Vertical Farming Proposal in India

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Abstract - *As the India's population grows in a rapid manner, the land required to produce the food required also increases. The concept of a vertical farm was introduced to remedy this crisis. In vertical farming, farms are stacked on top of one another, instead of branching out horizontally. After the Industrial revolution carbon footprint produced from the industries has increased in rapid manner resulting in climate change and global warming which had adversely affected agricultural production in many ways like degrading the quality and quantity of crops. Many variables to consider are cultivation quantity and quality, design and supporting technology in order to have successful implementation of vertical farming in India. Vertical farming is the practice of producing food and medicine in vertically stacked layers, vertically inclined surfaces or integrated in other structures such as in a skyscraper, used warehouse, or shipping container, terrace etc. The project study is restricted to propose a self-sustained structure based on vertical farming using a modern farming technique of soil-less agriculture to counter the problems generated in current conventional farming i.e. horizontal farming practiced in India. The project study also concludes cost benefit of vertical farming over horizontal farming. Project focuses on use of technique of hydroponic in vertical farming. The resulting social benefit from project is that the future population gets fed with organic and nutritious food. The project implements optimum uses of resources such as land and water so that maximum output can be achieved to overcome the food scarcity in future.*

***Key Words*:** **Vertical Farming, Conventional Farming, Self-sustainable, Soil-less Agriculture, Organic food, Hydroponics, Cost benefit, Designing.**

1. INTRODUCTION

Vertical farming is the practice of producing food and medicine in vertically stacked layers, vertically inclined surfaces and/or integrated in other structures (such as in a skyscraper, used warehouse, or shipping container) by,[2] Modern methods of farming:-
a. Hydroponics
b. Aeroponics
c. Aquaponics

Fig. 1.1 resembles model of vertical farming skyscraper. In this fig. it is shown that the crops and vegetation is done in vertically stacked layer. The building includes several floors of particular heights. The modern ideas of vertical farming use indoor farming techniques and Controlled - environment agriculture (CEA) technology, where all environmental factors can be controlled. These facilities utilize artificial control of light, environmental control (humidity, temperature, gases...) and fertigation. [3]

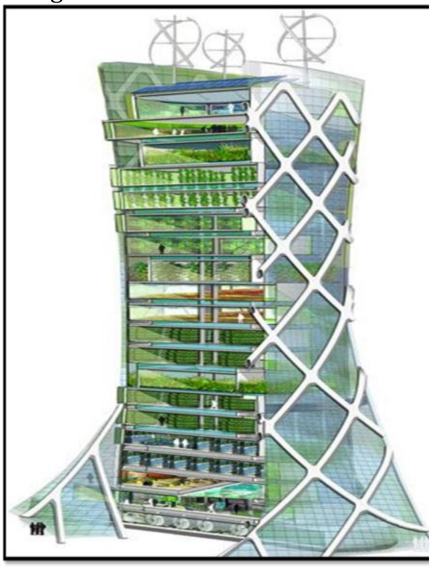


Fig -1: Model of Vertical Farming Skyscraper (economist.com)

Hydroponics is a technology for growing plants in nutrients solution (water + fertilizer), with or without the use of an artificial medium (e.g. sawdust, coco peat, rock wool) to provide mechanical support. Liquid hydroponics systems have no other supporting medium for the plant roots; aggregate system have a solid medium of support. [12]

Aquaponics is a production system that combines fish farming with soil-less vegetable production in one re-circulating system. • Nitrifying bacteria convert fish waste (ammonia) into plant food (nitrate). The same nitrification process that happens in soil also happens in the aquaponic system. • The most important part of aquaponics, the bacteria, is invisible to the naked eye. [11]

Aeroponic method of plant cultivation was defined by International Society for Soilless Culture as „a system where roots are continuously or discontinuously exposed to an environment saturated with fine drops (a mist) of nutrient solution" [Nichols and Christie 2002]. Plant roots are developed in two-phase root environment – liquid and air. There is not solid phase, typical in soils and substrates. In Aeroponic culture does not occur the antagonism between water and air in the root environment. Continuously contact with oxygen stimulates metabolic processes which have positive effect on the development of roots and nutrient uptake [Stoner and Clawson 1997]. [13]

