

**ECONOMIC ANALYSIS OF HYDROPONIC FARMING IN
KOLHAPUR DISTRICT- A CASE STUDY**

by

Mr. Gujar Pradeep Shivaji
(Reg. No. 019/205)

A thesis submitted to the
MAHATMA PHULE KRISHI VIDYAPEETH
RAHURI - 413 722, DIST-AHMEDNAGAR
MAHARASHTRA, INDIA.

In partial fulfillment of the requirements for the degree

of

MASTER OF SCIENCE (AGRICULTURE)

in

AGRICULTURAL ECONOMICS



DEPARTMENT OF AGRICULTURAL ECONOMICS
POST GRADUATE INSTITUTE
MAHATMA PHULE KRISHI VIDYAPEETH,
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MAHARASHTRA, INDIA

2021

CANDIDATE'S DECLARATION

I hereby declare that this thesis or part
there of has not been submitted
by me or other person to any
other University or Institute
for a Degree or
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CERTIFICATE

This is to certify that the thesis entitled, “**ECONOMIC ANALYSIS OF HYDROPONIC FARMING IN KOLHAPUR DISTRICT- A CASE STUDY**”, submitted to the Faculty of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Dist. Ahmednagar (Maharashtra) in partial fulfilment of the requirement for the award of the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **AGRICULTURAL ECONOMICS**, embodies the result of a piece of bonafide research work carried out by **Mr. GUJAR PRADEEP SHIVAJI** under my guidance and supervision and that no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been duly acknowledged.

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Date : / /2021

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Place: M.P.K.V., Rahuri

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(Mr. Gujar Pradeep Shivaji)

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LIST OF ABBREVIATIONS

%	:	Per cent
/	:	per
₹	:	Rupee
BCR	:	Benefit Cost Ratio
<i>et al</i>	:	<i>et alia</i> (And other)
Dist.	:	District
kg	:	Kilogram (s)
Fig.	:	Figure
g	:	Grams
etc	:	Et Citra, and so on
i.e.,	:	Id Est., that is
Ib.	:	libra (Pound)
FAO	:	Food and Agricultural Organization
US \$:	United State Dollar
ha	:	Hector
m	:	Meters
No.	:	Numbers
eg.	:	Exempli gratia (for example)
NPV	:	Net Present Value
IRR	:	Internal Rate of Return
BEQ	:	Breakeven Quantity
PBP	:	Pay Back Period

ABSTRACT

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2021

Research Guide: Dr. R.B. Hile**Department** : Agricultural Economics

Hydroponics is largely recognized as a solution for sustainable food production as it follows a biomimetic natural system and the circular economy principles, allowing large food productivity on non-agricultural land, and at the same time strongly reducing inputs and waste. The traditional farming system will not be able to cover the world's emergent demand for food with rising pollution level and oscillations in climate. The design and development of new farming and planting system technique is urgent requirement to stay away from food catastrophe in future. In view of this, there is need to study the structure, cost and returns structure, problems faced and remedial measures followed by hydroponically vegetables grower.

Present study was undertaken on “Economic analysis of hydroponic farming in Kolhapur district – A case study”. The present investigation was conducted keeping view the overall objective of studying the economic analysis of hydroponics farming in Kolhapur district as a case study. The study was conducted to examine employment generated by hydroponics unit, costs, returns, economic performance of hydroponic farming unit and constraints faced by the owner of unit. The primary data for the year 2019-20 was collected from the general manager of the unit. The economic analysis was conducted with help of BCR, NPV, IRR, BEQ, PBP and financial ratio analysis.

The result revealed that, there are 7 different vegetables in total *viz.* Iceberg Lettuce, Arugula / Rocket Leaves, Flat Kale, Romaine Lettuce, Swiss chard, Curled Kale American, Baby Spinach, Spinach/Palak. The total employment generated through hydroponic units during one cycle of vegetable production was 535.51 days, out of which 167.04 male days and 368.47 female days were generated from vegetable production, packaging and rearing of fishes.

The initial investment of establishment cost was ₹ 767.2 lakhs, with the Fan pad system of poly house accounting for ₹ 105 lakhs (13.69 %), which includes construction and sheet, GI pipe, polythene sheet, cooling pads, exhaust fans, and other items.

Abstract contd.**Mr. P.S. Gujar**

For the study period 2019-20 total vegetables production were obtained 149.265 MT, with total production of fish as by-product was 61.98 MT. The annual gross returns of the unit were estimated ₹559.32 lakhs, with a total cost of ₹334.62 lakhs, and a total net profit of ₹224.70 lakhs. The total profitability of the unit was worked out over fixed costs and variable cost. The unit as whole the vegetable wise production in hydroponic unit was higher than level of break-even quantity, and overall level Net Present value was ₹14854850.45 at 10 per cent discounted rate, IRR was 13.46 per cent and BCR was 1.67 which is greater than unity. The Pay Back Period of unit was 2 year 9 months. The ratios measure the relationship between two or more components of financial statements and all the financial ratios shows positive trends over the study period. The problems faced by the hydroponic unit were regarding to high initial investment, unavailability of skilled labours, unavailability of healthy and disease free seedlings, control of diseases and pest observed.

The results show us that hydroponic is economically feasible under some reasonable assumptions such as certified organic production. This activity is also environmentally advantageous since it reduces considerably the use of water and fertilizers.

The study suggested that, to improve economic of the business activity to a higher level, the unit may try to procure increased quantity of products and thereby increase the utilization of installed capacity and profitability of the business.

1. INTRODUCTION

1.1 Global Food Challenges and Agriculture

The program for Sustainable Development highlights the need of addressing global concerns such as climate change and poverty, with a concentration on long-term food and nutrition security. One of the world's greatest difficulties, as expressed in the UN's Sustainable Development Goal, is ensuring that a growing global population, predicted to reach roughly 10 billion by 2050, will be able to meet its nutritional needs. Food production will need to expand by 50 per cent globally by 2050 to feed an additional two billion people (FAO 2017).

According to recent research, current agricultural yield improvements will not be enough to meet world food demand is expected to grow by 2050 and that an expansion of agricultural areas will be required to ensure global food security. To meet the Millennium Development Goals, total food production will need to increase by more than 70 per cent in the coming decades (FAO 2009). Simultaneously, food production will certainly encounter other issues, such as climate change, pollution, biodiversity loss, pollinator loss, and arable land degradation. However, severe land degradation, as well as other environmental issues, appears to make this unfeasible.

Agricultural land currently covers more than one-third of the world's land area, yet less than a third of it is arable approximately 10 per cent (World Bank 2018). Over the last three decades, the availability of agricultural land has been slowly decreasing, as evidenced by more than 50 per cent decrease from 1970 to 2013. In short, the global population is rapidly growing, urbanizing and becoming wealthier. These conditions require the adoption of rapid technological advances and production methods which are more efficient and reliable, as well as food supply systems that are more economically viable.

1.2 What is Hydroponic System?

Hydroponics is a method of growing plants without the use of soil. It is a method of growing plants with the use of an inert medium to offer mechanical support, such as gravel, vermiculite, Rockwool, saw dust, coconut fibre, and so on. Hydroponics is originated from the Greek term hydro, which means "water," and ponos, which means "labour," and literally means "water works" Aquaponics is a form of hydroponics that combines two agricultural techniques: aquaculture, or fish farming, and hydroponics, or producing fruits and vegetables in a system without soil.

1.3 History of Hydroponics Farming

In the early 1930s, Professor William Gerick coined the word "Hydroponics" to explain the growing of plants in mineral-rich water without soil. Francis Bacon's 1627 book *Sylva Sylvarum* contained the first recorded work on cultivating terrestrial plants without soil. In 1940, Purdue University researchers invented the nutriculture system. Commercial hydroponics farms were established in Arizona, Abu Dhabi, Belgium, California, Denmark, Germany, Holland, Iran, Italy, Japan, Russian Federation, and other nations during the 1960s and 1970s.

1.4 Global Acreage Under Cultivation of Hydroponics Farming

There has been massive growth in hydroponic cultivation in a number of forward-thinking countries. Due to technological advancements within the industry and numerous economic factors, the global hydroponics market is forecast to grow from US\$226.45 million in 2016 to US\$724.87 million by 2023. The world commercial hydroponics industry has grown 4 to 5-fold in the last 10 years and is currently estimated at between 20,000 and 25,000 ha with a farm gate value of US\$6 to \$8 Billion. The consumer is becoming increasingly concerned over health issues, environmental issues, even water consumption cost and availability these all are catalyst for the further development of hydroponic growing techniques.

1.5 Hydroponics Farming in India

The English scientist W. J. Shalto Douglas introduced hydroponics to India in 1946 and wrote a book on the subject called "Hydroponics: The Bengal System". The earliest research studies took place at the Government of Bengal's Experimental Farm in Kalimpong, Darjeeling. After a detailed analysis of the most critical concerns, the Bengal system of hydroponics was designed in 1946-47, indicating efforts to fulfil Indian conditions. The Indian Hydroponics Market is expected to grow at a CAGR of 13.53 per cent during the period of 2020-2027. Hydroponics, a subset of hydro culture, is a growing plant without soil, using mineral nutrient solutions in a water solvent. Factors like depleting water resources, gradually decreasing land under cultivation and reducing infertility of the soil, etc. are raising the need to invent innovative and fruitful cultivation methods. Hydroponics is one such revolutionary method of farming. Several swaths of waste land in India with poor soil but abundance of water can be converted to hydroponics. All that is required is an impermeable surface at the bottom and water-retaining bunds. The same technology that is used to line canals with polythene might be utilised to build

enormous hydroponic farms to grow food crops, vegetables, and other plants. People in major cities like as Delhi, Chandigarh, Noida, and Bangalore are now growing leafy greens, tiny herbs, and spices on their roofs and balconies for fresh consumption. Today, hydroponics appears to have a brighter future than it had in the previous 50 years.

Retail and hotel chains, fast food chains, railway catering, international food service firms, defense installations, and NGOs are among the consumer markets for hydroponically grown fruits and vegetables. The increased need for high-quality fresh lettuce by commercial institutions, food chains, and restaurants to meet daily requirements is strengthening the market for hydroponically grown leafy greens such as lettuce, which dominates India's fruits and vegetables. India now imports 85 per cent of exotic vegetables from neighboring nations, with a growth rate of 15-20 per cent each year predicted.

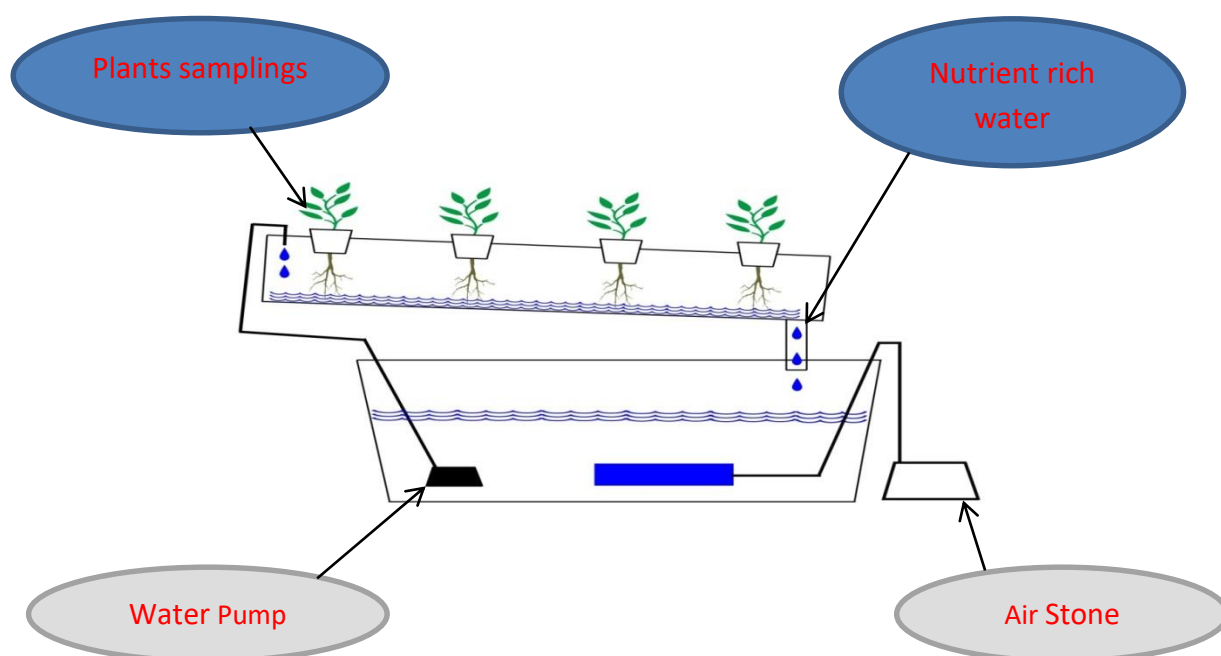


Fig.1.1 Diagram of structures of hydroponic system

for plant growth and development. In terms of water management, it can be thought of as the art of managing water, infusing it with the nutrition plants need, and delivering it to their thirsty roots.

Most hydroponic systems operate automatically to control the amount of water, nutrients and photoperiod based on the requirements of different plants. Plants grown hydroponically receive a well-balanced diet due to which these plants are healthier than their soil-grown counterparts. Unlike traditional agriculture, hydroponics allows for complete control of the crop's nutrition, allowing for the use of only the amount of

nutrients and water required by each crop, resulting in more effective nutrient regulation and better water management.

1.6 Type of Hydroponic Systems

For hydroponics cultivation, there are different systems available. However, while choosing a system, consider issues such as space and other available resources, projected production, availability of proper growing media, and desired quality of the food color, appearance, pesticide-free, and so on. The roots of plants cultivated in solution culture are suspended in nutritional solution.

- i) Circulating Methods (Active or Closed System)/ Continuous Flow Solution Culture
 - A) Nutrient Film Technique (NFT)
 - B) Deep Flow Technique (DFT)
 - C) Ebb and Flow Technique
- ii) Non-Circulating Method (Passive or Open Systems)/ Static Solution Culture
 - A) Root Dipping Technique
 - B) Floating Technique
 - C) Wick Technique

1.7 List of Crops that can be Grown in Hydroponics

Everything starting from flowers to fruits crops to medicinal plants can be grown using soil-less culture. List of crops are listed in Table 1.1, Table 1.2, Table 1.3.

Table 1.1 Various species of plants grown in hydroponic system

Sr. No.	Types of crops	Name of the crops
1	Cereals	Rice, Maize
2	Fruits	Strawberry
3	Vegetables	Tomato, Chilli, Brinjal, Green bean, Beet, Winged bean, Bell Pepper, Cucumbers, Melons, Green onion
4	Leafy vegetables	Lettuce, Spinach, Celery, Swiss chard, Atriplex
5	Condiments	Coriander leaves, Methi, Parsley, Mint, Sweet basil, Oregan
6	Flower/Ornamental crops	Marigold, Roses, Carnations, Chrysanthemum
7	Medicinal crops	Indian Aloe, Coleus

(Source: Singh and Singh, (2012). Hydroponics: A technique for cultivation of vegetables and medicinal plants)

Table 1.2 Vegetable productions under hydroponics farming in India

Sr. No.	Vegetables	Production (g/m ² day)	Sr. No.	Vegetables	Production (g/m ² day)
1	Carrot	56.5	7	Lettuce	226
2	Cucumber	226	8	Onion	56.5
3	Garlic	57	9	Peapod	113
4	Ginger	57	10	Potato	56.5
5	Leek	57	11	Salad greens	226
6	Green Bean	113	12	Tomato	113

(Source: Singh and Singh, 2012. Hydroponics A technique for cultivation of vegetables and medicinal plants)

Table 1.3 Comparison between hydroponic and ordinary soil yields per acre

Sr. No.	Name of crop	Hydroponic equivalent	Agricultural average
1	Wheat	5,000 lb.	600 lb.
2	Oats	3,000 lb.	850 lb.
3	Rice	12,000 lb.	750-900 lb.
4	Maize	8,000 lb.	1,500 lb.
5	Soybean	1,500 lb.	600 lb.
6	Potato	70 tons	8 tons lb.
7	Beet root	20,000 lb.	9,000 lb.
8	Cabbage	18,000 lb.	13,000 lb.
9	Peas	14,000 lb.	2,000 lb.
10	Tomato	180 tonnes	5-10 tonnes
11	Cauliflower	30,000 lb.	10-15,000 lb.
12	French bean	42,000 lb. of pods for eating	
13	Lettuce	21,000 lb.	9,000 lb.
14	Lady's finger	19,000 lb.	5-8,000 lb.
15	Cucumber	28,000 lb.	7,000 lb.

(Source: Singh and Singh, 2012. Hydroponics A technique for cultivation of vegetables and medicinal plants)

1.8 Importance of Hydroponics Farming

A hydroponic acre can yield up to ten thousand plants, while an acre of soil can yield up just one million. The technology enables for increased productivity at lower crop densities (up to 30 plants per m²) with greater control, as well as shorter crop cycles and improved product quality. Plants in a hydroponic system can produce 20–25 per cent more yields than those in a soil-based system, with productivity 2–5 times greater. Hydroponics saves a lot of water and only needs a quarter of the amount of food that a conventional plant does. Because water and fertilizers can be reused, they are kept. There is no mineral

leaching or water leakage. Crop rotation isn't necessary because nutrients aren't lost and soil illness isn't a problem. Rhizoctonia, Phytophthora, and soil nematodes are examples of soil-borne illnesses and germs that can be avoided using a hydroponics system.

