available, sustainable farming with environmental factors need to be given a chance. It is true that to have a running aquaponics an entire ecosystem has to be made and running, such as -farming, processing, storage and transportation. Currently one of the other issues in major countries is that they have land readily available, so the aquaponics is not be given a second thought but in second and third world countries where land is an issue, once started it will bring a revolution.

Current factor is the cost of starting an aquaponics farm, which is definitely an issue but people fail to foresee the future. Unlike conventional farming, once the setup for an aquaponics is done, only basic necessities are required like seeds, water, and labor to maintain the farm. Fish before being sold, can be bred and

seedlings harvested, and the number of seedlings will be far more than what first started with. At first the fish farming will bring far more capital than the vegetables but once the system kicks in vegetables will also catch up. Farmer needs to only change the net pots with new seedlings. Over all the entire cost of fertilizers, pesticides, huge water bills and natural fuel to run huge machinery will come to an end. Setup usually will last for the next 10-15 years, obviously with wear and tear along the way. Employment will also see an increase in due time.

Why is there so much stress being placed on having sustainable farming?
Few of the reasons are:

By 2030 there will be water deficiency by 40%:

By the year 2050, just to be able to meet food security there has to be an increase in production by 50%;

Due to the extensive use of land and current pollution levels, we have already lost over 30% of farmable land;

In countries like UK, only lil over 60 years of farming is left in the soil;

With over 70% of the farmable land is abroad(for UK), the cost of importing is high as well;

What makes the factors look worse is that over 70-80% of drinkable water is being wasted by the soil farmers. A basic example of small farm setup and its economic benefits: " For the 360sq ft farm, the set-up costs were around £7,000. Monthly revenue is projected around £2,100, and monthly costs are around £500. The revenue comes from 117kg Greens, 3-4kg herbs and 13kg of tilapia each month. There are currently 23 large carp and 63 carp overall, and the farm's full capacity is 200 (100kg of fish). Although in practice, the optimum ratio for fish biomass output (waste): Plant nutrient requirements seem lower than expected. These figures don't take into account an identified but not yet implemented identified energy saving of 8%. The revenue would also be significantly boosted by changing the fish species from Tilapia to Koi" [28].

Aquaponics farming is basically utilizing the current space you have more efficiently.

Current world population is over 7 Billion and by 2050, with the rate of increase, we are looking at around approximately 10 billion people. It is not to say that organic soil farming does not yield the results we are looking for but with the current population growth we are looking at higher yielding methods with minimum risks to the population and environment.

Aquaponics is better in many ways even organics, reason for that is there is no adding of any chemicals in the system as the fish will die. Even with many approved organic pesticides fish will die, no matter what. This forces the farmer to be honest and truthful about what is being used to grow vegetables or fruits in the system. While there is no need of soil in aquaponics, organic farmers still end up using fertilizers to grow plants. These fertilizers can be harmful one way or the other.

One health fact that needs to be considered aquaponics system uses fertilizers from the waste of cold blooded fish unlike the fertilizers of warm blooded whom are known to be carrying E Coli or Salmonella. Freshwater fish have no mercury, no growth hormones, no antibiotics, same as the plants, they contain no antibiotics.

Aquaponics has a great future in the developing countries not only for commercial use but also in the form of providing food for the population. It is a rising form of farming there already due to the water shortages that are also plaguing the world. The minimum water usage is great for the environment but also for the population. Being a self-sufficient system after feeding the fish makes it more attractive towards the farmers. Aquaponics potential can be seen in the form of securing the food security, increase in employment, environmental and even economic growth. Aquaponics remove the fact that wheat and rice is only available for nutrition, with aquaponics farming fish is also readily available.

Even though currently aquaponics system has its weakness based on cost and lack of knowledge but even then the cost of its returns is faster than any other farming system available. Aquaponics grows natural foods without fertilizers and pesticides, making their production healthy and rich in nutrients. When the

government will take initiative to promote aquaponics, small farmers again will have huge opportunities not only grow themselves but also contribute to the food security and economy.

Aquaponics is still a powerful concept appealing to promote sustainable and a tool to achieve food security.