1.1 Motivation

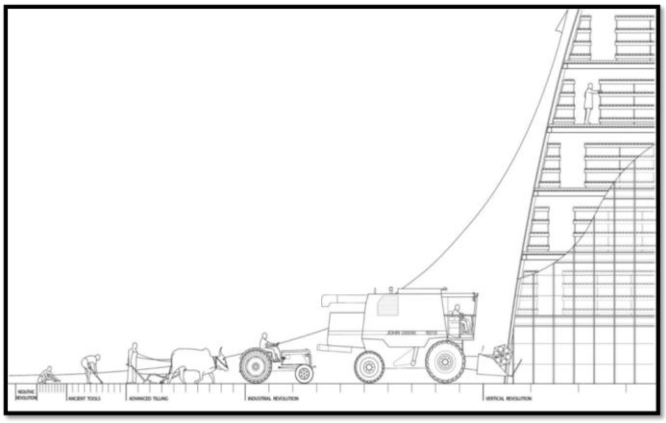


Figure 2. Development in farming techniques (Breathing High-rises)

1. Passion for sustainable future
2. Increase in pollution
3. Scarcity of fresh vegetables as presently we are eating food made with chemicals and injections.
4. Maintaining environment oxygen level.

1.2 Background

Urban Sky farm, Seoul, Korea

The Urban Sky farm is a vertical farm for a site located in Seoul, which is a heavily populated dense urban area., The Urban Sky farm is a vertical farm project which mainly supports local food production and distribution. It also leads to contribution of improving the environmental conditions through water, air filtration and production of renewable energy. The four major components of urban sky farm are root; trunk, branch and leaf each have their own spatial characteristics which are suitable for various farming conditions.

The root portion provides a column free environmentally controlled space which is ideal for marketplaces and public activities. The trunk divides into eight individual branches which each support about 60-70 farming decks which are suspended from each branch by structural trusses and tension cables. The farming decks which are the leaf portions are spread out as much as possible to receive the maximum amount of sunlight. Each farming deck is accompanied with supplementary heating such as glass shredders and LED lighting systems to provide peak environmental conditions for farming.

This project has won awards such as Second Prize, Urban Concept Category Rethinking the Future 2014, Winner, Concept Category Green Dot Design Awards 2013, Special Mention WT Smart City Awards 2014 and many more.

The Urban Sky farm acts as a living machine which helps improving the environmental quality by filtering water and air, providing green, and producing renewable energy. The dense urban development will benefit from the additional green space by having reduced heat accumulation, storm water runoff and carbon dioxide. The Urban Sky farm is a net zero facility which operates only with the renewable energy produced by solar and wind energy. The vegetations and plantations will consistently convert carbon dioxide into oxygen which will help the city become low carbon. The water processing system includes water collection, water filtering and final processing facilities which filter the grey water or storm water, process it and either distribute it for irrigation or give it back to the Cheonggyecheon stream.

Vertical Hydroponic Farm, Goa

In Goa, a Hydroponic farmer Ajay Naik started India's first hi-tech hydroponic vertical indoor farm(Letcetra Agritech pvt.ltd) and is concentrating on creating social awareness about vertical farming technology and helping farmers across the India to get maximum yield from minimum use of resources.

Letcetra Agritech is involved in the production of high-quality pesticide-free lettuce in a completely indoor farm. Using various technologies such as air conditioning systems control the temperature and humidity, while LED lights are used to compensate for sunlight. Automated systems are placed for monitoring and controlling water temperature, pH and nutrient level etc. Letcetra Agritech's produce – romaine lettuce, basil, rocket/arugula, oak leaf and lollo green is distributed to the local supermarkets.

2. Related Theory

2.1 Horizontal Farming

It is a practice of cultivating crops, vegetables, etc. horizontal cultivable area. All types of food can be cultivated without any restrictions of crop heights unlike vertical farming. Photosynthesis is done directly through sunlight and although it faces problems in absence of water or light. Requirement of water is too very high, and which is sacred in amount.

2.1.1 Problem Definition

1. Requires a huge land area.

In normal conventional farming the land required for farming is used in horizontal way which leads to usage of more land area compare to vertical farming to grow the same amount of crop.