Hydroponics is very useful for areas where stress on the environment (cold, heat, desert etc.) is a big problem. Seasonal fluctuations have no effect on growth. The use of hydroponics allows for year-round growth. Cloning or cutting already-bearing plants will shorten their vegetative growth and allow them to flower more quickly. Weeds and parasites are rare in regulated systems, and work is reduced. People will make good use of their time on the rooftop, increasing oxygen output in a suffocating situation. Plants can utilize their flowering and fruiting resources more efficiently thanks to root growth.

In recent years, NASA has done extensive hydroponic research for its Controlled Ecological Life Support System, (CELSS). As it does not require soil for plant growth, it may be helpful for the astronauts during their time in space to get their food. Hydroponics is considered an effective alternative of production by promoting self-sustainability in an environment friendly way, using only 10 per cent of the water used in conventional methods.

Hydroponics encompasses food production systems that are recognized as creative, eco-friendly, sustainable, dependable, and flexible, and consequently more efficient in resource optimization than soil-based agricultural approaches. Hydroponics crops can provide healthier and stronger products, attracting quality-conscious customers and securing a market niche. As a result, as agricultural diversification increases, so does demand for hydroponic products, allowing growers to make more money.

Crowder and Reganold (2015) looked at the financial competitiveness of organic cropping by comparing profit margins between conventional and organic agriculture, however they ignored externalities and ecosystem services. Farming, on the other hand, should be as profitable as it is environmentally beneficial, assuring high-quality goods, farmer well-being, and community development. Organic agriculture's social, economic, and environmental benefits should be promoted more strategically in order to increase its popularity. In the worldwide agricultural picture, hydroponics is becoming increasingly important, and it is usually found in locations where soil access is difficult.

1.9 General Problems of Hydroponics Farming

The problems of hydroponics farming are Initial cost of capital and operating costs are high. It requires specialized knowledge and equipment's. It is a method which is more complex and involved than traditional farming. Plant in a hydroponics system is sharing

the exact same nutrient and water borne diseases can easily spread from one plant to another. Hot weather and limited oxygenation can limit production and may result in crop loss. Maintenance of pH, EC and proper concentration of the nutrient solution is of prime importance. Finally, light and energy supply is required to run the system under protected structure.

1.10 Hydroponics Unit in Kolhapur

Mayank Gupta and Lalit Zawar established hydroponics and aquaponics unit in 2018. Prior to this both are working in other companies; Mayank was working in e-Commerce and Lalit was working in Revolutionary textiles. They visited some agriculture developing countries like Canada, Israel, USA, China, Hong Cong and they got the detail information about hydroponics i.e. “growing without soil.” On basis of this information, they established a hydroponics and aquaponics unit within 15 months. This has been regarded as a biggest project in a Western Maharashtra. They gathered information of various places and its climate, monsoon and transport system. After that, they selected a place “Hatkanangale.” There were two reasons behind selecting this area. One is climate of this region and other is logistic i.e., from this area it is possible to supply the production to about 6-7 metropolitan cities overnight.

1.11 Objectives of the Study

1. To study the structure of Hydroponic Farming
2. To assess the employment generated through Hydroponic farming
3. To estimate the economic performance and financial ratios of Hydroponic farming
4. To identify the problems associated with Hydroponic Farming

1.12 Hypotheses of the Study

1. Null: Hydroponics farming is not economically viable
Alternative: Hydroponics farming is economically viable
2. Null: Employment generated through hydroponic farming is low
Alternative: Employment generated through hydroponic farming is high

1.13 Scope and Utility of the Study

The hydroponics industry has seen a lot of investment in Western Maharashtra, but only a few of them have survived. Too many people are drawn to hydroponics because of the sustainable bio integrated food production system it represents, as well as the opportunity for local food production to supply healthy foods. In the region, there are no proven hydroponics business models that potential investors might review to assist them make informed judgments about entering the hydroponics sector. Financial guidelines can

be obtained by analyzing the financial risks connected with various practices, such as aquaponics and hydroponics.

The findings of the study would also be valuable to the unit owner in identifying flaws in the existing unit and implementing corrective actions if needed. The unit will benefit greatly from the examination of financial measures in recognizing the need for meaningful adjustments in the existing resource consumption and cost structure. The research would reveal the unit's production costs and profitability. In this case, the research will be critical in determining whether the unit is profitable in the area and whether it has generated significant revenue for the owner.

The study would also benefit customers by revealing the cost of production and raising consumer knowledge of fair prices at the time of purchase.

As a result, the study is beneficial to the unit manager, as well as policymakers, consumers, government officials, researchers, and planners. Despite the fact that the study was limited to a single unit, the findings could be applied to other hydroponics units.

1.14 Limitations of the Study

The study is based on the primary data collected by personal interview method in respect of manager. If the conclusions of the study are to be extended to other units with varied time periods, changing resource prices, and processing returns, they must be thoroughly confirmed. Kolhapur district is the research area. There was no information on revenue based on market share.

Fish tanks were installed as complimentary part of hydroponics unit. The feed given to fish produces ammonia which converted into nitrate and supplied to vegetable production tanks. Therefore no separate costs for fish production have been estimated while considered as variable cost in the vegetable production.

1.15 Topic of the Study

The purpose of this research is to look into the economics of hydroponic farming in the Kolhapur district. So far, researches have primarily focused on the cost, returns, and issues associated with vegetable cultivation. In light of the foregoing, it is vital to examine the economics of vegetable production in a hydroponics unit.

The current study, titled "**Economics Analysis of Hydroponics Farming in Kolhapur District-A Case Study**" is a little step in that direction, and it aims to uncover the economics of production, cost, and returns. In view of the aforementioned issues, the current study was conducted in the Kolhapur district of Maharashtra with the overarching goal of learning more about the economics of hydroponics farming.

2. REVIEW OF LITERATURE

Vegetable crops have not only proved as profitable crops, but have a good potential for earning of foreign exchange through export. They also help in demand creation for labour and other agricultural inputs.

In any systematic research the review of literature on relevant aspects under study forms an integral part of the research work. This would help in highlighting the methodology and results obtained by different research workers in similar fields and would serve as a guideline for the research to be carried out.

Some of these studies have some relevance to the objectives of the present study are reviewed under following headings.

- 2.1 Structure of Hydroponic Farming
- 2.2 Employment generated through Hydroponic farming
- 2.3 Economic performance and financial ratios of Hydroponic Farming
- 2.4 Problems associated with Hydroponic Farming

2.1 Structure of Hydroponic Farming

Sardare and Admane (2013) examined a review on plant without soil – hydroponics. The findings revealed that, from the dawn of civilization, open field/soil-based agriculture has faced a number of significant obstacles, the most significant of which is a drop in per capita land availability. Per capita land was 0.5 ha in 1960, when the world's population was 3 billion people; now, with 6 billion people, it is only 0.25 ha, and by 2050, it will be 0.16 ha. Arable area under agriculture will continue to shrink as a result of increased urbanization and industrialization, as well as the melting of icebergs (as a result of global warming). Again, soil fertility has reached a saturation point, and more fertilizer application does not result in greater productivity. Furthermore, poor soil fertility in some cultivable areas, less chance of natural soil fertility build-up by microbes due to continuous cultivation, frequent drought conditions and unpredictability of climate and weather patterns, rise in temperature, river pollution, poor water management and wastage of large amounts of water, decline in ground water level, and other factors are posing a threat to food production. In such circumstances, feeding the entire population only through open field agricultural production will become untenable in the not-too-distant future. To cope with these issues, soil-less culture is becoming more relevant in the current context. Plants are raised without soil in soil-less cultivation. Improved space and water-

saving food production systems under soil-less culture have demonstrated some encouraging outcomes around the world.

Goda *et al.* (2015) studied the bio economic features for aquaponic systems in Egypt. The results revealed that, to reduce the negative environmental impact of aquaculture, plants in aquaponic systems purify the water by absorbing nitrogen and phosphorus from the fish farm and using it for growth as fertilizers, rather than being discharged and contaminating the environment. For the sake of sustainability, two systems were explored in this study employing Renewable Energy Systems: 1) Nutrient Film Technique (NFT) System, Integrated Multi-Trophic Aquaculture (IMTA). 2) IMTA–Floating Raft System (FRS) vs. standard soil culture system. The IMTA–FRS and IMTA–NFT systems had the highest average net income, allowing them to cover costs and attain economic surplus capacity of 53 and 47 per cent, respectively. The results proved the ability of these two systems to resist the weight of higher production costs or take the risk of dropping fish and vegetable prices (risk reduction). However, IMTA–FRS might be called a successful aquaponic model because the duration of capital recovery is shorter (2.17 vs. 3.34 year).

Tokunaga *et al.* (2015) studied economics of commercial aquaponics in Hawaii. The model case's system configuration is shown in the output. Because the size of the raceways and fish tanks on the farms analyzed differed, the researchers developed estimates based on biological considerations and items collected from each farm. The combination of vegetable and fish production is one of the fundamental assumptions. 1.63 gal/sq. ft. is supposed to be the ratio between fish tank volume and vegetable grow bed surface area. To be prudent, this is slightly higher than the three farms' average of 1.47 gal/sq. ft. Each of the four aquaponic systems on the model farm has a 5,000-gallon fish tank, eight 384 square foot raceways, a bio filter, a 0.2 kW water pump, and a 0.4 kW air blower. The racetrack surface area of the farm is 12,288 square feet, and the fish tank volume is 20,000 gallons. Some farms employ an external bio filter, while others use a bio filter in the form of volcanic cinder growing material. Solid's removal devices are present on all farms. We put a bio filter in our system for the purpose of simplicity.

Borges and Dal'Sotto (2016) developed a family agriculture project of lettuce and arugula hydroponic production in a 532 m² greenhouse at the Western Paraná, with an initial investment of \$ 12,515.6 also identified that lettuce is responsible for the largest share of income in the productive system they studied, that is, the representativeness of lettuce in sales reached 83 per cent, followed by arugula with 17 per cent. The NFT

(Laminar nutrient flow) system was employed as the hydroponic cultivation model. This system is made up of a nutrient solution tank, a pumping system, cultivation channels, and a return system to the reservoir.

Karras *et al.* (2016) studied plants palette for hydroponic structures on buildings. The results revealed that, establishment of appropriate hydroponic structures is an interesting means of greening buildings, as these can follow any slope, in contact or in a distance from the structural surfaces. In addition to the technical issues associated with the establishment of such systems, the creation of a palette of plants (ornamentals or vegetables) that could cast shade and decorate a particular part of the building is of great interest, as in most situations these structures are widely visible from multiple points of view. The preservation of various plant species with different requirements at a high-quality level in a single system is a real challenge. The limits set by environmental conditions both in the air (sunlight intensity, temperature, humidity, wind, etc.), and the root zone (EC, pH, oxygen content, moisture levels, etc.) need to be considered. In this paper, the evaluation of various alternatives regarding the use of ornamental plants in such systems is presented. Plants used in both horizontal and vertical hydroponic planting structures were evaluated. Furthermore, two different closed loop systems of nutrient solution supply, especially designed for this type of hydroponic installations, were used. The plant parameters that have been taken into account to evaluate the two systems were the following: aesthetical and functional properties, performance in closed loop hydroponic systems using a single nutrient solution composition, and finally maintenance demands (irrigation, pruning, plant protection, etc.). The best results were received for *Santolina chamaecyparissus*, *Dimorphoteca sinuata*, *Rosmarinus officinalis* 'Prostratus', *Petunia* 'Surfinia', *Pelargonium capitatum*.

Kaur (2016) conducted the field experiment for the development of hydroponic system for greenhouse tomato in the Demonstration Farm of Department of Soil and Water Engineering, PAU, Ludhiana. The experiment was set up in a completely randomised manner with three Hoagland solution treatments (100%), (75%), and (50%). Under regulated conditions, the crop was cultivated in PVC pipes. The temperature and relative humidity in the greenhouse were kept between 24 and 32 degrees Celsius and 40 and 65 per cent, respectively. In the tank, the pH and EC of the Hoagland solution were kept at 5.5 to 6.5 and 1.5 to 2.5 ds/m, respectively. T1 (100%) yielded 72.57 tonnes per hectare, which was equivalent to T2 (75%) yield of 69.28 tonnes per hectare.

Kessens (2016) estimated the growth rate and health aspects of leafy vegetables produced in small-scale aquaponic systems with fish fed on conventional and insect-based fish food. Aquaponics is the mix of fish farming (aquaculture) with growing fruit and vegetables in a hydroponic system, according to the findings. It's a water-saving method for producing a wide range of foods on a small scale. Two aquaculture systems and a hydroponic system that served as a reference were developed in Bethlehem, Palestine, to explore the growth rates of fish and vegetables in small-scale units. Swiss chard was grown in every system (*Beta vulgaris* subsp. *vulgaris*). Each of the aquaponic systems had about 100 Nile tilapia (*Oreochromis niloticus*) in it. An insect-based fish diet was tested to find alternatives to the unsustainable fish meal, which is often utilized as a protein source in fish food. The fish in one system were given fish food made from fish meal, while the fish in the other system were fed fish food made from the larvae of the black soldier fly (*Hermetia illucens*). To assess the health risks of plants grown in various systems, the nitrate concentration of harvested plant tissue, which is thought to be carcinogenic, was measured. The aquaponic systems were also compared in terms of cost effectiveness. The period of data collection began on March 4, 2016 and ended on June 1, 2016. Due to nutrient deficit in the beginning, monthly plant growth in the aquaponic systems (1.24 0.71 kg m²) was lower than in the hydroponic systems (10.42 3.18 kg m²). In the last three harvests, no significant differences across the systems were detected due to heat stress. The amount of fish that grew was significant.

Reshma (2016) examined the Standardization of hydroponics in tomato. The results revealed that, the benefit cost ratio was highest (1.92) in control treatment. Among the hydroponic treatments, F₂S₁M₁, (a combination of Ebb and Flow Technique, Cooper's solution and coco peat) was the best with respect to growth, yield per plant (1.67 kg) and benefit cost ratio (1.33). There was only a reduction of 19.71 per cent in yield for this treatment when compared to plants grown in soil. Under Deep Flow Technique in a unit area of 1m², 14 plants were accommodated, whereas in control there were only 9 plants. When yield per unit area was considered, F₁S₁M₁ (a combination of Deep Flow Technique, Cooper's solution and coco peat) was the best (18.48 kg), and this was on par with the plants grown in soil (18.72 kg). The quality parameters (TSS and acidity) were influenced by the hydroponic methods. The TSS of fruit was higher and acidity was lower under hydroponics compared to soil. The influence of nutrient solutions on the growth and yield parameters of tomato plants were significant. Out of the two nutrient solutions tested, Cooper's solution was significantly better. The growth and yield parameters were

significantly influenced by the growing media and were the best in coco peat medium, followed by pebbles. This may be because of the high nutrient content in coco peat (N- 0.32%, P- 0.01%, K- 0.36 %). In expanded clay pellets, plants were less vigorous. Diseases were totally absent and only stray incidence of insect pests like serpentine leaf miners, mealy bugs and plant hoppers were noticed during the course of the experiment. Biocontrol measures were employed as and when the incidence was observed. Though limitations have been experienced as the first experiment of its kind, hydroponics can be practiced in Kerala by adopting cost effective and locally available growing media, since there is space constraint for conventional cultivation.

Forchino *et al.* (2018) studied the eco-designing aquaponics: a case study of an experimental production system in Belgium. According to the findings, good eco-design is required to reduce environmental impacts while also increasing economic viability. The environmental and economic implications of a proposed experimental indoor aquaponic system in Belgium were estimated using a combination of Life Cycle Assessment (LCA) and Life Cycle Costing (LCC). The findings revealed that the key crucial concerns for achieving both environmental and economic sustainability of this aquaponic system are energy consumption, infrastructure, and water usage.

Lastiria *et al.* (2018) evaluated the Model-based management strategy for resource efficient design and operation of an aquaponic system. The results revealed that, Aquaponics is a method of producing aquatic species and soilless plants in a single system that blends aquaculture with hydroponics. The fundamental problem is balancing the circumstances required for many species to develop, resulting in a dynamic, high-complexity system. Mathematical models aid in the understanding of aquaponics' complicated dynamics, allowing for the construction of more efficient systems. In an existing INAPRO aquaponic demonstration system in Abtshagen, Germany, we devised a water and nutrient management approach for the production of Nile tilapia (*Oreochromis niloticus*) and tomato (*Solanum lycopersicum*). Improved water and nutrient efficiency are the goals of this management technique. We created a system-level mathematical model and simulation for this objective. In our simulations, we discovered that the Abtshagen aquaponic system's current configuration and water management result in an excessive volume of water discharged from the RAS. As a result, moving more nutrient-rich water from fish to plants can help save water and fertilizer. However, excessive concentrations of specific nutrients may result from this water transfer, putting fish, plants, or both at risk. We designed an improved management plan based on our simulations that strikes a

balance between resource efficiency and water quality conditions. This management method keeps fish from getting too much TSS and plants from getting too much Na^+ and $\text{NH}_4^+ -\text{N}$. Simulated water requirements (263 L/kg fish and 22 L/kg tomato) were similar to current commercial RAS and greenhouse horticulture under the enhanced management strategy. Simulated nitrogen, calcium, and magnesium fertilizer requirements (52, 46, and 9 mg/kg tomato, respectively) were one order of magnitude lower than in highly efficient commercial closed greenhouse production.

Sharma *et al.* (2018) studied the hydroponics advanced technique for vegetable production. The findings revealed that, due to effective resource management and high-quality food production, hydroponic farming is currently gaining popularity around the world. Various hydroponic structures, such as wick, ebb and flow, drip, deep water culture, and the Nutrient Film Technique (NFT) system, are discussed in this article, along with their operations, benefits, and limitations, as well as the performance of various crops such as tomato, cucumber, pepper, and leafy greens and water conservation. The NFT approach has been successfully employed commercially around the world for the production of leafy and other vegetables with water savings of 70 to 90 per cent. The Netherlands, Australia, France, England, Israel, Canada, and the United States are the world leaders in hydroponic technology. It is critical to develop low-cost procedures that are simple to run and maintain, need less labour, and have a lower overall setup and operational cost for commercial hydroponic technology to be profitable.