2. Consumes 70% of water of present. (https://www.ncbi.nlm.nih.gov>articles) [9]

The water consumption in old conventional method of farming is comparatively more as more land area is required to be irrigated and the method of irrigation commonly used is canal irrigation which has its own adverse effects as more amount of water gets supplied leads to wastage and causes soil to lose fertility or even leads to soil erosion by flooding of fields.

3. Presence of pesticides.

The use of pesticide is made to make grown crops pest free from rats, snakes, etc. which leads to failure in growth of crops. But the pesticides used for these purpose makes the quality of these crops deteriorate that may harm the health on consumption. Long term diseases like Cancer, Neurological, Reproductive effects, other.

4. Health and environmental hazards.

The presently used farming techniques in India although provide food at a good rate but the increased in food demand in future can't be satisfied in future. The quality of food is also decreasing on daily basis due to use of pesticides and fertilizers used to increase the health and quantity of crops grown. Soil erosion, huge amount of water consumption, long term diseases like cancer, etc. are the side effects caused due to normal method of farming.

5. Disadvantageous to small farmers.

Small farmers are those farmers who have limited availability of land mass for agriculture and their livelihood depends on these crops. Due to droughts or soil degradation the quality and quantity of crops gets affected which affect their living and cost them to repay their dues loaned to grow crops for pesticides, fertilizers, seeds, water supply, transport and many more.

6. It potentially harms the soil.

Use of pesticides, fertilizers and over water irrigation causes the soil erosion and lowers the fertility by degrading the quality. The growth of crops lowers year by year due to soil degradation and also crop rotation.

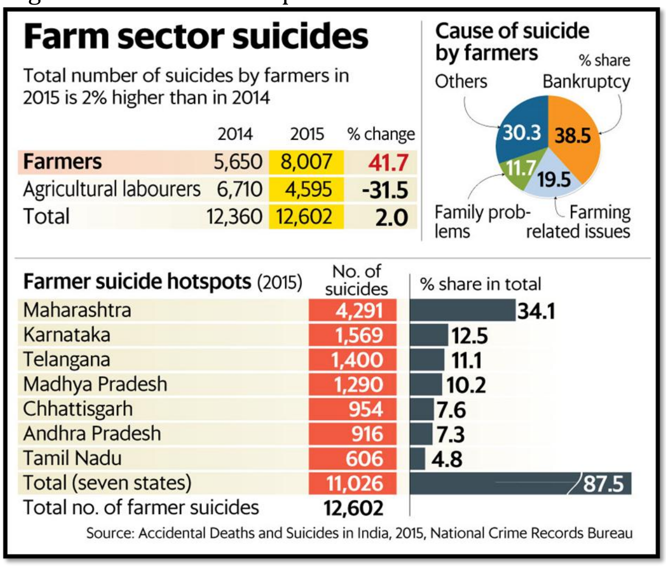


Figure 3. Farmer suicides rate in India (livemint.com)

2.2. Vertical Farming

In 2001, Dickson Despommier, the professor of Environmental Health Science at Columbia University, proposed a theory to reduce agriculture's ecological footprint by using vertical farming which built agriculture into the city and expanded it in stacked layers. The concept has been discussed widely and is under study at present. Dickson Despommier discussed problems associated with urban agriculture on a limited land base. To solve this problem, he proposed the concept of creating crop cultivation in buildings that enables the production of large amounts of food. The vertical farming concept, if applied to India, can be conducted with greater effectiveness because of the warm climate when compared to planting in places with a cold climate since there is no need to grow vegetables in a closed environment, which requires climate control. Vertical farming is the practice of producing food and medicine in vertically stacked layers, vertically inclined surfaces and/or integrated in other structures (such as in a skyscraper, used warehouse, or shipping container

Key variables in this concept are: economic feasibility, food security, urban agriculture, architecture, design and technology.

Vertical farming can be done using following techniques of modern farming:-

2.2.1 Hydroponics system
2.2.2 Aeroponics system
2.2.3 Aquaponics system

2.2.1. Hydroponics System

Figure 4. Hydroponic systems (colorgardening.com)

This system is useful for providing a continuous of flow nutrient solution to the roots of plants. The system includes a tubular assembly of horizontally inclined members interconnected to each other at elbow joints, and comprising cutouts configured to receive the roots of the of plants, and having a top entry and a bottom exit. A pump is placed to pump the nutrient solution to the top entry of the tubular assembly, wherein the angles of the horizontally inclined members let the solution to flow downward through the tubular assembly before leaving through the bottom to return back to the pump.