Goddek and Korner (2019) studied the fully integrated simulation model of multi-loop aquaponics: A case study for system sizing in different environments. The decoupled multi-loop aquaponics systems separate the recirculation aquaculture system (RAS) and hydroponic (HP) components, resulting in detached ecosystems with intrinsic advantages for both plants and fish, according to the findings. This provides the benefit of increased crop and fish cultivation while using the least amount of resources. Until now, the primary focus of aquaponics systems has been on fish culture and the treatment of RAS effluent for optimal use in HP, and systems have been designed and sized using plant growth, evapotranspiration, and nutrient needs as rule of thumbs, with the slow responses of RAS dynamics as a foundation. However, the diverse systems and changes in temporal responses of the underlying process must be considered in order to get the best fit between RAS and HP. Fish and plant growth are sluggish processes that take hours or days, whereas photosynthesis and transpiration in crops are quick processes that take seconds or minutes. Because plant transpiration is the primary source of water in a closed loop

system, the system and sub-system sizes required are determined by plant transpiration. As a result, we set out to create an aquaponics-sizing simulator based on deterministic mathematical models that could be easily parameterized and used to a variety of situations. We've combined a full-scale greenhouse simulator with a simulation time of less than one minute, including HP, greenhouse construction, and physics, as well as a very detailed plant energy and growth model with a model for a multi-loop aquaponics system that includes distillation technologies and sumps. We conducted scenario simulation experiments at three different locations to demonstrate the quality and broad application of our theoretical implementation of a multi-loop aquaponics system in greenhouse circumstances, Using the same RAS size and simulating on the fitting HP area, diverse climate zones like sub-arctic cold, mild, and arid subtropical regions (i.e., Faroe Islands [66°N], The Netherlands [52°N], and Namibia [22.6°S]) were created.

Jaeger *et al.* (2019) studied the mass balanced based LCA of a common carp-lettuce aquaponics system. An aquaponics system (AS) is an integrated system that combines a recirculating aquaculture system and a hydroponics system, according to the findings (HS). Its purpose is to recover nutrients generated by fish and transfer them to plants, resulting in a system that is more environmentally friendly than the two systems working independently. As a result, a number of AS are being developed, but little information regarding their overall effectiveness is available. The purpose of this research was to evaluate the nutrient-use efficiency and environmental consequences of an AS, specifically a common carp-lettuce AS grown in a greenhouse. At the same time, nutrient budgets for nitrogen (N) and phosphorus (P) were computed, and a Life Cycle Assessment (LCA) was completed for the AS and a lettuce Individual Hydroponics System (IHS) functioning in the greenhouse, which was comparable to the HS of the AS. In terms of climate change, acidification, eutrophication, land competition, and cumulative energy demand, one kilograms of lettuce growth in the AS had clearly lower environmental impacts than in the IHS; however, no reduction in water reliance was detected. The AS's reliance on natural resources, particularly fish meal and fish oil, was underlined by the indicator for net primary production consumption. In comparison to the IHS's use of chemical nutrients, the AS's use of nutrients from formulated feed reduced climate change impact while increasing natural resource utilization.

Jain (2019) evaluated performance of hydroponics systems for different crops under soil less media, Present study was carried out for performance evolution of hydroponic systems for different crops under soil less media at the Centre of Excellence on

Protected Cultivation and Precision Farming (CoE-PCPF), IGKV Raipur (C.G.) during the year 2018-19. The experiment was laid out with four treatments T₁ (A-frame structures Clay-pellets media), T₂ (A-frame structures Coco-peat media), T₃ (U-shaped structures Clay-pellets media), T₄ (U-shaped structure Coco-peat media) of hydroponic systems. Performance of hydroponic system was evaluated by transplanting Two vegetable crops (Pak-choi and Leafy-garlic) and two flower crops (Chrysanthemum and Petunia) in two different media i.e. coco-peat and clay-pellets. In this system irrigation was applied to the crop by ebb and flow system. Nitrogen, Phosphorus, and Potassium was mixed in water at right balance to make the nutrient solution. Different concentration of nutrient solution was made for different plant growth stages for optimizing the nutrient solution. Results revealed that the yield of pak-choi was found to be more in coco-peat media as compared to clay-pellets media. On the other hand yield of chrysanthemum crop was recorded to be more in clay-pellets media as compared to coco-peat media. Further, Petunia crop yielded higher in clay-pellets media however yield of leafy-garlic was found to be also more in coco-peat media as compared to clay-pellets. At the present investigation we found that fibrous roots crop growth rate is high in coco-peat media, but tap-roots crop growth rate is high in clay-pellets media. In hydroponic cultivation high water use efficiency can be achieved with comparatively lesser area. Under protected cultivation with less cultivated area, more number of plants can be grown as that is more beneficial to small or marginal farmer can earn more profit. Also it was revealed that if hydroponic system of cultivation under protected condition is done one can plant 1.5 times more plants as compared to over land cultivation, because vertical farming is possible in case of hydroponic system of cultivation. This system requires per plant less unit area for planting. On the basis of this study it can be concluded that hydroponic system is very much helpful in cultivation of high value crop like vegetable and flower under protected condition for increasing the farmer income. The present studies are very helpful to do cultivation in hydroponic systems in commercially or any such things to do in future.

Singh *et al.* (2019) estimated the hydroponic farming system of wheat, spinach and sword lily for sustainable development of agriculture. The findings demonstrated that, as the world's population grows, the ongoing increasing need for food production grows. With rising pollution levels and climate oscillations, the old farming system will not be able to meet the world's emerging food need. Designing and developing new agricultural and planting system techniques is an important requirement if we are to avoid a future food crisis. The goal of this study was to look into an efficient lab to land transfer approach for

the hydroponic system, which is an alternative Agri-farming technology. The in vitro data was compared to *Triticum sp.* (Poales: Poaceae), *Spinacea sp.* (Caryophyllales: Amaranthaceae), and *Gladiolus sp.* using numerical methods (Asparagales: Iridaceae). With compared to tap water, the results showed that wheat, spinach, and sword lily grew exceptionally well in Hoagland solution. As a result, the proposed hydroponic system for cereals, vegetables, and flowering crops will be used in the field to meet current and future global demand using sustainable agriculture farming methods.

Emmanuel *et al.* (2021) studied the economics of small-scale aquaponics system in West Africa: A SANFU case study. The findings demonstrated that the essence of aquaponics and soilless agriculture is the integration of hydroponics and aquaculture in a closed system. Aquaponics has been suggested as a way to increase nutrition security in developing countries; however this is a topic that has gotten little attention. This study examines data from the “Sustainable Aquaponics for Nutritional and Food Security in Urban Sub-Saharan Africa” small-scale aquaponics experiment (SANFU). To prove the technological feasibility of this production system, the SANFU aquaponics system depended mostly on rather expensive foreign-sourced components. With a nitrogen outflow of 48.5 g, this aquaponics system can produce approximately 27.9 kg of fish and 3 kg of vegetables each year. Over a 20-year period, this amounts to a relatively unfavorable Net- Discounted Benefit-Cost Rate (DBCR) of 0.08. The same system with locally obtained components and a larger fish stock density, on the other hand, was simulated with a DBCR of 1.12. As a result, aquaponics systems made with local materials may be economically viable, contributing to the beneficiaries' food and nutrition security.

2.2 Employment Generated through Hydroponic Farming

Mhatre (2011) verified that, in the nursery business, the majority of the work was done manually. As a result, this activity employs both expert and unskilled laborers. It was discovered that in the instance of group-I, employment generation was 72.50 female and 61.10 male days, with 51.40 male days being unskilled labour and 9.70 days being skilled labour. Employment was necessary in Group II for 214.60 female days and 140.7 male standard days. Out of these male days, 17.40 days were spent doing skilled labour and 123.30 days were spent doing unskilled labour. Out of the male employment days, group-III generated total employment of 586.20 male and 729.80 female days. Unskilled labour generated 490.80 days, whereas skilled labour generated 95.40 days.

Kazungu *et al.* (2014) studied on the role of nursery gardens as small scale agribusiness enterprises in improving livelihood in Arusha, Tanzania. It documents the

challenges, opportunities, and contributions of industry actors to their livelihood. Some notable contributions include household betterment, access to education, food, and health services, as well as weather and climate regulation. Financial services, dependable markets, increasing input prices, growth space, industrial support, and entrepreneurial skills were all mentioned as hurdles. The study demonstrated the need of appreciating their existence, enhancing production, and improving the situation in a context-specific manner by applying the findings to other cities in the same environment.

Tokunaga *et al.* (2015) studied the economics of small-scale commercial aquaponics in Hawaii. Results revealed that because aquaponic vegetable production require minimal weeding and spraying, the majority of the labor hours are spent dealing with harvesting and post-harvest activities. Processing and packing takes 44 per cent of the labor hours. Our operation assumes both harvest and delivery to occur twice per week. If we increase the frequency of harvesting and delivering, labor hours would increase further. Fish production does not require as much labor input. Using automatic feeders may further reduce feeding hours. For all the farms we studied who sell fish, wholesalers pick up the live fish directly from the farm. Hence, there is no labor input associated with processing and delivering of the fish. Our sensitivity analysis revealed that the overall operational cost is most sensitive to hourly wage, followed by electricity cost. It is unlikely for an hourly wage to fall below the current minimum wage of \$7.25; hence, in order to achieve higher MIRR by reducing labor cost, farms need to reduce labor input.

Quagraine *et al.* (2018) studied the economic analysis of aquaponics and hydroponics production in the U.S. Midwest. The profitability of aquaponics in the Midwest of the United States was investigated in this study. For the study, three operating aquaponics farms, a university greenhouse experiment, and published research were used as sources of data. Results revealed that, quantity of labor required, small farm needs 23 hours per day, a medium farm 31.2 hours, and a large farm 65.8 hours, distributed among the employees. All labor costs \$10/hour.

Nikalje (2020) evaluated the registered vegetable nurseries in Satara district of Maharashtra. The results revealed that the average age of the sample nursery owners was 40.2 years, according to the study's findings. All of the nursery owners in the study were literate. In the nursery units, the majority of the work was done by hand. As a result, nursery work offered ordinary employment.

2.3 Economic Performance and Financial Ratios of Hydroponic Farming

Succop (1998) studied the hydroponic greenhouse production of fresh market basil. Due to its high dollar value and increasing demand, the results demonstrated that common green sweet basil, *Ocimum basilicum L.*, is a viable crop for fresh market greenhouse production. Organic and hydroponically cultivated products help companies save natural resources while also giving them a marketing and sales advantage. During the offseason, hydroponic organic growing methods meet a need for locally farmed organic produce. Colorado growers require data on greenhouse production of fresh market basil in order to be efficient and profitable. The hydroponic greenhouse production of fresh market basil was affected by the growing/irrigation systems. In the 1996 and 1997 experiments, the physical appearance and health of the plants deteriorated after four months of weekly harvesting. The 1996 study reveals a general negative trend in fresh weight and dry weight yields for all growing systems when light intensities decrease, but the 1997 study shows an upward trend in fresh weight and dry weight yields for all growing systems as photoperiod responses increase.

Tisdell (1999) overviewed the environmental and sustainability issues in aquaculture. The findings revealed that aquaculture development is raising questions regarding its environmental repercussions and long-term viability. As the aquaculture sector grows in economic importance, these issues are likely to intensify. This introduction provides an overview of the papers in this issue of Aquaculture Economics and Management, which explore some of these critical issues from an economic and management perspective, and provide policies and processes to solve these concerns.

Adler *et al.* (2000) studied the conventional treatment alternatives for phosphorus in wastewater, whether they employ chemical precipitation, physical removal, or land application technologies, represent a significant additional cost to the owner of an aquaculture operation. The investment study shows that this combined system will be profitable during its estimated 20-year life. For a wide variety of discount rates, net present values are positive. Internal rate of return research indicates that for a total investment of \$244,720, this system has the potential to generate a 12.5 percent return. The combined system's potential profitability is driven by the hydroponic system, which generates 67 percent of annual returns from plant production.

Boaretto (2005) studied four different production systems for lettuce: cultivation in open field, low tunnel, greenhouse soil and hydroponics. The author verified that the

hydroponic system presented the best economic performance, with NPV of \$ 58,677.86 and IRR of 34.26 per cent, in a 12-year horizon.

Chaves *et al.* (2008) estimated the economic and technical viability of incorporating tomatoes grown hydroponically into a recirculation system for channel catfish production. A unit was planned and budgeted to produce 20 tonnes of fish per year. The results revealed that, the internal rate of return (IRR) was calculated to be 27.32 per cent. Comparative results were obtained for a system that only produced catfish. At the budgeted margins, there was minimal change in financial results. However, the joint system's sensitivity to various margins revealed the prospect of higher returns, and the reduction in effluent would offer even more value in terms of societal costs. Thus, merging fish and crop production appears to have economic potential if the margins from both are sufficiently high. However, if the crop output and margin are based on fish effluent as a nutrient, the scale of the crop output and margin is likely to be minimal in comparison to that of fish production.

Rupasinghe and Kennedy (2010) evaluated the economic benefits of an aquaculture-hydroponic integrated system using a hydroponic-lettuce and barramundi fish production system as a case study. Technical data were obtained for a case study farm located at Port Stephens, New South Wales and Australia. Using a capital budgeting methodology, the net present values of yearly cash flows over a 10-year planning horizon were computed for barramundi and lettuce production as stand-alone units, and alternatively as integrated units. The utilization of barramundi effluent as a source of nutrients for lettuce cultivation is possible because too integrated production. This results in an increase in net benefits equivalent to the cost savings from the lettuce system's water and nutrient savings, as well as the cost savings from the barramundi effluent disposal.

Suryawanshi *et al.* (2013) evaluated economics of production and marketing of gerbera cultivation under polyhouse in Kolhapur district. The results revealed that, the average capital investment on construction of polyhouse unit, land value, investment on irrigation system, spraying system, packing house on sample farm was ₹8.47 lakh without subsidy situation whereas it has reduced upto ₹5.66 lakh in with subsidy situation. The per sq. m. investment on polyhouse unit was ₹808.97 and ₹540.59 in without subsidy and with subsidy situation. The total investment on account of land development was ₹157400 and expenditure on planting material was ₹195000 in without subsidy condition. In land development major expenditure was on red soil, rice husk followed by expenditure on farm yard manure. The average fixed cost contributed more than 64 per cent and 53 per

cent in without and with subsidy situation, respectively of the total cost of cultivation of gerbera under polyhouse. This fixed cost comprised of apportioned cost of land development for five years, planting material for three years, poly film for 5 years, polyhouse structure for 20 years and interest on fixed capital @12.50 per cent per annum. Establishment cost on erecting polyhouse constitutes major share followed by cost on account of land development and planting material. The expenditure on account of labour contributed more than 16 per cent followed by expenditure on fertilizers and plant protection chemicals. The total cost of cultivation was found to be ₹4.32 lakh and ₹3.57 lakh in without and with subsidy situation. Per flower cost of cultivation of gerbera at variable cost was ₹0.56 for both the situations whereas at total cost level ₹1.56 and ₹1.20 for without subsidy and with subsidy situation. Per unit cost of production under without subsidy situation worked out to ₹2.32 whereas ₹1.98 under with subsidy situation. The per unit price realized was ₹2.43 for both situations and average net returns estimated were to the tune of ₹0.11 and ₹ 0.45 for without and with subsidy situation, respectively. The B:C ratio and IRR were 1.05 and 14.07 per cent for without subsidy situation and magnitudes of the same were 1.23 and 35.89 per cent. The results clearly indicated that the significance of subsidy for gerbera cultivation under polyhouse. Until and unless farmers are supported with the subsidy for the polyhouse unit they cannot sustain in the gerbera production.

Seibert *et al.* (2014) analyzed the economic viability of a farm's hydroponic greenhouse project at the Northwest Rio Grande do Sul and verified that the investment value greatly depends on the material choice and local conditions. The cost of a galvanized metal structure with countertops, a water reservoir, a pump, and pipes might be as high as \$ 40.68 per square meter. The expenses and costs were calculated. The costs of installation and production of the two crops: lettuce and tomato; as well as the income from this project, represented the largest variable costs and expenses (64.29%), followed by variable taxes (31.12%) and maintenance of machinery, vehicles, equipment, and improvements (4.59%) of the financial and economic feasibility the costs of installation and production of the two crops: lettuce and tomato; as well as the income from this project, respectively. The study's findings suggest that both initiatives are doable. Presenting lettuce production as a shorter-term investment with a higher NPV (net present value), IRR (internal rate of return), and PI (profitability index), but the differences in the results are not significant, and it is important to note that there are no hydroponic tomato producers in the city, and according to market research, tomato production will increase. As a result, it is up to the

enterprising to decide which crop to invest in, with the option of doing both at the same time. The sensitivity analysis was conducted with a 10 per cent decrease in income and a 10 per cent rise in production expenses. Despite this, the feasibility of both projects remains.

Surnar *et al.* (2015) conclude the aquaponics systems aimed to improve the economics and long-term viability of indoor and outdoor fish production. We must reassess agriculture sciences in order to improve farmer health in areas such as sustainability, development, and economic efficiency. This means developing environmentally friendly technology. By combining aquaculture and hydroponics, we can create aquaponics, a new innovation that adheres to sustainable agriculture principles (wastewater bio filtration by plants) and allows us to increase economic efficiency by adding an additional production (organic vegetables) to produce nutrient-dense food.