This system provides a continuous flow nutrient solution to the roots of a plurality of plants, comprising: a tubular assembly of horizontally inclined members connected to each other at elbow joints, and comprising a plurality of cutouts subjected to receive the roots of the plurality of plants, and having a top entry and a bottom exit, a support structure configured to couple to and support the tubular assembly, and a pump operable to coupled to the top entry and the bottom exit of the tubular assembly, and subjected to pump the nutrient solution to the top entry of the tubular assembly, wherein the angles of the horizontally inclined members let the solution to flow downward through the tubular assembly while contacting the roots before exiting through the bottom to return to the pump.

2.2.2. Aeroponics System

Figure 6. Aeroponic system (pitsburggreenstirey.com)

The principles of Aeroponics are based on the possibility of cultivating vegetables whose roots are not inserted in a substratum (the case with hydroponics) or soil, but in containers filled with flowing plant nutrition. In these containers roots can find the best condition regarding oxygenation and moisture. These conditions allow for better plant nutrition assimilation in a more balanced way, with consequential faster development of the cultivated plants. Plant containers can be mounted on top of one another and because they are light and handy, they can be easily moved according to agricultural needs. Numerous plants are mounted in vertical columns within a greenhouse or shade house space. Nutrients are allowed to trickle down through the growth columns. Most agricultural plants need a direct exposure to the sun during the first vegetative development. Afterwards this direct exposure is no longer relevant. Based on this observation, plant containers are periodically displaced. Young plants are placed at the highest level of the growth column. Afterwards they are progressively lowered utilizing a rotational mechanical system. With the rotation periodically repeated, this permits constant production without any interruption. The Aeroponic system is agriculture with a non-stop production cycle.

In comparison with the traditional agriculture the most relevant advantages are the following:
1. Limited water consumption. This system has had commercial success in desert areas of Rajasthan.
2. Agriculture independent of land and soil quality. Soil composition is not relevant because soil is never going to be used in the process.
3. Intensive production on a limited land surface area. The 3-dimensional growing system has the highest output per square foot of land per year of any known system.
4. The system can be constructed at consumers. The greenhouse can be constructed near urban centers and markets, with consequent reduction of costs and offering consumers fresh cropped products.

2.2.3. Aquaponics System

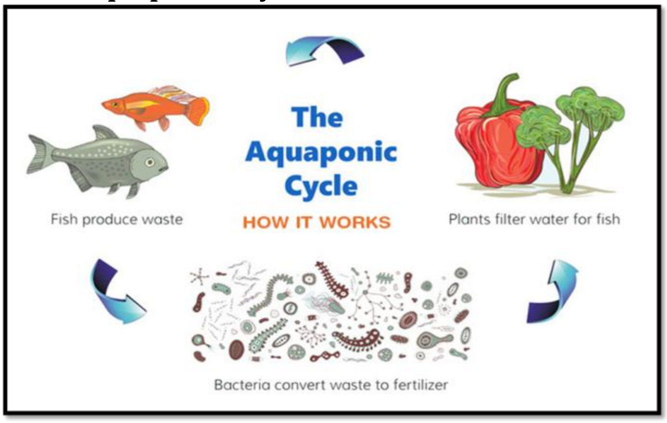


Figure 7. Aquaponic system (http://www.evofarm.com/aquaponics/)

Figure 3.5. Resembles the aquaponic cycle where the process of aquaponic is explained in flowchart. Aquaponics is a production system that combines fish farming with soil-less vegetable production in one recirculating system. • Nitrifying bacteria convert fish waste (ammonia) into plant food (nitrate). The same nitrification process that happens in soil also happens in the aquaponic system. • The most important part of aquaponics, the bacteria, is invisible to the naked eye.[11]

There are five key water quality parameters for aquaponics: dissolved oxygen (DO), pH, water temperature, total nitrogen concentrations and hardness (KH). Knowing the effects of each parameter on fish, plants and bacteria is crucial. Compromises are made for some water quality parameters to meet the needs of each organism in aquaponics. The target ranges for each parameter are as follows:[11]

Fishes used in Aquaponics are as follows:-
Tilapia, blue Gill/brim, Sunfish, Crappie, Koi, fancy goldfish, Pacu, various ornamental fish such as angelfish, guppies, tetras, swordfish, mollies, etc.