Walters (2015) studied the quantifying effects of hydroponic systems, nutrient solution, and air temperature on growth and development of basil (*Ocimum L.*) species. Basil (*Ocimum sp.*) is the most popular fresh culinary herb, according to the findings. Because of the increased demand for locally grown food, greenhouse growers are increasing their supply of hydroponically grown culinary herbs. However, there is a dearth of data describing the effect of characteristics such as hydroponic production technology, cultivar, daily light integral (DLI), nutritional solution concentration, and plant density on hydroponically produced basil growth and development. The influence of temperature on basil production is also poorly approximated. Quantify the effect of nutrient solution electrical conductivity (EC) on the growth of basil species and cultivars grown under high and low DLIs, quantify the effect of air temperature on growth and development of basil cultivars grown in nutrient film technique (NFT) and deep flow technique (DFT) hydroponic systems, quantify the effect of nutrient solution electrical conductivity (EC) on the growth of basil species and cultivars grown under high and low DLIs This thesis details the research that was done to achieve these goals, as well as the logic behind it and a discussion of the ramifications.

Borges and Dal'Sotto (2016) developed a family agriculture project of lettuce and arugula hydroponic production in a 532 m² greenhouse at the Western Paraná. Payback (PPD), Net Present Value (LPV), Internal Rate of Return (IRR), and Equilibrium Point were utilized to verify viability. The findings revealed that this activity has a return rate of around 20 per cent per year, which is deemed acceptable in any manufacturing process.

The findings also indicated a quick return on investment, with a time of 2 years, 5 months, and 20 days.

Buzby *et al.* (2016) evaluated the aquaponic crops in a freshwater flow-through fish culture system. The establishment and growth performance of 34 food crops cultivated in a cold, low-nutrient aquaponic system were investigated in this study. The plant growth operation employed process water from a spring-fed flow-through trout raceway with an average fish biomass of 3630 kg as the water and fertilizer supply. The temperature of the process water entering the plant growing channels was 13°C, with average concentrations of ammonium, nitrate, and phosphate of 0.35, 0.34, and 0.19 mg•L⁻¹, respectively. Lettuce, Asian greens, mustards, various greens, vegetables, and herbs were among the crops grown. Low flow (18.9 L/min), high flow (75.7 L/min), and an amended high flow treatment were used to evaluate stand establishment (% filled cells), harvest, and individual biomass. The adjusted high flow treatment was made up of vermiculite planting media that had been amended with composted fish waste and placed in a high-flow channel. These treatments exhibited a nutrient availability gradient, with the low flow treatment receiving the fewest nutrients and the adjusted high flow treatment receiving the most. Due to a lack of area, cultivars were sown in two groups. Set two cultivars were sowed as space became available after set one cultivars were harvested. For most cultivars, stand establishment was better than 80 per cent in all treatments. The herbs sage, garlic chives, and lovage, as well as the crops Swiss chard and beets, which were sown late in the study, showed poor stand establishment. For most cultivars, stand establishment was not significantly different among treatments. The stand establishment of most cultivars did not change significantly across treatments. On the low flow treatment, the majority of cultivars produced the least biomass. Cilantro, parsley, and mint were notable outliers. The high flow treatment grew the best for eight cultivars, including kohlrabi and the bibb lettuce 'Rex'. The remaining 21 cultivars gained the most biomass from the altered treatment, while the increase was minimal in several cases. Furthermore, large increases in stand establishment offset losses in growth for several cultivars. Water quality improved just slightly, most likely due to nutrient mobilization from deposited sediments within the aquaponic channels. Many producers wish to grow aquaponic vegetables, but there is a scarcity of basic information, such as that offered in this study, about stand establishment, predicted harvest biomass, and harvest time, making this work particularly relevant to commercial aquaculture.

Rover *et al.* (2016) verified the economic viability of a hydroponic lettuce production system in the municipality of Tijucas in Santa Catarina, with an initial investment estimated at \$ 17,006.39. A greenhouse project was created to meet the identified need for hydroponic lettuce, which is approximately 3.840 heads of lettuce each month. The project's original expenditure was expected to be \$54, 352, 42, and the system's yearly costs are roughly \$33.091,57, with an annual gross revenue of \$ 62.208,00. The Net Present Value (NPV), Internal Rate of Return (IRR), and discounted Payback economic metrics were used to assess the project's economic viability. The investment was also subjected to a risk analysis utilizing sensitivity analysis. Because the NPV found was \$ 156.765,06, the IRR was 53.45 per cent, and the investment recovery period was 2 years and 2 months, the project to produce hydroponic lettuce in Tijucas was determined to be economically viable.

Quagraine *et al.* (2018) studied the economic analysis of aquaponics and hydroponics production in the U.S. Midwest. The profitability of aquaponics in the Midwest of the United States was investigated in this study. For the study, three operating aquaponics farms, a university greenhouse experiment, and published research were used as sources of data. In the first analysis, the economics of aquaponics and hydroponics systems are compared under similar operating conditions. In comparison to the hydroponics system, the aquaponics system demands a larger initial investment and operational expense, but produces fewer vegetables. Aquaponics, on the other hand, becomes profitable if the vegetable production is managed as an organic production and the harvest is sold at a 20 per cent premium price. The second analysis created three distinct representative farm sizes for basil and tilapia aquaponics production—small, medium, and big. Basil cultivation yields higher financial returns than fish farming. When the basil price is over \$10.00 per kg, any farm size is feasible. Because of cheaper production costs, the larger farm produces the best outcomes.

Gilmour (2018) studied the consumers' willingness to pay for hydroponic lettuce. The findings revealed that, as hydroponic plant production technology improves, a growing number of farms are turning to hydroponic techniques to grow leaf lettuce and other food crops in a controlled environment. The ongoing debate over hydroponics' participation in the USDA organic programme has emphasized the uncertainties surrounding hydroponic vegetable marketing. The National Organic Standards Board decided in November 2017 that hydroponic farms should not be barred from qualifying for organic certification. Because of the ongoing issue, a group of organic farmers has formed

an independent certification programme that excludes hydroponic vegetables. While producers may gain from hydroponic production, it is uncertain how consumers now perceive hydroponic farming. This study employed a non-hypothetical choice experiment to determine consumer willingness to pay for hydroponic and regular lettuce, both with and without organic certification, using responses from 198 supermarket consumers. To see if specific sorts of marketing could change people's opinions and willingness to pay, randomized groups of shoppers were given one of three types of information regarding hydroponic cultivation. Consumers who were not told about the benefits of hydroponic lettuce required a considerable discount to choose it, but those who were given favorable information were unconcerned about whether lettuce was grown hydroponically or traditionally. Furthermore, providing information boosted attitudes toward incorporating hydroponics into the organic programmed greatly.

Nirgude *et al.* (2018) evaluated economics of farmer producer organization (FPO): A case study of Abhinav Farmers Group, Narayangaon, Pune. The findings demonstrated that current assets contribute 11.37 per cent whereas intermediate assets contribute 12.51 per cent and fixed assets share was 76.12 per cent amongst total assets. In current assets highest share was contributed by pre cooling and cold storage receipt i.e. 10.94 per cent. In case of intermediate assets highest share was contributed by cold storage i.e. 6.36 per cent. In case of fixed assets highest share was contribute by building i.e. 76.12 per cent. In total liabilities highest share was contributed by long term liabilities (51.25%) followed by current liabilities (30.35%) and intermediate liabilities (18.40%). In current liabilities highest share was contributed by labour payment (8.31%) followed by container loading charges (4.93%) and employee payment (4.71%). Benefit-cost ratio of FPO was 1.32 at 30 per cent discounted rate and internal rate of return was 32.10 per cent along with payback period of 18.4 years.

Romeoa *et al.* (2018) studied the Environmental impacts of urban hydroponics in Europe: a case study in Lyon. The findings demonstrated that European cities' food provisioning is reliant on the global food supply chain. Economic crises, environmental pressures, and climate change consequences, on the other hand, all pose a threat to food chain stability. Urban agriculture (UA) boosts cities' self-sufficiency and resiliency while also providing beneficial environmental and social outcomes. However, its effectiveness is dependent on a number of factors, including the type of UA and the city's geographic position. From a life cycle perspective, this article examines Reformer's pilot farm, a vertical high-yield hydroponic croft located near Lyon, France. The results reveal that the

hydroponic farm outperforms heated greenhouse cultivations and is comparable to traditional open field farms. Furthermore, the source of the electrical input is a determining factor that permits vertical hydroponic production to beat the two conventional types of agriculture if carbon neutral (e.g., wind energy).

Asciuto *et al.* (2019) studied the financial feasibility study of an aquaponic system in a Mediterranean urban context. In this study, we gathered technical, economic, and production data from a prototype aquaponic plant growing lettuce (*Lactuca sativa*) and Nile tilapia (*Oreochromis niloticus*) in an urban setting in Sicily (Southern Italy), a climate-friendly location for aquaponic production. Its financial feasibility has been assessed through the determination of Net return and Break-Even Point, analyzing on the one hand the items that contribute to the investment (plane Consumers' Willingness to Pay for Hydroponic Lettuce, construction and set up) and the running costs, and on the other hand the revenues from lettuce and tilapia sales. The financial analysis for the first year of the pilot unit's experimental operation clearly revealed that aquaponic farming is likely to be successful, since the operating income is positive and around €290. According to the sensitivity analysis presented in this research, a fall in overall revenue may be slightly more vulnerable to the pilot unit's economic viability than a decrease in operating costs. The findings will aid future aquaponic entrepreneurs in developing a business plan, as well as enable for the further development of such a profitable technology as a viable technique for expanding urban farming in the Mediterranean environment.

Gimenes *et al.* (2019) examined the economic viability of a hydroponic system using a distinguished approach to treat investment risk. The risks of the proposed investment project were factored into an investor's minimal attractiveness rate, which was calculated using theoretical models of established financial markets that were tweaked to account for the unique characteristics of emerging markets like Brazil. Between July and October 2017, the production expenses of a hydroponic farm in Mato Grosso do Sul (Brazil) were investigated. Net Present Value (NPV), Internal Rate of Return (IRR), Modified Internal Rate of Return (MIRR), Benefit-Cost Ratio (BCR), Cash Generating Index (CGI), and Discounted Payback Period were used to assess the project's economic viability (DPP). As a minimum acceptable rate of return, a 9.1060 per cent annual interest rate was selected (MARR). For risk analysis, a sensitivity analysis based on a Monte Carlo simulation was used. The project's initial investment was anticipated to be \$89,653.66, with gross yearly revenue of \$103,903.63. The following financial values were found in the economic viability analysis: NPV (\$ 177,845.74), IRR (30,45%), MIRR (16,81%),

EAV (\$ 24,856.30), BCR (2,13), CGI (2,29), and DPP (\$ 24,856.30). (5,24years). Sensitivity analysis revealed that variations in the farmer's prices have the greatest impact on NPV. The planned investment project's economic viability was confirmed by a risk analysis using the Monte Carlo method.

Perez-Urrestarazu *et al.* (2019) studied the food safety concerns in urban aquaponic production: Nitrate contents in leafy vegetables. Aquaponics is a farming system that may be applied in urban contexts for the simultaneous production of plants (hydroponics) and fish, according to the findings (aquaculture). The fish eat the feed provided, and their waste is naturally converted to nitrate and other nutrients, which are then taken up by the plants, which operate as a natural water filter. Concerns concerning nitrate accumulation in leafy vegetables produced using this technology have been raised in terms of food safety. Three distinct species are examined in this study utilizing a small-scale aquaponic system to see if they are suitable for food based on nitrate levels in their leaves. The detected nitrate concentrations (613, 2387.8, and 1425.4 mg kg⁻¹ for romaine lettuce, Swiss chard, and curly kale, respectively) are below the European Commission's current regulations' nitrate limitations. They also fall within the range of values obtained for the same vegetables grown in a traditional manner.

Mandla (2020) analyzed the economic analysis of production and marketing of major vegetable crops in kullu valley of Himachal Pradesh the results of the study indicate that about 64.09 per cent of the surveyed people were engaged in agriculture. Tomato, cauliflower, and peas were the most common vegetable crops grown. Cropping intensity in the research region ranged from 150.66 to 173.58, indicating that there is room for improvement in farm management to boost returns. The entire cost of cultivation was calculated for three major crops, with tomato (₹129036.00/ha) coming out on top, followed by pea (₹125674.51/ha), and cauliflower (Rs.104969.00/ha). Tomatoes had the highest net returns (₹144266.00), despite the high cost of cultivation, followed by cauliflower (₹125021.00) and peas (₹125021.00) (₹.112361.43).

Ashok and Sujitha (2020) studied hydroponic vegetable cultivation. As a result of the rapid expansion in the world population, several difficulties have come to the fore in recent years. One of these concerns is the shrinking amount of land accessible for soil-based agriculture per population, which has resulted in additional agricultural and environmental issues. It became important to develop new technologies and procedures to endure the current scenario in these crucial situations. While there have been countless studies on soil and in vitro plant cultivation, there have been few on soilless crops. Soilless

agriculture is a new and promising strategy for increasing the yield of several income crops. Apart from the preservation and restoration of cultivation land, soilless farming, particularly the close-loop method, has a number of advantages: it uses recycled fixed quantities of water, saves 85–90 per cent of irrigation water, can be implemented in unfavorable areas for conventional farming, produces near-zero pollution of the environment, and produces a higher yield than traditional farming. As a result, enhanced space and water management approaches for food production under soilless cultivation have yielded encouraging results all around the world.

Bione *et al.* (2021) studied the hydroponic production of 'Biquino' pepper with brackish water. The findings revealed that a study was conducted with this crop grown in an NFT (Nutrient Film Technique) hydroponic system for 120 days after transplanting in order to generate information about the potential of the 'Biquinho' pepper as an alternative crop for regions with limited freshwater but available brackish water, such as the semiarid region, in order to generate information about the potential of this crop as an alternative crop for regions with limited freshwater but available brackish water, such as the semiarid region (DAT). The experiment used a nutrient solution prepared in water from the local municipal supply system (electrical conductivity of water $-EC_w = 0.34 \text{ dS m}^{-1}$) and six other brackish waters prepared artificially by adding NaCl, with electrical conductivity of the nutrient solution $-EC_{sol}$: 2.70 (control), 3.64, 4.58, 5.28, 6.09, 6.90, and 7.77 dS m^{-1} , resulting in seven treatments repeated six times in total. Fruit yield, salt tolerance, and the yield earliness index were all assessed. The yield of 'Biquinho' pepper grown in an NFT hydroponic system with no salinity restrictions was 2.87 kg per plant, or 46.1 Mg ha⁻¹, based on an estimated area of 0.62 m² per plant. The threshold salinity of the 'Biquinho' pepper, which was 5.22 dS m^{-1} in the nutrient solution, corresponding to the relative potential yield, was determined using a plateau followed by exponential decay model. The yield earliness index of the 'Biquinho' pepper was lowered by salinity.

Majid *et al.* (2021) evaluated hydroponic systems for the cultivation of Lettuce (*Lactuca sativa* L., var. Longifolia) and comparison with protected soil-based cultivation. The findings demonstrated that the world's population growth has resulted in the abuse of land and water resources, resulting in their scarcity. Changing climatic conditions and variable weather patterns have exacerbated the existing issues of land and water scarcity, putting a strain on agriculture. The use of cutting-edge technologies in combination with advanced agricultural production methods will undoubtedly improve our ability to deal with today's resource problems. Crop quality improved as well under the deep-water

growing system, as evidenced by higher values of quality parameters such as chlorophyll, total soluble solids, protein, and crude fibre content. Both hydroponic and soil-based systems produced significantly larger yields and nutritionally better product in less time ($P < 0.05$). Under hydroponic conditions, however, the dry matter content was significantly reduced. When compared to the other two ways, the nutrient film technology saved 64 per cent more water. Both hydroponic techniques outperformed soil-based systems according to economic analysis indicators, with benefit-cost ratios greater than 2. Because of its simplicity, ease of operation, higher yield, economic feasibility, and nutritionally superior produce, deep water culture emerged as the most viable technology for adoption under protected agriculture. The study's findings validated hydroponic lettuce production as a viable and long-term replacement for traditional soil-based lettuce cultivation.

2.4 Problems Associated with Hydroponic Farming

Suryawanshi *et al.* (2013) evaluated economics of production and marketing of gerbera cultivation under polyhouse in Kolhapur district. The results revealed that, the huge investment needed for establishment of polyhouse unit, and difficulties and delay in getting subsidy were major problems reported by sample gerbera growers in establishment of polyhouse unit. Cent per cent sample High rate of seedling, pest and disease attack, irregular electricity supply and high cost of fertilizer and pesticide were major problems in production of gerbera. The major problems reported by sample gerbera grower regarding marketing of gerbera were price fluctuations, high commission and transportation charges and lack of market information. The suggestions for the problems in gerbera cultivation under polyhouse were assessed from the sample farms. The fixed price or minimum support price for their produces was the major and foremost suggestion made by the sample gerbera producers in the study area whereas market facility in vicinity area, increase in subsidy amount, easiness in preparing loan proposal, easiness in getting compensation of insurance were other major suggestions made by sample gerbera growers

Tokunaga *et al.* (2015) studied the economics of small-scale commercial aquaponics in Hawaii. Results revealed that commercial farms face a chance of incurring a catastrophic event. For instance, two of the farms they studied experienced a loss of their entire crop because of pest infestation. This caused them severe economic damage via the loss of a key vender in one case. Even if they had not lost the account, the loss would still be significant. By using the model case as an example, the loss of the entire vegetable crop translates to a 17 per cent loss of the total annual production volume, which is equivalent to \$13,292 of lost sales income. Decision reversal analysis suggests that total annual

revenues have to be at least \$88,094 for an investment in aquaponics to be worthwhile. A loss of the entire vegetable crop can happen no more than 19 times during the 30 yrs. period of operation for the farm to maintain average annual revenues above the required level of \$88,094. In other words, an investment in aquaponics becomes not worthwhile if the loss of the entire vegetable crop occurs more than 19 times during 30 yrs. of operation.

Gimenes *et al.* (2019) examined the economic viability of a hydroponic system using a distinguished approach to treat investment risk. The risks of the proposed investment project were factored into an investor's minimal attractiveness rate, which was calculated using theoretical models of established financial markets that were tweaked to account for the unique characteristics of emerging markets like Brazil. Between July and October 2017, the production expenses of a hydroponic farm in Mato Grosso do Sul (Brazil) were investigated.

Poznickova (2019) studied the hydroponic farming and circular economy - implementation of circular economy into hydroponic production. The findings demonstrated that vertical hydroponic farming is an emerging business that has the potential to mitigate the negative effects of traditional farming. Hydroponic farming is a type of controlled environment agriculture in which the plants grow without the use of earth. It is mainly done indoors. Hydroponic production has various advantages for the food system, including water efficiency, space efficiency, year-round production, and system productivity. Despite a number of advantages mentioned in the literature, hydroponic farming has certain drawbacks, including a reliance on electricity to grow, a limited choice of crops appropriate for hydroponic cultivation, and a higher product price. This study examines the issues that arise when plants are produced in the Urban Oasis hydroponic farm in Stockholm, Sweden, and illustrates how the circular economy concept could be implemented into hydroponic farming production to address the issues observed.

To summarize that, the above researchers have studied the economic analysis of hydroponics farming in different crops on particular area. An attempt therefore, will be made in the present investigation to study structure, employment generation, economic performance and financial ratios and problem associated with hydroponics unit in order to find the actual cost, profit, employment generation and problems incurred by the unit in the process of running.

3. METHODOLOGY

Every research project has to be planned and adopted with appropriate methods and procedure to obtain the desired results of the scientific study chosen. This chapter deals with the explanation of method and techniques was used in conducting the present study. The study has been carried out to analyses the financial performance, production cost of vegetables in Hydroponics unit and the production constraints what the unit is facing.

The methodology adopted for the present investigation has been discussed under following headings.

3.1 Selection of the Study Area

The Kolhapur district of Western Maharashtra was purposively selected, as hydroponics unit is located in Kolhapur district and climatic condition is suitable for the production of exotic vegetable in hydroponics unit.

3.2 Data Requirement

The present investigation on Economics Analysis of Hydroponics Farming in Kolhapur District-A Case Study contemplates the study of resource use costs and returns structure, economic viability of unit, employment generated by unit, problems and opinion of the owner in regarding cultivation of vegetables in hydroponics unit. Therefore, detailed data were required on the following aspects.

3.2.1 The major aspects of data requirements were as under

- i. Primary information of the unit.
- ii. Details of production of vegetables.
- iii. Initial investment of the unit.
- iv. Fixed and operating cost of the unit
- v. Repairs and maintenance cost.
- vi. Fees, taxes, insurance and other relevant expenses.
- vii. Labours, supervisory staff and decision makers engaged with their bills, salaries and allowances.
- viii. Problems encountered by the unit in acquisition of raw materials, production processes

3.3 Sources of Data

The study contemplates to assess the performance of hydroponics unit in Kolhapur District of Maharashtra. Obviously, the data were required on various factors of different vegetables which are being produced in that unit. The data was collected from the

available records, registers of the hydroponics unit through discussion with the management also through personal interview with the manager of unit.

3.4 Collection of Data

The primary data was collected for the year 2019-20 regarding the data of production, sales, financial information, employment generated and production cost of the vegetables by survey method through personal interview with the manager of unit. The efforts were made to prepare report with the manager through the personal assistance of owner and other supervisors. The data was collected from the available records, registers of the Hydroponics unit through discussion with the management.

3.5 Method of Analysis

The data collected from the unit was compiled according to different vegetables. The compiled data was further analysed to obtain a results of the study.

3.5.1 Estimation of Production Costs and Returns

The production cost was estimated with the help of fixed cost and variable cost concept. The direct and indirect costs were estimated. The details of operating cost used in present study was as below,

i) Items of direct costs

1. Male and female labour wages
2. Cost of seedlings
3. Cost of inert medium
4. Cost of organic fertilizer
5. Cost of fish feed
6. Cost of plant protection material
7. Land revenue
8. Miscellaneous expenditure.

ii) Items of indirect costs

1. Interest on working capital
2. Interest of fixed capital
3. Depreciation on sheds, machinery, irrigation structure, hand tool and implements
4. Rental value of land
5. Supervision charges

3.5.1.1 Operating costs

The operating costs are the fixed and variable costs. The variable costs that vary according to level of output. These are incurred on the production component with which they are closely related and are included in the enterprise budget for that component only.

a) Fixed cost

It includes the cost on account of annual land rent, depreciation on building, machinery, polyhouse, electrification maintenance and depreciation, license fees, interest on fixed capital, insurance and taxes.

The methodology adopted for valuation of different items of cost in estimation of cost of cultivation is discussed in subsequent paragraphs.

i. Rental value

To calculate the annual fixed cost, the rental value of land was calculated at the actual rent paid by the unit owners.

ii. Depreciation cost

The farm assets, such as implements and farm buildings, as well as machinery, were valued at current market prices while taking into account the assets' condition.

The straight line technique was used to compute the depreciation of these assets for the current year. The present value and remaining useful life of assets were assessed for this purpose.

$$\text{Depreciation} = \frac{\text{Present value} - \text{Junk value}}{\text{Expected remaining life of assets}}$$

The junk value of the asset was considered to be 10 per cent of the present value of the asset.

iii. Interest on fixed capital

The interest was imposed at a rate of 10 per cent per year on the present value of fixed assets (excluding land) such as agricultural buildings, implements, and equipment. The interests on permanent assets, such as irrigation structures, were not considered in the research because the hired expenses towards them were taken into account.

iv. Land revenue and other taxes

This item of cost included land revenue and other relevant taxes which were actually paid by the unit owner.

b. Variable cost

The variable costs that vary according to level of output.

i. Human labour

It included hired human labor. Human labor cost comprises of,

- a. Wages actually paid to the hired labor as also those paid to the labor obtained on contracts for the whole year or part thereof.
- b. Wages paid to the attached farm servants for the different operations that have been included in the hired labor.

ii. Planting material

Seedlings were purchased from commercial nurseries by the growers. The current rates in the area were used to calculate the cost of planting material.

iii. Fish Cost (fingerlings)

Fingerlings were obtained from commercial fingerling nurseries by the growers. The current rates in the area were used to calculate the cost of fingerling.

iv. Feed for fishes

The fish are fed a 32 per cent protein feed. The current market rates were used to calculate the cost of feed.

v. Organic fertilizers

The fertilizers cost were calculated using the grower's real fertilizers pricing.

vi. Bio Insecticides and bio pesticides

Bio insecticides and bio pesticides were charged at the actual price paid by the grower.

3.5.2 Financial Performance Analysis**3.5.2.1 Break even analysis**

The break-even point is the level of operation at which total revenue equals to total costs. The break-even quantity is estimated by using the formula,

$$\text{BEQ} = \frac{\text{TFC}}{\text{P} - \text{VC}}$$

Where,

BEQ = Break even quantity

TFC = Total annual fixed cost (₹)

P = Price per kg produced (₹)

VC = variable cost per kg produced (₹)

3.5.2.2 Net present value

It is simply the present worth of cash flow stream. The selection criterion of the current NPV were estimated by using the following equation,

$$NPV = \frac{P_1}{[1+i] t_1} + \frac{P_2}{[1+i] t_2} + \dots + \frac{P_n}{[1+i] t_n} - c$$

Where,

- P = Net cash flow
 i = Discount rate
 t = Time period
 c = Initial cost of investment

3.5.2.3 Internal rate of return

The internal rate of return of an industry is the discount rate, which makes net present value equal to zero. It was calculated by using the formula.

$$IRR = \text{Lower Discount Rate} + \frac{\text{Difference between two discount rate}}{\left\{ \frac{\text{NPW at lower discount rate}}{\text{Difference between NPW At two discount rates}} \right\}}$$

3.5.2.4 Payback period

Payback period (PP) is the number of years it takes by a unit to recover its original investment in a project, when net cash flow equals zero. In the calculation of the payback period, the cash flows of the project are estimated. The payback period was simple calculation.

$$PP = \text{Years full Recovery} + \left\{ \frac{\text{Unrecovered cost at beginning of last year}}{\text{Cash flow in following year}} \right\}$$

3.5.2.5 Benefit: cost ratio

The efforts were made to estimate benefit cost ratio to compare the relative economic efficiency unit. It is the ratio of total returns to total cost. It is worked out by applying the formula the formula;

$$BCR = \frac{T_R}{T_C}$$

Where,

- BCR = Benefit cost ratio
 T_R = Total return (₹)
 T_C = Total cost (₹)

3.5.3 Financial Indicators

Tests of liquidity were framed to test the ability of the farming units to meet the current financial obligations. Liquidity plays a prominent role in business enterprises through its sensitive characters of meeting immediate financial demands.

1. **Current Ratio** =
$$\frac{\text{Total Current Assets}}{\text{Total Current Liabilities}}$$
2. **Acid test or Quick ratio** =
$$\frac{\text{Quick assets}}{\text{Current liabilities}}$$
3. **Net working capital ratio** =
$$\frac{(\text{Current assets} - \text{Current Liabilities})}{\text{Total assets}}$$
4. **Net capital ratio** =
$$\frac{\text{Total assets}}{\text{Total liabilities}}$$
5. **Debt equity ratio** =
$$\frac{\text{Total Liabilities}}{\text{Net worth}}$$

3.5.4 Problems in Production of Vegetables in Hydroponic Farming

The problems in production of vegetables in hydroponic unit were analyzed by using a tabular method. In the tabular method, constraints of production of vegetables in hydroponics unit were presented. The constraints were estimated with the help of simple percentage.

4. RESULTS AND DISCUSSION

This present chapter has been devoted to explain the results of data analysis, with certain linkage of facts arrive at some meaningful inference, in relation to objectives under study. The major emphasis of the study is on resource structure, costs and returns of hydroponics farming. The employment generated and problems in production of vegetables were also studied. The primary data for the year 2019-20 regarding the production, sales, financial information, and production cost of the vegetables was collected by survey method through personal interview with the manager of unit and the results are presented as below. In general, this chapter deals and presents the objective wise findings of the study under the following major heads.

- 4.1 Structure of Hydroponic Farming
- 4.2 Employment generated through Hydroponic Farming
- 4.3 Economic performance and financial ratios of Hydroponic farming
- 4.4 Problems associated with Hydroponic Farming

4.1 Structure of Hydroponic Farming Unit

Information regarding structure of hydroponics unit was discussed under different heads.

4.1.1 Organizational Structure

4.1.1.1 Owners

They are in charge of articulating the unit's vision and mission, as well as developing strategies and offering support to the vision. The unit is under their control and supervision, examines the unit strategies progress, administration of the unit and overall planning for development and growth of the organisation and its activities. Providing resources like human, work environment, infrastructure, interfaces management with local suppliers, review of quality management of internal/external and interfaces for assuring continuous improvement of units performance, image and goal.

Take care of all customer relations in compliance with the unit policies and objectives, interacting with them for quality, services, suggestions, modification, resolving complaints, arranges for market survey analysis. Manages all the material procurement, appoint suppliers and review the total performance.

4.1.1.2 Manager

The manager is in charge of making the best use of resources (such as materials, machines, and information, as well as investment) to carry out all production-related

activities, such as planning production/packing, manpower planning and utilisation, unit utilisation and maintenance. Planning and maintenance, product improvement, and maintaining calibration of all testing equipment and measuring equipment's, (at work and at collection centres) maintaining and improving work environment, workmen training, increasing productivity and quality on continuous basis, following safety and regulatory norms and complying statutory requirements. The manager is in charge of owner reporting, and his report is based on the information gathered.

4.1.1.3 Head of department

1. Agronomy department

The head of department of agronomy was in charge of production scheduling of the unit. The unit keeps track of production data such as transplanting dates, which is provided by a head of department appointed by the unit.

The agronomist also advises the employees on spraying schedules. The agronomist assures that the farm is free of pests and diseases and estimates the harvesting date. Agronomists supervise the vegetables unit every day.

2. Procurement department

The acquisition of essential inputs is the responsibility of head of the procurement department. One of the key limiting elements that affect the quality of vegetables is the seedling. The diseases and pests that occur on vegetables are transmitted from nursery to field and that is why the selection of good and healthy nursery seedlings is very important. Also, this department completes the requirements for other inputs like seaweed, chelated iron, protein feed for fish, packaging materials, stationery for the office, etc.

3. Production department

The head of production department plans the year's production. This plan was created based on information provided by the accounting department regarding vegetable demand. The order is then sent to the procurement department by the production department. The input, such as nursery seedlings, organic fertilisers, fish feed, bio pesticide and bio fungicide treatment, is then collected according to the qualitative and quantitative requirements.

4. Packaging department

The responsibility of the head of this department is to maintain proper sanitation and hygiene during the packaging process. The packaging of vegetables is a very important practice in this unit as vegetables are perishable goods and quality packaging increases the shelf life of the vegetables.

5. Accounting and finance department

The head of accounting and finance department were responsible for all receivables, cash transactions, banking, bill payments, all outside licences, mending finance statements, all store activities, and central service department, as well as maximising resource use. He was incharge of the accounts receivable accountant, cashier, storekeeper, and computer operator.

6. Maintenance department

The head of maintenance department were responsibility for all maintenance of unit.

- a) Maintaining quality during harvesting and packaging in the unit.
- b) Maintaining inventory in accordance with established procedures.
- c) Issuing alerts for items that are out of stock.
- d) Receiving material requests from all departments.

i. Electrician

The electrician was part of the maintenance department and he was responsible for all electrical activities carried out viz., to check the electric supply of the pumps and motors in the unit, to check all the pumps, motors, and exhaust fans in the unit, and to check the bulbs, CCTV, and other electric instruments in the unit.

4.1.1.4 Human resource management

Human resource is the most important in any business which is, solely responsible for the success or failure of any unit. It is a special branch of management, dealing with the human factor and human relationships in the company.

Table 4.1 No. of workers of Hydroponic unit

Sr. No	Labours	Male	Female	Overall
1	Skilled	3	4	7
2	Unskilled	2	9	11
	Total	5	13	18

Table 4.2 Other employee of hydroponic unit

Sr. No.	Employee / Workers	Number of employees
1	Manager	1
2	Agronomist	1
3	Supervisor	2
4	Technician	1
5	Office staff	3
6	Drivers	2
7	Security guards	2
	Total	12

It is concerned with the development and application of manpower planning, recruitment, training, terms of employment, methods and standards of remuneration, working conditions, etc. for the welfare of employees in the unit. Opportunity for permanent employment through improved Skill and knowledge. Also, the unit require number of skilled labour and hence, there is problem of availability of labour.

4.1.2 Infrastructure

The hydroponics unit occupies nearly a 2 acre area, out of which a 6000sq. m. area was under the polyhouse and the remaining area includes an office building, cold storage room, loading space, store rooms etc

Table 4.3 Specifications of Hydroponics System

Sr. No.	Particulars	Specifications
A	Grow beds/ Raft	
I	Length	80 ft.
ii	Width	8 ft.
li	Surface area per raft	640 sq. ft.
Iv	Number of rafts	32
V	Total surface area for vegetable production	20,480 sq. ft.
B	Fish tank	
I	Diameter	30 ft.
ii	Depth	4 ft.
iii	Fish tank volume	2827.43 cubic ft.
Iv	No of fish tanks	16
V	Total fish tank volume	43238 cubic ft.
C	Area under building, storage, cold storage and open space	21527 sq. ft.

It is observed from Table 4.3, the total surface area for vegetable cultivation was 20480 sq.ft. The length and width of the growing bed were 80 ft. and 8 ft., respectively. The total surface area under one raft, i.e., growing bed, was 640 sq. ft. and there were 32 total rafts. Each growing bed can accumulate 96 foam sheets. The foam sheets were of various sizes, i.e. 18, 36, 72 seedlings per sheet. The aeration was supplied to all rearing tanks and to the hydroponic tanks with diffused air from 2 regenerative blowers, 1 hp and ½ hp. Water was pumped through the system with a ½-hp circulating pump. From one valve, nutrient reaching water was taken inside and, from the other end; it was expelled and forwarded to the filter. After filtration, the water is transferred to the fish tanks.

In the fish tank compartment, there were a total of 16 fish tanks available, each measuring 30 ft. in diameter and 4 ft. in depth. The total volume of each tank was 2827.43 cubic ft. and it accumulates 2000 fish in each tank. 10 kg of 32 per cent protein feed was mixed into each tank daily. The water containing fish excreta from the tank was then transferred to a filter where ammonia in the water was converted to nitrate with the help of MBBR bio filters. Each filter contains nearly 40 kg of MBBR. After conversion, that water was forwarded to a tank where seaweed and iron were mixed. 100 gm. of chelated iron and 150 gm. of seaweed were mixed per day. Then that nutrient rich water was transferred to the rafts and the cycle was completed.