Water Requirement for Aquaponics	
Ammonia	0 mg/liter
DO	5-8 mg/liter
KH	60-140 mg/liter
Nitrate	5-150 mg/liter
Nitrite	0mg/liter
Ph	6-7
Water Temperature	18-30 ^{o}C

3. Methodology

Step 1: Study of Vertical Farming.
Step2: Modern Techniques of farming.
Step 3: Selected Hydroponic technique to implement in vertical farming.
Step 4: Site visit.
Step 5: Study of Hydroponic system.
Step 6: Modeling of Hydroponic setup for 1M* 1M.
Step 7: Cost analysis of Hydroponic setup for 1M* 1M.
Step 8: Cost analysis of 100 M* 100 M area in Vertical Farming.
Step 9: Cost analysis of 100 M* 100 M area in Horizontal Farming.
Step 10: Cost comparison between Vertical Farming and Horizontal Farming.
Step 11: Proposing G+11structure and G+3 warehouse.

3.1 ARSS 1 Unit Growth Light (1sqm)

Figure 8. ARSS 1 Unit Growth Light (1 sqm)
(http://www.evofarm.com/aquaponics/)

ARSS 1 Unit Growth Light (1sqm)	
Size 800 x 800 x 300 (mm)	
1 sqm includes the basic below mentioned parts	
Waterways (no.)	4
Plant Growth point in each Waterway (no.)	5
Total no. of Plant Growth Point in 1sqm area (no.)	10
12Watts LED Growth Light Panel (no.)	4
Water Inlet Harness (no.)	1
Water Outlet Harness (no.)	1
M.S. Frame Structure (m)	3.2
Inserts, Fasteners, Sponge and Accessories (no.)	1

ARSS 1 Unit Growth Light Costing (1 Sq Meter)			
Size: (800 MM X 800 MM X 300MM)			
Ex-Work Costing (India - Maharashtra)			
Description	Qty	Unit Rate (INR)	Amount (INR)
LED Growth Light Panel 12 Watt	4	180.00	720.00
Electrical Harness With connector	1	200.00	200.00
Water Inlet Harness	1	200.00	200.00
Water Outlet Harness	1	200.00	200.00
Growth Pots	20	15.00	300.00
Germination Tray with bed (Each Tray Grows 600 Seedling)	1	25.00	25.00
Inserts, Fasteners, Sponge and Accessories	1	200.00	200.00
MS Frame Structure	3.2	300.00	960.00
Hydroponic Waterway	4	115.00	460.00
Total (1 Unit: 1 Sq Mt)			3,265
1 Sq Mt Cost			3,265.00
Installation in Sq Mt for Plants			1
Installation in Sq Mt for Sapling			1
Total Installation in Sq Mt			2
Built Up Area in Sq Mt			1
Cost			6,530
Net Payble for Growth Light System (INR)			6,530
*Accessories Included: Cleaning & Tool Kit, Water Tank, Air Circulation Fan, Control Panel & Water Circulation Pump			
*Yield 25 Kg in 22/24 Days (1 Unit Yield)			
*Enclosure and Air Conditioning/Heating System Cost not included			
*Foundation, Plumbing & Basic Electrification (At actual From Local Contractor)			
*Our representative will available at site for 1 Growth Cycle.Accomodation and food to be arranged by the client			
*Our representative travel ticket will be provided by Hanul			
*Temperature should be less than 24 Celsius			

* Taxes as applicable

Summary		
Unit Cost of Electricity (₹)	8.75	
Installation for Plants (sqm)	1	(A)
Installation for Saplings (sqm)	1	(B)
Cost for 1sqm (₹)	3,265	(C)
Total system cost (₹)	6,530	((A+B) X C)
Operational Cost for 1year (₹)	15,073	
Sales Cost for Vegetables per kg (₹)	150	(D)
Sales Cost for Sapling (₹)	8	(E)
Vegetable Sold in Wholesale Market in 15cycles (₹)	2,250	(D X 15cycles) (F)
Saplings Income in 18cycles (₹)	1,440	(E X 18cycles) (G)
Average Sale in a year	3,690	(F+G)
Total Lighting Load (KW)	0.24	
Connected Load as Operation is in 2 shifts	0.12	