The area under the building was 21527 sq. ft. and it included an office, a storeroom, a cold storage room, a packaging room, etc. The similar findings were reported by Karras *et al.*, Sharma *et al.* and Tokunaga *et al.*

4.1.3 Production of Different Vegetables by Hydroponics Unit

Table 4.4 List of the vegetables produced in hydroponics unit

Sr. No.	Vegetables	Cultivation period in unit (Weeks)	No. of cycles per year
1	Iceberg Lettuce	6	8
2	Arugula / Rocket Leaves	4	12
3	Flat Kale	4	12
4	Romaine Lettuce	6	8
5	Swiss Chard	4	12
6	Curled Kale American	4	12
7	Baby Spinach	4-5	11-12
8	Spinach	4-5	11-12

A huge number of plants, crops or vegetables can be grown in a hydroponics system. The consistency of the stock, flavour, and nutritional content of the finished products is frequently better than that of natural soil cultivation. Leafy greens (lettuce, spinach, parsley, celery, and atriplex, among others) can be grown successfully and easily in hydroponic systems. Due to their increased growth and nutrient absorption capacity, lettuce and spinach are the most promising species to develop in integrated hydroponic and aquaculture systems.

The hydroponic unit produces eight different types of vegetables. The information regarding different vegetables that cultivated in the unit is represented in Table 4.4.

The total cultivation period of iceberg lettuce and arugula/rocket leaves is 8 weeks. These vegetables take 15 days in the nursery and 6 weeks in the unit to cultivate. This

indicates that these two crops go through eight cycles in a year. The remaining eight vegetables had a total cultivation period of 6 to 7 weeks in which it takes 4-5 weeks in units along with a 15-day nursery period, which means they go through 11-12 cycles in a year.

4.2 Employment Generated through Hydroponic Farming

Human labour is one of the most important inputs in any manufacturing process. The skilled and unskilled labour are needed in the hydroponics unit to perform various tasks, such as filling cups with coconut fibre, transplanting seedlings, cleaning, thinning, spraying, harvesting, and packaging of vegetables.

The skilled labour was required for the transplanting of seedlings, spraying and harvesting. Other work, like filling cups, cleaning, and thinning, is done by unskilled labour. Harvesting and packing of lettuce was very labour intensive.

The employment generated through hydroponics unit are estimated and depicted in Table 4.5. It is seen from the table, the total employment generated through hydroponic units during one cycle of vegetable production was 535.51 days, out of which 167.04 male days and 368.47 female days were generated from vegetable production and packaging. The total employment generated through hydroponic units during the study year from vegetable production was 5734.20 days, out of which 1790.16 male days and 3944.04 female days were generated.

The iceberg lettuce and romaine lettuce vegetables have a higher cultivation period and complete 8 cycles in a year. The iceberg lettuce vegetable generated the highest employment per cycle than other vegetables, which was 16.71 per cent, out of which 16.94 per cent of total male days and 16.61 per cent of total female days were generated.

The arugula / rocket leaves, flat kale, swiss chard, curled kale American, baby spinach and spinach are six vegetables that were completed 12 cycles annually.

The baby spinach vegetable generated the highest employment per year than other vegetables, which was 13.92 per cent, out of which 14.04 per cent of total male days and 13.87 per cent of total female days were generated annually.

Similar results were observed by the Quagraine *et al.* in the report of Economic analysis of aquaponics and hydroponics production in the U.S. Midwest and paper was published in Journal of Applied Aquaculture (2018).

The hypothesis stated that employment generated through hydroponics farming is high has been proved.

Table 4.5 Employment generated through hydroponics farming unit

Sr.No.	Name of the Vegetables	Male		Female		Total	
		Days/cycle	Days/Year	Days/cycle	Days/Year	Days/cycle	Days/Year
1	Iceberg Lettuce	28.29 (16.94)	226.32 (12.64)	61.20 (16.61)	489.60 (12.41)	89.49 (16.71)	715.92 (12.48)
2	Arugula / Rocket Leaves	17.10 (10.24)	205.20 (11.46)	41.26 (11.20)	495.12 (12.55)	58.36 (10.90)	700.32 (12.21)
3	Flat Kale	19.28 (11.54)	231.36 (12.93)	39.00 (10.58)	468.00 (11.87)	58.28 (10.88)	699.36 (12.20)
4	Romaine Lettuce	25.29 (15.14)	202.32 (11.30)	58.20 (15.80)	465.60 (11.81)	83.49 (15.59)	667.92 (11.65)
5	Swiss Chard	20.30 (12.15)	243.60 (13.61)	43.15 (11.71)	517.80 (13.13)	63.45 (11.85)	761.40 (13.28)
6	Curled Kale American	16.08 (9.62)	192.96 (10.78)	37.1 (10.07)	445.20 (11.29)	53.18 (9.93)	638.16 (11.13)
7	Baby Spinach	20.95 (12.55)	251.40 (14.04)	45.58 (12.37)	546.96 (13.87)	66.53 (12.42)	798.36 (13.92)
8	Spinach/Palak	19.75 (11.82)	237.00 (13.24)	42.98 (11.66)	515.76 (13.07)	62.73 (11.72)	752.76 (13.13)
	Total	167.04 (100)	1790.16 (100)	368.47 (100)	3944.04 (100)	535.51 (100)	5734.20 (100)

(Figure in parentheses indicates percentage to respective total)

4.3 Economic Performance and Financial Ratios of Hydroponic Farming

4.3.1 Initial Investment

Table 4.6 Total investment in hydroponics unit (2017-18)

Sr. No.	Name of Assets	Amount (₹ lakh)	Per cent
1	One time deposit included land rent during establishment period		
	a. One time deposit	70	9.12
	b. Land rent during establishment period	15	1.96
2	Land development	37	4.82
3	Water resource	19	2.48
4	Buildings	73	9.51
5	Polly house	105	13.69
6	Electricity setup and CCTV	28	3.65
7	Grow beds	9	1.16
8	Fish Tank	3.2	0.42
9	HS Motors and Plumbing	42	5.47
10	Installed Machinery	8.07	1.05
11	Solid filter and MBBR	26	3.39
12	Foam and Cups	8.5	1.11
13	Refrigerators and Coolers	40	5.21
14	Packing Machinery	18	2.35
15	Wages and Salary	87	11.34
16	Consultancy and registration	18	2.35
17	Admin and Vehicle	22	2.87
18	Furniture, Computers and office stationary	19	2.48
19	Interest for first 18 Months	65.43	8.53
20	Margin money for working capital	54	7.04
	Total	767.2	100

The capital investment plays an important role in the creation of infrastructure facilities for running any activity on a commercial scale. The information regarding the initial investment for the creation of infrastructural facilities such as land, pollyhouse, and machineries for carrying out various operations of hydroponic units during its first year of operation was estimated and depicted in Table 4.6.

It is observed from the table, the entire initial investment was ₹ 767.2 lakhs, out of which the highest share was observed for the structure of the pollyhouse, which was accounted for ₹ 105 lakhs (13.69%), which includes sheet, GI pipe, polythene sheet, cooling pads, exhaust fans, irrigation and drainage systems, etc.

The expenditure share on polyhouse was followed by wages and salaries, which was accounted ₹ 87 lakhs (11.34%), paid to the labour and employees during the establishment period, followed by building, which was ₹ 73 lakhs (9.51%) that included office, storeroom building, loading area and fencing followed by a one-time deposit of ₹70 lakhs (9.12%).

The share of interest for the first 18 months incurred ₹ 65.43 lakhs (8.53%) followed by margin money for working capital that is to the tune of ₹ 54 lakhs (7.04%), which the unit requires to manage for its short-term financial goals. The share of expenditure on land development incurred ₹ 37 lakhs (4.82%) and it were included leveling of land, road construction, etc.

The share of water resources was incurred ₹ 19 lakhs (2.48%) and it was included well and boar well. The installed machinery included all machinery, air pumps and other accessories and the share was accounted to ₹ 8.07 lakhs (1.05%).

4.3.2 Operating Costs

The operating costs are the fixed and variable costs. The variable costs that vary according to level of output. These are incurred on the production component with which they are closely related and are included in the enterprise budget for that component only. The information related to annual fixed and operating costs for the study year 2019-20 is depicted in Table 4.7.

The total cost estimated was ₹ 334.62 lakhs, with the total annual fixed cost being ₹133.55 lakhs (39.91%) and the variable cost being ₹ 201.07 lakhs (60.09%). Among annual fixed costs, the highest expenditure share was on taxes (7.30%) due to they had high investment and business value. The expenditure on the depreciation of machinery and equipment (7.14%) and insurance (5.38%), which protect the unit from various risks were the major items of fixed costs.

In the operating cost the highest expenditure share was on labor pay and wages (17.18%) followed by seedlings (Nursery charges) 12 per cent, electricity power charges (10.46%) and feed for fishes (8.1%) were noticed.

In line with findings from other studies (Quagraine *et al.*, 2017; Tokunaga *et al.*, 2015; Rupasinghe and Kennedy, 2010), labour is the main cost item. Energy costs were also higher reported by Tokunaga *et al.* (2015) and Quagraine *et al.* (2017).

Table 4.7 Total operating costs for vegetable production for the year 2019-20

Sr. No.	Particulars	Amount (₹ lakhs)	Per cent
A	Fixed costs		
1	Annual land rent	9.50	2.84
2	Depreciation on Building	8.52	2.55
3	Depreciation on Machinery and Polly house	23.90	7.14
4	Depreciation on Furniture	01.90	0.57
5	Electrification maintenance and depreciation	12.64	3.78
6	Interest on fixed capital @10%	12.16	3.63
7	License fees	17.50	5.23
8	Insurance	18.00	5.38
9	employee insurance	5.00	1.49
10	Taxes	24.43	7.30
	Subtotal (A)	133.55	39.91
B	Variable cost		
11	Cost of seedling (Nursery charges)	40.17	12.00
12	Fish fingerlings cost (hatchery charges)	0.65	0.19
13	Feed for fishes	27.10	8.10
14	Organic fertilizers and nutrient source	5.67	1.69
15	Organic Plant Protection (Neem oil, etc.)	4.50	1.34
16	Labour wages & Salary of employee	57.50	17.18
17	Telephone and Internet Charges	0.76	0.24
18	Legal expenses	2.32	0.69
19	Water charges	0.60	0.18
20	Electricity charges	35.00	10.46
21	Repair and maintenance	2.80	0.84
22	Office expenses	0.50	0.15
23	Boxes	5.30	1.58
24	Labels	1.50	0.46
25	Packaging Bags	3.70	1.11
26	Fuel charge	13.00	3.88
	Subtotal (B)	201.07	60.09
	Total cost (A+B)	334.62	100

4.3.3 Per kg Cost of Vegetable Production

The information regarding per kg cost of vegetable production is presented in Table 4.8. Among total vegetable production, the maximum per kilogram production cost was observed for the arugula / rocket leaves (₹ 489.26) followed by the romaine lettuce (₹ 241.08), curled kale American (₹ 214.56), flat kale (₹ 210.65), swiss chard (₹ 210.62) and

baby spinach (₹ 208.15). The minimum per kilogram production cost was observed for the iceberg lettuce (₹ 139.67) followed by spinach (₹ 188.38) due to low seedling cost.

Table 4.8 Per kg cost of vegetable production

Sr. No.	Vegetables	Annual production (MT)	Total cost (Lakh ₹)	Cost of vegetable (₹/kg)
1	Iceberg Lettuce	17.856	24.94	139.67
2	Arugula / Rocket Leaves	11.544	56.48	489.26
3	Flat Kale	20.760	43.73	210.65
4	Romaine Lettuce	17.152	41.35	241.08
5	Swiss Chard	20.160	42.46	210.62
6	Curled Kale American	20.004	42.92	214.56
7	Baby Spinach	20.317	42.29	208.15
8	Spinach	21.472	40.45	188.38

4.3.4 Return from Vegetable Production

The information regarding returns obtained from vegetables production is presented in Table 4.9. It is revealed from the table; the total annual production of vegetable was 149.265 MT.

Table 4.9 Returns from vegetable production

Sr. No.	Vegetables	Annual production (MT)	Unit price (₹)	Revenue (Lakh ₹)	Per cent
1	Iceberg Lettuce	17.856	195	34.82	07.25
2	Arugula / Rocket Leaves	11.544	550	63.49	13.22
3	Flat Kale	20.760	345	71.62	14.92
4	Romaine Lettuce	17.152	345	59.17	12.32
5	Swiss Chard	20.160	295	59.47	12.39
6	Curled Kale American	20.004	395	79.02	16.46
7	Baby Spinach	20.317	295	59.94	12.48
8	Spinach	21.472	245	52.61	10.96
	Total	149.265		480.14	100

Among the total vegetable production, the maximum production was obtained from the spinach (21.47 MT) followed by the production of flat kale (20.76 MT), baby spinach (20.31 MT), swiss chard (20.16 MT), curled kale American (20.00 MT), iceberg lettuce (17.85 MT), romaine lettuce (17.15MT) and arugula / rocket leaves (11.54 MT).

The highest price was received ₹550 per kg for arugula / rocket leaves and the lowest price was received ₹ 195 per kg for iceberg lettuce.

It's also worth noting that the total returns from vegetable production were ₹480.14 lakhs. Among which curled kale American (16.46%), flat kale (14.92%), arugula / rocket leaves (13.22%), baby spinach (12.48%), swiss chard (12.39%), romaine lettuce (12.32%) and spinach (10.96%) were the top contributors. The lowest return was obtained from the iceberg lettuce (07.25%) due to its lower price and high production cost.

4.3.5 Returns from Fish Production

The information regarding returns obtained from fish production was estimated and presented in Table 4.10.

Table 4.10 Returns from Fish production

Sr. No.	Species	Total Production (MT)	Price (₹ / kg)	Total Return (Lakh ₹)
1	Rohu (<i>Labeo rohita</i>)	29.90	120	35.88 (45.31)
2	Catla (<i>Catla catla</i>)	32.08	135	43.30 (54.69)
	Total	61.98		79.18 (100)

(Figure in parentheses indicates percentage to respective total)

It is seen from the table, the total fish production was 61.98 MT, out of which the production of catla was 29.90 MT, whereas the production of rohu fish was 32.08 MT. The price obtained for catla fish was ₹ 135 per kg and for rohu species it was ₹ 120 per kg.

The total returns from fish production were ₹ 79.18 lakhs. Catla is the leading contributor at 54.69 per cent, followed by rohu (45.31%).

4.3.6 Financial Performance Analysis

The financial analysis has great importance to various accounting users or various matters of the unit. The income statement, balance sheets and other financial data provides information about expenses and sources of the income, profit or loss and also helps in assessing the financial position of business. The analysis of financial statement helps the finance manager in assessing the operational efficiency and managerial effectiveness of the hydroponic unit. The financial analysis is used to evaluate economic trends, set financial policy, build long term plans for business activities and identify unit for investment.

4.3.6.1 Net profit of hydroponics unit

The information about the net profit of hydroponic unit was estimated and presented in Table 4.11. It is seen from the table; the net profit of hydroponic unit was

obtained ₹ 224.70 lakhs during the study period. The total returns and total cost of hydroponic unit were ₹ 559.32 lakhs and ₹ 334.62 lakhs, respectively.

The highest net return was obtained from curled kale American (₹ 36.10 lakhs) followed by flat kale (₹ 27.89 lakhs) vegetables, because those two vegetables had higher demand and higher price with low production cost.

Table 4.11 Net profit and cost-benefit ratio of hydroponics unit (₹ lakhs)

Sr. No.	Particulars	Total return	Total cost	Net return
1	Iceberg Lettuce	34.82	24.94	09.88
2	Arugula / Rocket Leaves	63.49	56.48	07.01
3	Flat Kale	71.62	43.73	27.89
4	Romaine Lettuce	59.17	41.35	17.82
5	Swiss Chard	59.47	42.46	17.01
6	Curled Kale American	79.02	42.92	36.10
7	Baby Spinach	59.94	42.29	17.65
8	Spinach	52.61	40.45	12.16
9	Fishes (By product)	79.18	-	79.18
	Total	559.32	334.62	224.70
	B:C	1.67		

The arugula/rocket leaves (₹ 7.01 lakhs) and iceberg lettuce (₹ 09.88 lakhs) vegetables were the lower contributors as they had higher production costs.

The unit as whole, the overall total returns and cost of vegetables and fish production of hydroponic unit were estimated ₹ 559.32 lakhs and ₹ 334.62 lakhs and cost-benefit ratio of unit was 1.67.

The fish tanks were installed as a supplementary part of the hydroponic unit. Therefore, no separate costs for fish production have been estimated, while they are considered as variable costs in vegetable production. And hence, the total cost incurred for fish production is considered as zero.

4.3.6.2 Cost-Benefit Ratio

A Cost-Benefit Ratio is a ratio used in a cost-benefit analysis to summarize the overall relationship between the relative costs and benefits of a proposed project. BCR can be expressed in monetary or qualitative terms. If a project has a BCR greater than 1.0, the project is expected to deliver a positive net present value to a firm and its investors. Benefit-cost ratios (BCRs) are most often used in capital budgeting to analyse the overall value for money of undertaking a new project.

The information regarding vegetable wise B: C ratio is presented in Table 4.12. It

is revealed from the table, the overall B: C ratio of vegetables was obtained 1.43. The overall total returns and cost of vegetables production of hydroponic unit were estimated ₹480.14 lakhs and ₹ 334.62 lakhs, respectively.

Table 4.12 Vegetable wise total returns, Costs and B: C ratios

Sr. No.	Vegetables	Total return (₹ lakhs)	Total cost (₹ lakhs)	B:C Ratio
1	Iceberg Lettuce	34.82	24.94	1.40
2	Arugula / Rocket Leaves	63.49	56.48	1.12
3	Flat Kale	71.62	43.73	1.64
4	Romaine Lettuce	59.17	41.35	1.43
5	Swiss Chard	59.47	42.46	1.40
6	Curled Kale American	79.02	42.92	1.84
7	Baby Spinach	59.94	42.29	1.42
8	Spinach	52.61	40.45	1.30
	Total	480.14	334.62	1.43

(Figure in parentheses indicates percentage to respective total)

Among the vegetables, the highest B: C ratio was observed in curled kale American (1.84), followed by flat kale vegetable (1.64), romaine lettuce (1.43) and baby spinach (1.42) vegetable. The lowest B: C ratio was obtained in arugula / rocket leaves (1.12) vegetable followed by spinach (1.30) and iceberg lettuce (1.40) vegetables due to higher production cost and demands of these vegetables were low.

In the profit of hydroponic unit from vegetable production, the curled kale American, flat kale, romaine lettuce, baby spinach and iceberg lettuce vegetables were the top contributors.

4.3.6.3 Breakeven analysis for different vegetables

In general, BEP is the point at which gains equal losses. At breakeven point, the revenues of the business are equal to its total costs and its contribution margin equals its total fixed costs. The break-even point is calculated by dividing the total fixed costs of

production by the price per individual unit less the variable costs of production. Fixed costs are costs that remain the same regardless of how many units are sold (Investopedia).

The breakeven analysis of hydroponic unit were estimated and presented in Table 4.13.

From the table, it can be seen that, the breakeven quantity was highest in Spinach vegetable of hydroponic unit which is 12.992 MT, due to efficient use of the inputs. It was less in curled kale American vegetable which is 4.994 MT. The breakeven quantity of swiss chard and baby spinach vegetables were estimated 10.143 and 10.762 MT. The similar range of breakeven quantity was observed in arugula / rocket leaves, romaine lettuce, flat kale and iceberg lettuce (8.776, 8.336, 8.331 and 8.009 MT) vegetables.

Table 4.13 Break even analysis (2019-20)

Sr. No.	Vegetables	Total production (MT)	Break even quantity (MT)
1	Iceberg Lettuce	17.856	8.009
2	Arugula / Rocket Leaves	11.544	8.776
3	Flat Kale	20.760	8.331
4	Romaine Lettuce	17.152	8.336
5	Swiss Chard	20.160	10.143
6	Curled Kale American	20.004	4.994
7	Baby Spinach	20.317	10.762
8	Spinach	21.472	12.992

The hydroponic unit produces more than its break-even quantity for a variety of vegetables. As a result, it can be concluded that all of the vegetables are risk-free, and their worth has been surpassed by their respective production levels. The similar result was confirmed by Adler *et al.* (2000).

4.3.6.4 Net present value

The net present value is the difference between the present value of cash inflows and the present value of cash out flows. NPV is used in capital budgeting to analyze the profitability of an investment or unit. The purpose of an investment analysis is to demonstrate the profitability over the expected life of the investment.

The economic viability of this combined vegetable and fish production system were evaluated using net present value analysis (NPV), which takes into account the time value of money and the variability of annual cash flows over time. The NPV method is used to reduce the 5-year stream of revenues and expenses from the combined system to a single number in which these future annual cash flows are discounted.

Table 4.14 Net present value of the hydroponic unit

Sr. No.	Outflows (₹)	Inflows (₹)	Net Benefit (₹)	Dis. factor 10%	Dis. factor 15 %	NPV at 10%	NPV at 15%
1	76720000	0	-76720000	0.91	0.87	-69745454.55	-66713043.48
2	17453126	43976598	26523472	0.83	0.76	21920224.79	20055555.39
3	20107423	48014000	27906577	0.75	0.66	20966624.34	18349027.37
4	22770967	52110095	29339128	0.68	0.57	20039019.19	16774741.66
5	23456409	58363306	34906897	0.62	0.14	21674436.67	4915895.79
						14854850.45	-6617822.79

The information regarding net present value is presented in Table 4.14. It is observed from the table, the cash inflows and outflows were estimated over the 5 years, out of which 4th and 5th years are estimates in advance, because hydroponic unit has completed for only 3 years. The overall Net Present Value was worked out to be ₹14854850.45 at a 10 per cent discount rate. The NPV indicates the value of the investment in the combined system over its 5 year life in terms of today's rupees. Lower discount rates increase the NPV because the value of future cash flows is reduced less than they would be for higher discount rates. In selecting between competing investments opportunities, the decision maker would select the one that maximizes expected NPV.

The positive NPV indicates that the unit activity is economically viable, socially acceptable, and financially profitable.

4.3.6.5 Internal Rate of Return

The IRR is the discount rate that equates a project's initial cost with the sum of its discounted future cash flows. In other words, the IRR is the discount rate which would reduce the NPV of a project to zero.

$$\begin{aligned}
 \text{IRR} &= \text{Lower Discount Rate} + \text{Difference between two discount rate} \times \left\{ \frac{\text{NPW at lower discount rate}}{\text{Difference between NPW At two discount rates}} \right\} \\
 &= 10 + 5 \times \left\{ \frac{14854850.45}{14854850.45 - (-6617823.27)} \right\} \\
 &= 10 + 3.46 \\
 &= 13.46
 \end{aligned}$$

At the overall level, the internal rate of return was worked out to be 13.46 per cent, implying that the unit owner receives ₹113.46 in exchange for investing ₹100 in the production and sale process of the vegetables. The results of the IRR analysis show that for the initial investment of ₹767.2 lakhs this system can potentially provide a return of 13.46 per cent over the life of the facility.

4.3.6.6 Pay Back Period

Another widely used investment criterion is the payback period. This is the length of time required to recover the initial fixed costs of an investment. Simply put, the payback period is the length of time an investment reaches a point. The desirability of an investment is directly related to its payback period. Although widely used as an evaluation tool, the payback period approach has two major deficiencies: 1) it fails to consider the time value of money and 2) it ignores the length and magnitude of cash flows after the payback period. The payback period should not be used to compare investment alternatives unless they are of the same magnitude and expected life. The shorter paybacks period mean more attractive investments.

Table 4.15 Pay Back Period of the hydroponics unit

Year	Net cash flow (₹)	Cumulative cash flow (₹)	Uncovered cost (₹)
0	-76720000		
1	26523472	26523472	50196528
2	27906577	54430049	22289951
3	29339128	83769177	
4	34906897	118676074	

$$\begin{aligned}
 \text{PP} &= \frac{\text{Years full} + \frac{\text{Unrecovered cost at beginning of last year}}{\text{Cash flow in following year}}}{\text{Recovery}} \\
 &= \frac{2 + \frac{22289951}{29339128}}{1} \\
 &= 2 + 0.76 \\
 &= 2.76 \quad \text{i.e. 2 years and 9 months}
 \end{aligned}$$

According to this criterion, it will take approximately 2 years 9 month to recover the initial fixed costs of ₹ 767.2 lakhs. The payback period is estimated to be 2 years 9

months that means the owner of the unit will recover all his initial investments made during establishment year.

4.3.6.7 Net present value, internal rate of return and payback period

The net present value, internal rate of return and payback period were estimated and presented in Table 4.16

Table 4.16 Net present value, internal rate of return and payback period

Sr. No.	Particulars	Results
1	NPV @10% discounted rate	₹14854850.45
2	IRR (%)	13.46%
3	Payback period (in years)	2 years 9 months

For the hydroponics unit, cash flow estimates were generated over a 5 year period. An initial cash investment was made to purchase capital items for the facility's construction. Operating expenses and sales revenues were incurred in the years after that. The net present value (NPV) and internal rate of return (IRR) were determined. The NPV was calculated using a 10 per cent discount rate. The farm unit was profitable at that level. The internal rate of return, which gives the actual rate of return for the investment, was 13.46 per cent. The investors must determine their requirements for acceptable returns when choosing their farm size. If the IRR is too low, than other investment opportunities must be found. The similar findings were confirmed by Adler *et al.* (2000) and Borges and Dal'Sotto (2016).

4.3.6.8 Financial ratios

Tests of liquidity and solvency were framed to test the ability of the farming units to meet the current financial obligations. Liquidity plays a prominent role in business enterprises through its sensitive characters of meeting immediate financial demands.

The net worth statement is also known as balance sheet. It is summery of assets, liabilities and owners' equity at given point of time. A project is considered solvent if the value of assets exceeds debt level. It is very useful for the lender for scrutinizing the loan application. The test of liquidity was worked out by using ratios *viz.*, Current ratio, quick ratio, net working capital ratio, net capital ratio and debt equity ratio with the help of balance sheet.

The information of Net worth statement of hydroponic unit for the year 2019-20 was presented in Table 4.17. It is seen from the table; the current asset contributes 42.86 per cent that includes cash in bank, cash in hand and short term savings. An intermediate asset contributes 13.81 per cent where as long term assets were 43.33 per cent, among total

assets. In total liabilities highest share was contributed by current liabilities (65.01%) and long term liabilities (19.29%). The lowest share was contributed by intermediate liabilities (15.70%).

Table 4.17 Net worth statement of hydroponics unit for the year 2019-20

Sr. No.	Assets	Amount (₹)	Sr. No.	Liabilities	Amount (₹)
1	Current Assets	46900000 (42.86)	1	Current liabilities	22832000 (65.01)
2	Intermediate Assets	15100000 (13.81)	2	Intermediate Liability	5510000 (15.70)
3	Long term Assets	47420000 (43.33)	3	Long term liabilities	6774285 (19.29)
	Total Assets	109420000 (100)		Total liabilities	35116285 (100)
	Net worth	74303715			

(Figure in parentheses indicates percentage to respective total)

1. Current ratio

The current condition of the business is indicated by the current ratio, it is the ratio between current assets and current liabilities.

$$\begin{aligned}
 \text{Current Ratio} &= \frac{\text{Total Current Assets}}{\text{Total Current Liabilities}} \\
 &= \frac{46900000}{22832000} \\
 &= 2.05
 \end{aligned}$$

At the overall level current ratio worked out to be 2.05, which indicated that for every rupee of current liability, the amount of current assets available was 2.05. This showed that the hydroponics unit was not much dependent on short term borrowings and hence possessed a good liquidity position.

2. Quick ratio

The quick ratio based on current assets which are highly liquid i.e. inventories are excluded from current assets.

$$\text{Acid test or Quick ratio} = \frac{\text{Quick assets}}{\text{Current liabilities}}$$

$$\begin{aligned}
 \text{Acid test or Quick ratio} &= \frac{\text{Current Assets - Inventories}}{\text{Current liabilities}} \\
 &= \frac{46900000 - 12100000}{22832000} \\
 &= 1.52
 \end{aligned}$$

It is important index of unit's liquidity. A ratio 1:1 is considered safe. Quick ratio is 1.52 it indicates that unit is in safe.

3. Net working capital ratio

The net working capital ratio is the net amount of all elements of working capital. It is intended to reveal whether a business has sufficient amount of net funds available in the short term to stay in operation.

$$\begin{aligned}
 \text{Net working capital ratio} &= \frac{(\text{Current assets} - \text{Current Liabilities})}{\text{Total assets}} \\
 &= \frac{(46900000 - 22832000)}{109420000} \\
 &= 0.21
 \end{aligned}$$

4. Net capital ratio

The ratio indicates the degree of liquidity of the unit in the long term. It measures the degree of availability of assets to pay off long term liabilities.

$$\begin{aligned}
 \text{Net capital ratio} &= \frac{\text{Total assets}}{\text{Total liabilities}} \\
 &= \frac{109420000}{35116285} \\
 &= 3.11
 \end{aligned}$$

5. Debt equity ratio

This ratio indicates the relative proportion of debt and net worth in the financing assets of a firm. A ratio 1:1 is considered as safe.

$$\begin{aligned}
 \text{Debt equity ratio} &= \frac{\text{Total Liabilities}}{\text{Net worth}} \\
 &= \frac{35116285}{74303715} \\
 &= 0.47
 \end{aligned}$$

Table 4.18 Different financial ratios of hydroponics unit

Ratios	Current Ratio	Quick Ratio	Net Working capital Ratio	Net Capital Ratio	Debt Equity Ratio
Value	2.05	1.52	0.21	3.11	0.47

4.3.6.8.1 Different financial ratios of hydroponics unit

The information of different financial ratios of hydroponics unit were estimated and presented in Table 4.18. The current ratio has been regarded as an important barometer of the liquidity position of any business concern. The current ratio estimated was 2.05 and it shows satisfactory trend and could be concluded that the unit had maintain a reasonable level of the liquidity position, had sufficient current assets to meet the current liabilities. Higher the current ratio, the greater the short term solvency.

The quick ratio based on current assets which are highly liquid i.e. inventories are excluded from current assets, as they are least liquid component of current assets. The net capital ratio was estimated 3.11. It indicated that the assets of the unit were sufficient to cover its liabilities. The debt equity ratio registered was 0.47. The lower debt equity ratio, the more desirable it is. The hypotheses state that the hydroponic farming is economical viable has been proved.

4.4 Problems associated with Hydroponic Farming

The information regarding problems faced by the unit to run its business is shown in the Table 4.19.

The table above shows that, despite its many benefits, hydroponic farming has certain drawbacks. Commercial application necessitates technical expertise and a significant initial investment, but the payoff was substantial. Soil-less culturing is limited to high-value crops because to the expensive expense. When it comes to plant health control, extreme caution is essential. Finally, energy inputs were required to keep the system running.

Table 4.19 Problems in production of vegetables in hydroponics unit

Sr. No.	Problems
1.	High initial investment
2.	Shortage of skilled labors
3.	Unavailability of healthy and disease free seedlings
4.	Poor control over diseases and pests through organic measures.

The service of professional labor with all of the technical knowledge of vegetable cultivation is extremely important for quality, but their services were expensive.

Seedlings were one of the most important limiting elements that influenced vegetable quality. Diseases and pests that affect vegetables were spread from the nursery, making it one of the most serious issues.

Under hydroponics farming, maintaining a sterile root-zone environment was critical for good plant vigor. Minimizing the number of plant pathogens in the root zone with eco-friendly measures was exceedingly difficult to do but crucial. Wilt, caused by *Fusarium* and *Verticillium*, was a common disease in hydroponic solutions. Major roots were destroyed by *Pythium* and *Phytophthora* species. Thus poor control over diseases and pests through organic measures was noticed in the hydroponic unit. These findings confirmed the results reported by Tokunaga *et al.* (2015).

5. SUMMARY AND CONCLUSION

5.1 Summary

In recent years hydroponics is seen as a promising strategy for growing different crops. As it is possible to grow short duration crop like vegetables round the year in very limited spaces with low labor, so hydroponics can play a great contribution in areas with limitation of soil and water and for the landless people. In India, the hydroponic industry is expected to grow exponentially in near future. To encourage commercial hydroponic farm, it is important to develop low cost hydroponic technologies that reduce dependence on human labor and lower overall startup and operational costs. Growing demand for sustainable and protected farming practices and higher yield of crops grown under hydroponic facilities over traditional farming are the driving factors for its growth.

The consumer markets for fruits and vegetables produced in hydroponics unit include retail and hotels, fast food chains, railway catering, foreign food service companies, defense establishments, and NGOs. Leafy Vegetables dominates India's fruits and vegetables due to the growing demand for high-quality fresh lettuce by the commercial institutions, food chains, and restaurants to meet the daily requirements are boosting the market for hydroponically produced leafy greens such as lettuce. Currently, India is importing 85 per cent of exotic vegetables from neighboring countries, and it is expected to grow at a growth rate of 15-20 per cent per year.

Mayank Gupta and Lalit Zawar established hydroponics unit in 2018. Prior to this both are working in other companies; Mayank was working in e-Commerce and Lalit was working in Revolutionary textiles. They visited some agriculture developing countries like Canada, Israel, USA, China, Hong Cong and they got the detail information about hydroponics and aquaponics i.e., “growing without soil.” On basis of this information, they established a hydroponics and aquaponics unit within 15 months. This has been regarded as a biggest project in a western Maharashtra. They also collected information about various places and its climate, monsoon and transport system. After that, they selected the place “Hatkanangale.” There were two reasons behind selecting this area. One is climate of this region and other is logistic i.e., from this area it is possible to supply the production to about 6-7 metropolitan cities overnight.

The main aim of present investigation was to study the “Economics Analysis of Hydroponics Farming in Kolhapur District-A Case Study” was undertaken with following specific objectives,

1. To study the structure of Hydroponic Farming
2. To assess the employment generated through Hydroponic farming
3. To estimate the economic performance and financial ratios of Hydroponic farming
4. To identify the problems associated with Hydroponic Farming

The present study is based upon the relevant data obtained from the annual reports of the unit and personal interviews of the officials of the unit for the year 2019-20. The analysis was mostly concerned with the management aspects in production, procurement, packaging to study costs and returns of the unit, to examine profitability and economic viability of the unit also employment generated through unit. The results were obtained and briefly summarized as under.

5.2 Conclusions

1. From the study organizational structure owners are the final authority and 6 different departments were worked under the manager and reporting to manager. The total 7 types of vegetables were cultivated in unit on the water containing excreta of the fishes. Among those some vegetables have cultivation period 45 days i.e. 15 days in nursery and 30 days in hydroponics unit, while some vegetables have cultivation period 45 days in unit with same period in nursery.
2. The results revealed that hydroponic requires large initial investment. Our study shows a total investment cost of ₹ 767.2 lakhs for the hydroponic farm with raceway surface area of 20480sq.ft and fish tank volume of 43238cub.ft.
3. The unit as whole, total employment generated from hydroponic unit was 535.51 labor days per cycle, out of which 167.04 male days and 368.47 female days were generated. The total employment generated from hydroponic unit in one year was 5734.20 labour days out of which 1790.16 male days and 3944.04 female days were generated from vegetable production and packaging.
4. The results concluded that the, total operated cost for vegetable production in hydroponics unit was ₹ 334.62 lakhs, with the total fixed cost being ₹ 133.55 lakhs and the variable cost being ₹ 201.07 lakhs. Our sensitivity analysis revealed that the overall operational cost is most sensitive to hourly wage, followed by electricity cost.
5. The study as whole total production of vegetables were 149.265 MT and total returns generated from the vegetables production was ₹ 480.14 lakhs. The net profit of the hydroponic unit was obtained ₹ 224.70 lakhs during study period.