3.2 Proposal of Vertical Farming (Hydroponics)

ARSS 1 Unit Growth Light (100sqm)	
Floor to Floor Height min. 4m	
100 sqm includes the basic below mentioned parts	
One Floor Calculations	
Waterways (no.)	2112
Each Waterway (no. of Plants Growth Point)	257
36 Watts LED Growth Light Panel (no.)	38528
Water Inlet Harness (no.)	32
Water Outlet Harness (no.)	32
M.S. Frame Structure (m)	7
Inserts, Fasteners, Sponge and Accessories (no.)	64

ARSS Growth Light Costing (100*100 Sq Meter)			
Work Costing (India - Maharashtra)			
Description	Qty	Unit Rate (INR)	Amount (INR)
LED Growth Light Panel 45 Watt	11008	1,400.00	15,411,200.00
Electrical Harness With connector	32	402.00	12,864.00
Water Inlet Harness	32	402.00	12,864.00
Water Outlet Harness	32	402.00	12,864.00
Growth Pots	542784	1.70	922,732.80
Germination Tray with bed (Each Tray Grows 600 Seedling)	6513	335.00	2,181,855.00
Inserts, Fasteners, Sponge and Accessories	64	995.00	63,680.00
MS Frame Structure	602	300.00	180,600.00
Hydroponic Waterway	2112	240.00	506,880.00
Total (1 Unit: 100*100 Sq Mt)			19,305,540
1 Sq Mt Cost			1,930.55
Installation in Sq Mt for Plants			2,752
Installation in Sq Mt for Sapling			1,376
Total Installation in Sq Mt			4,128
Built Up Area in Sq Mt			2,064
Cost			7,969,327
Net Payble for Growth Light System (INR)			7,969,327
*Accessories Included: Cleaning & Tool Kit, Water Tank, Air Circulation Fan, Control Panel & Water Circulation Pump			
*Yield 25 Kg in 22/24 Days (1 Unit Yield)			
*Enclosure and Air Conditioning/Heating System Cost not included			
*Foundation, Plumbing & Basic Electrification (At actual From Local Contractor)			
*Temperature should be less than 24 Celsius			

* Taxes as applicable

Summary		
Unit Cost of Electricity (₹)	8.75	
Installation for Plants (sqm)	2752	(A)
Installation for Saplings (sqm)	1376	(B)
Cost for 1sqm (₹)	1,931	(C)
Total system cost (₹)	7,969,327	((A+B) X C) =(H)
Operational Cost for 1year (₹)	39,203,386	(I)
Combined Cost for a year (₹)	47,172,712	(H+I)
Sales Cost for Vegetables per kg (₹)	150	(D)
Sales Cost for Sapling (₹)	10	(E)
Vegetable Sold in Wholesale Market in 15cycles (₹)	30,960,000	(D X 15cycles) =(F)
Saplings Income in 18cycles (₹)	297,216,000	(E X 18cycles) =(G)
Average Sale in a year	328,176,000	(F+G)
Total Lighting Load (KW)	495.36	
Connected Load as Operation is in 2 shifts	247.68	

4. Cost Analysis

Investment cost for Horizontal Farming:

Total number of Cycles= 6
Total cost = 6* 26,900 = 1,61,400/-

Cost of Horizontal Farming				
Sr. no	MATERIAL	Requirement	Cost per unit(Rs)	Cost (in Rs.)/cycle
1.	Seeds	40 kg	100	4000/-
2.	Water	20,000 liters	0.5	10,000/-
3.	Potash and dye	10 kg	240	2400/-
4.	Fertilizer	50 kg	10	500/-
5.	Labor cost	10 person	1000	10000/-
			Total	26,900/-

Sale cost for Vegetable= Rs 20/kg
Crops cultivated in a year (6 cycles) = 600 quintals
Therefore total income = 600*100*20= Rs 12,00,000/-
Thus, total profit obtained = Rs 12,00,000 – Rs 1,61,400 = Rs 10,38,600/-
*Note: - above specified rates may vary according to site location and conditions

*Costing was carried out in year 2017-2018.