6. The unit produces more than its break-even quantity for a variety of vegetables. As a result, it can be concluded that all of the vegetables are risk-free, and their worth has been surpassed by their respective production levels.
7. The financial feasibility of investments of hydroponic unit, measures of project appraisal was computed. The net present value at 10 per cent discounted rate were positive which indicates that hydroponics unit is economically viable. The payback period was 2 years 9 months. The benefit cost ratio of unit was 1.67 and which was more than unity. The internal rate of returns 13.46 per cent which indicates a higher average earning power money invested in the unit and profitable position of the hydroponics unit owner.
8. The business performance of the hydroponics unit was observed through the financial ratios such as solvency and liquidity ratios, showed that the hydroponic unit was more efficient. The liquidity ratios in general, have revealed that the hydroponic unit was in better position to meet the long term financial obligations, and hence did not suffer from want of working capital. Liquidity ratios were higher in hydroponics unit employing satisfactory position with good velocity of conversion of current assets into cash.
9. High initial investment, shortage of skilled labors, problem of unhealthy and diseased seedlings, control of diseases and pest were the major problems faced by the unit owners.

5.3 Suggestions

1. Among all the different vegetables flat kale and curled kale American shown more economic profitability as compared to other vegetables, hence production of these two vegetables must be encouraged. The high yielding varieties may be used to increase the production and income from rocket leaves.
2. Hydroponic unit should not only concentrate on production but marketing and export may also be handles on priority basis.
3. Instead of having dependent on third party for supply of planting material and also to avoid damaged and contagious material, hydroponics unit may lead to develop their own planting material.

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7. VITAE

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MASTER OF SCIENCE (AGRICULTURE)

IN

AGRICULTURAL ECONOMICS

2021

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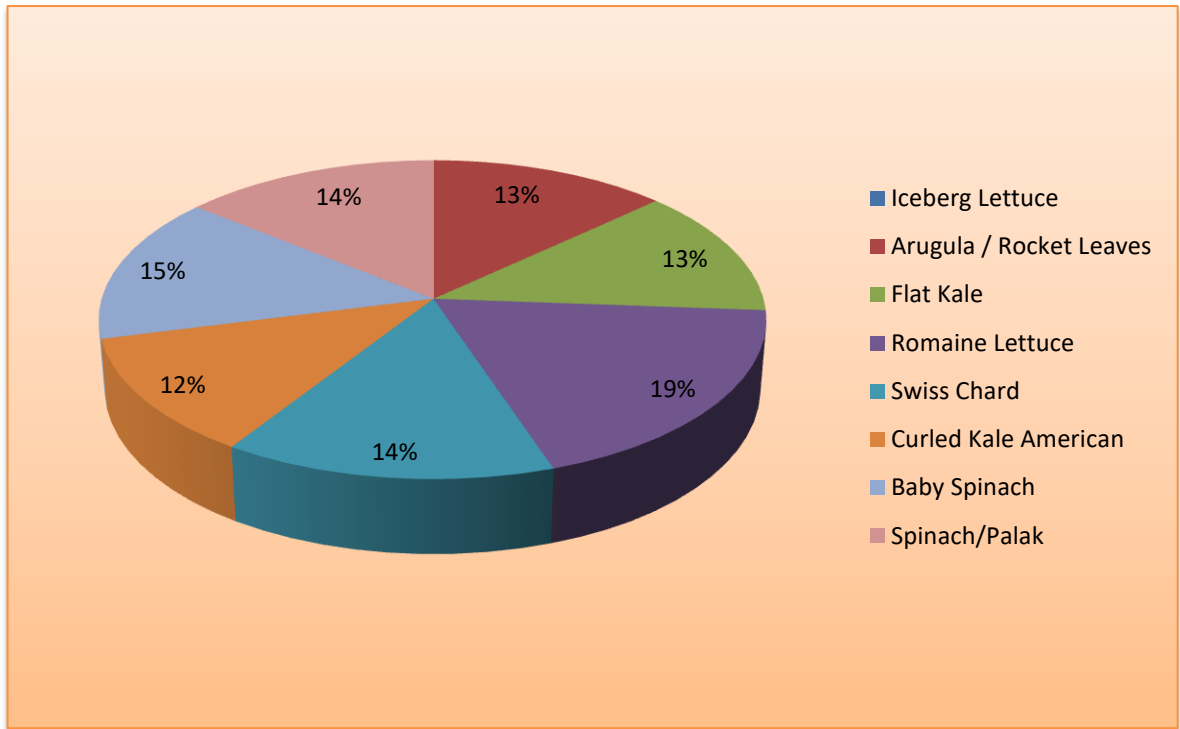


Fig 4.2 Employment generated by different vegetables through hydroponics farming unit

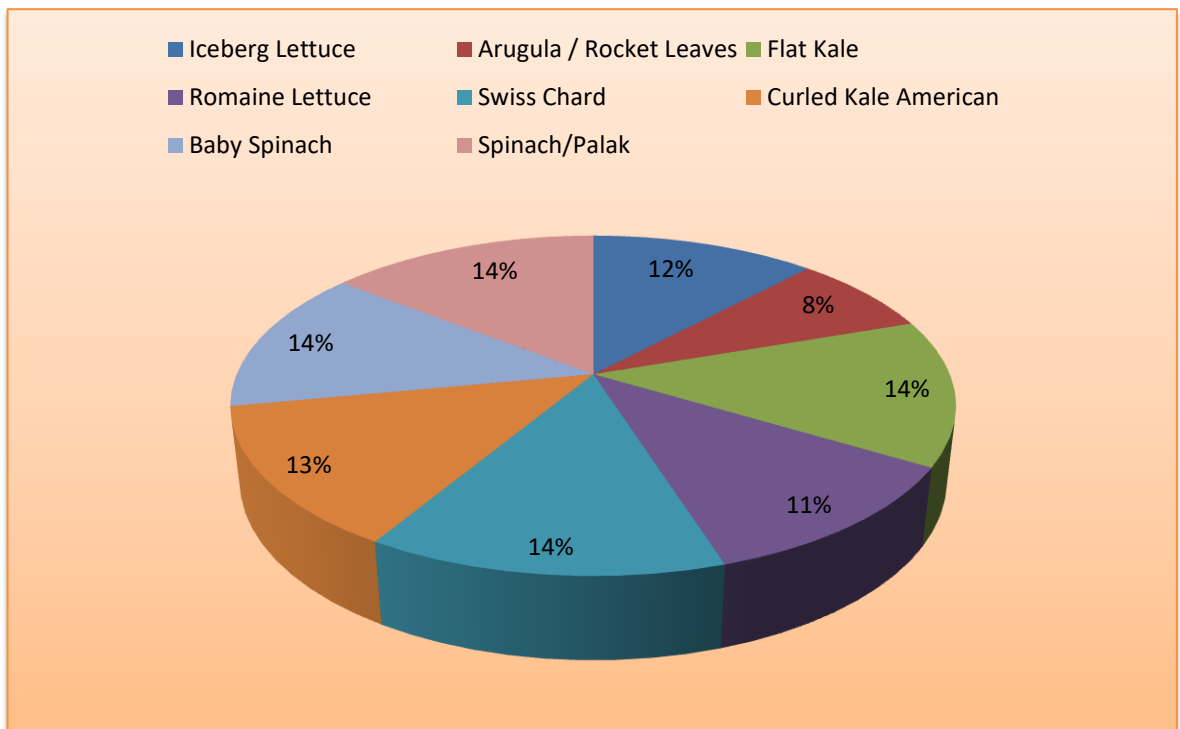


Fig 4.3 Annual Production of different vegetables

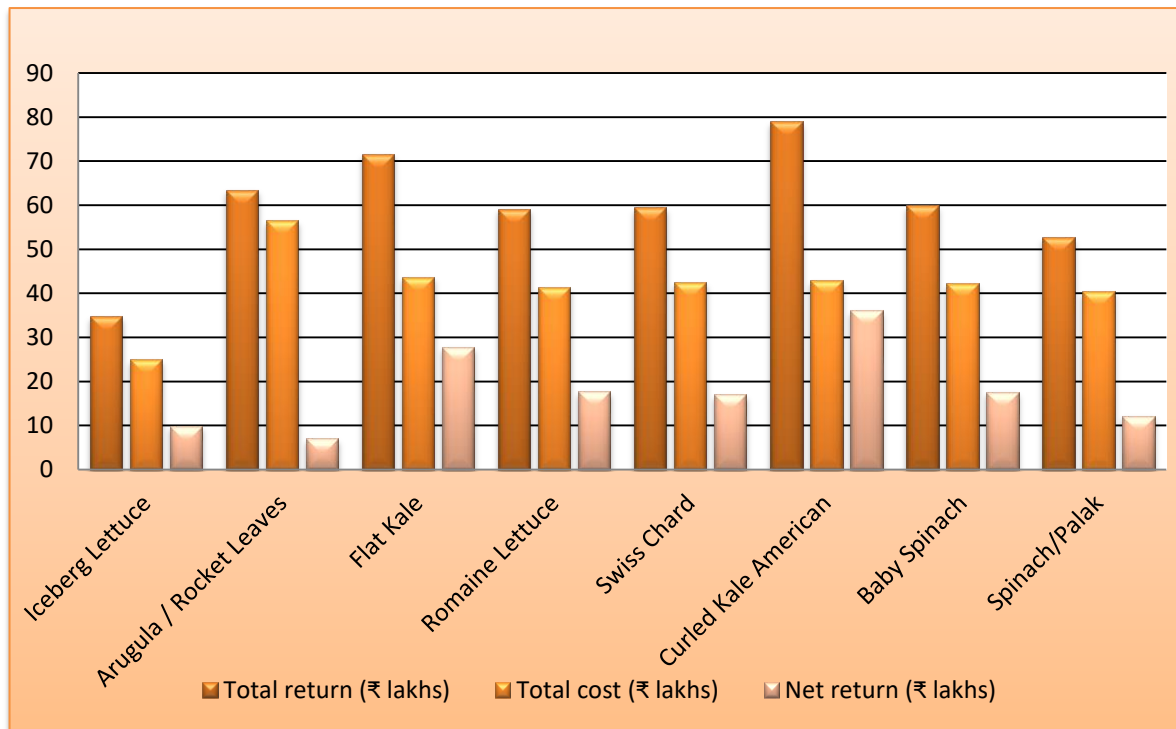


Fig 4.4 Total cost, total return and net profit

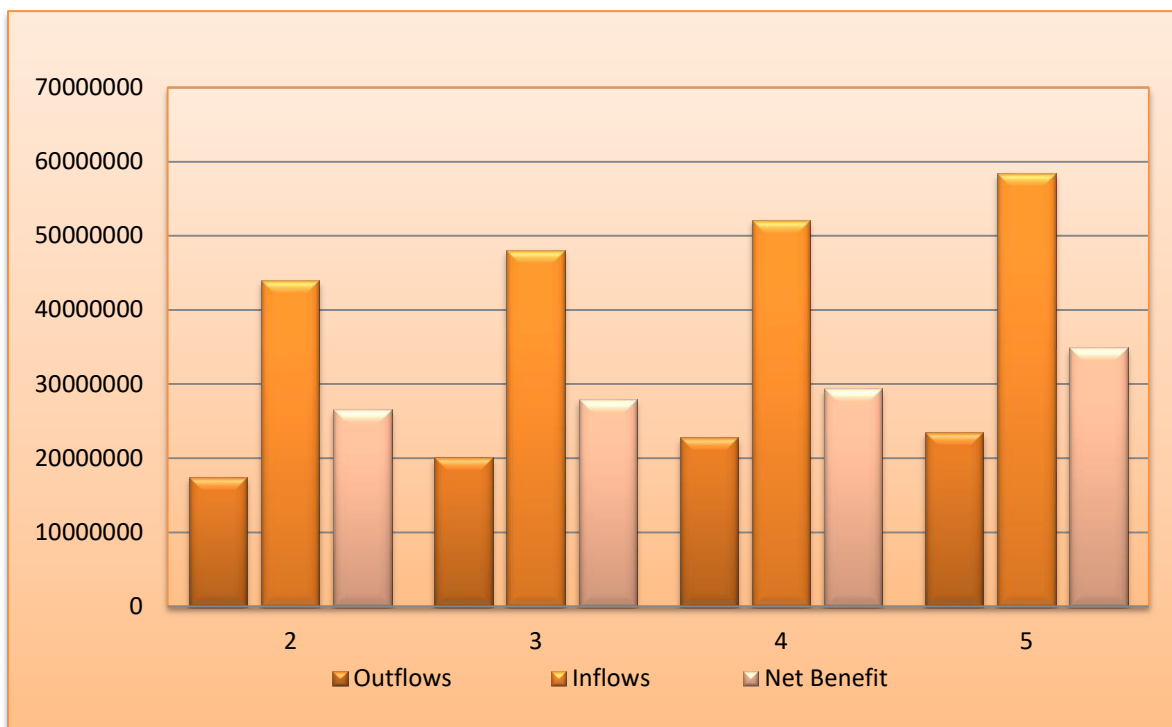


Fig 4.5 Cash outflow, Cash Inflow and Net Return



Transplanted vegetables



Grow Bed/Raft



Cooling Pads



Exhaust Fans



Fish Tanks



MBBR

Plate 4.2 Infrastructure of hydroponics unit



Cup



Foam



Transplanting



Harvesting



Packaging of Vegetables

Plate 4.1 Employment generated through hydroponics unit

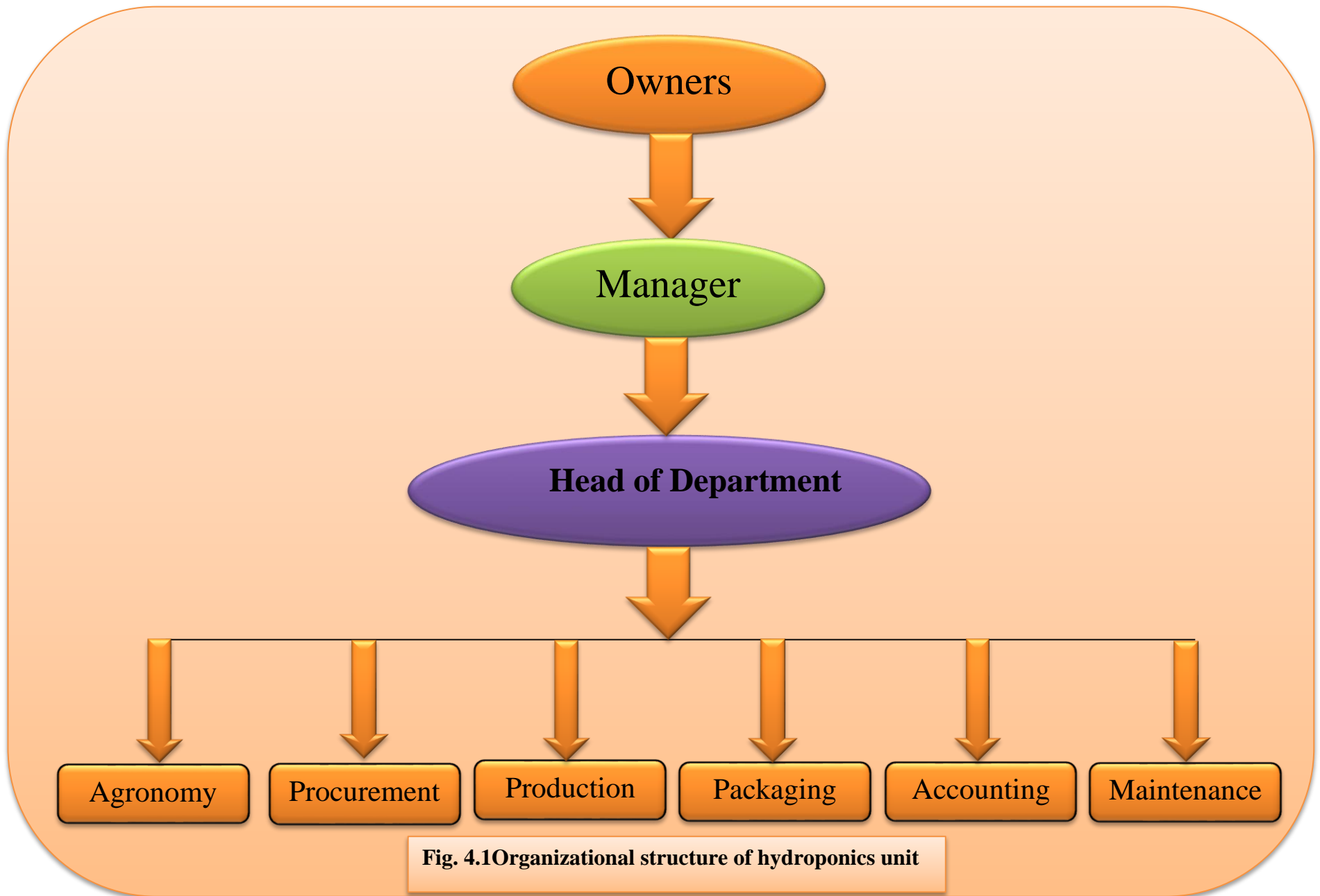


Fig. 4.1 Organizational structure of hydroponics unit