4.1 Layout for the Building to be proposed

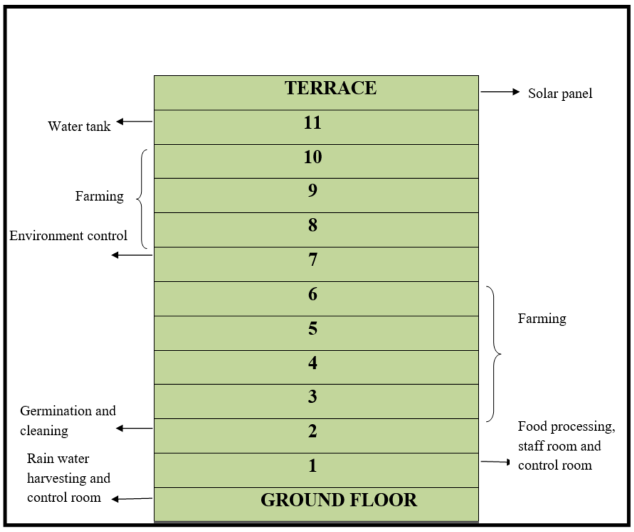


Figure 9. Vertical Farming Structure

Vertical Farming Structure	
NO. OF FLOORS	DESCRIPTION
1 (Ground)	(G – Rain water harvesting and control room)
1 (floor 1)	Food Processing, Staff Room and Control Room
1 (floor 2)	Germination and Cleaning
4 (floor 3, 4, 5, 6)	Farming
7 (floor 7)	Environment control
3 (floor 8, 9, 10)	Farming
1 (floor 11)	Water Tank
Terrace	Solar Panels
Total: 13(including Ground floor)	Vertical Farming Structure

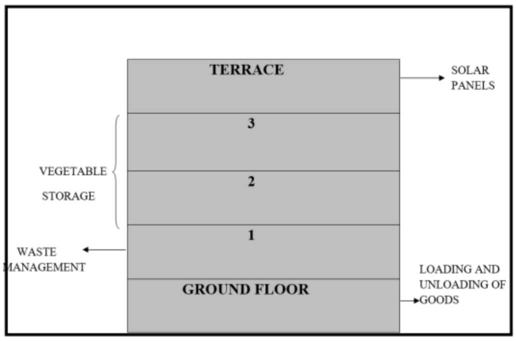


Figure 10. Warehouse

Vertical Farming Structure	
NO. OF FLOORS	DESCRIPTION
1 (Ground)	Loading and Unloading of Goods
1 (floor 1)	Waste Management
1 (floor 2)	Vegetable Storage
Terrace	Solar Panels
Total: 4(including Ground floor)	Warehouse

4.2 Floor Layout

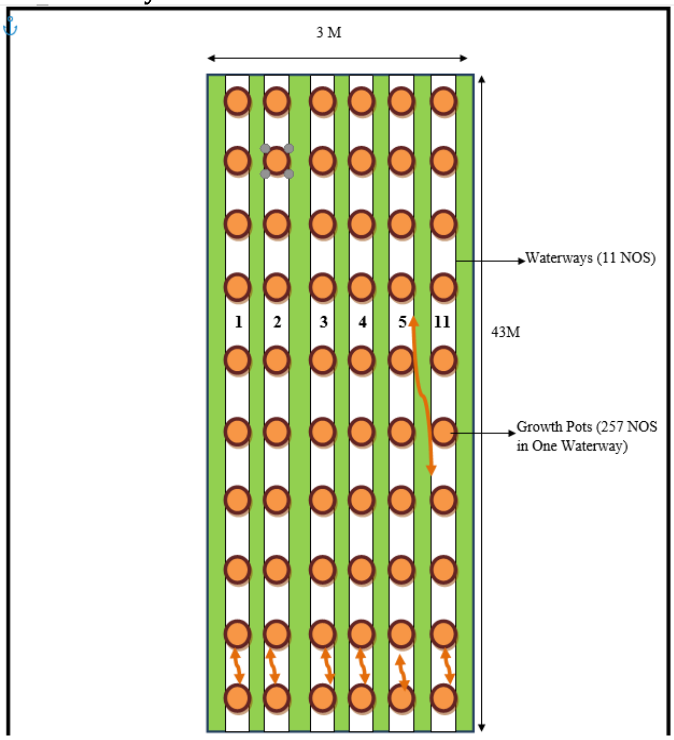


Figure 11. Tower Plan

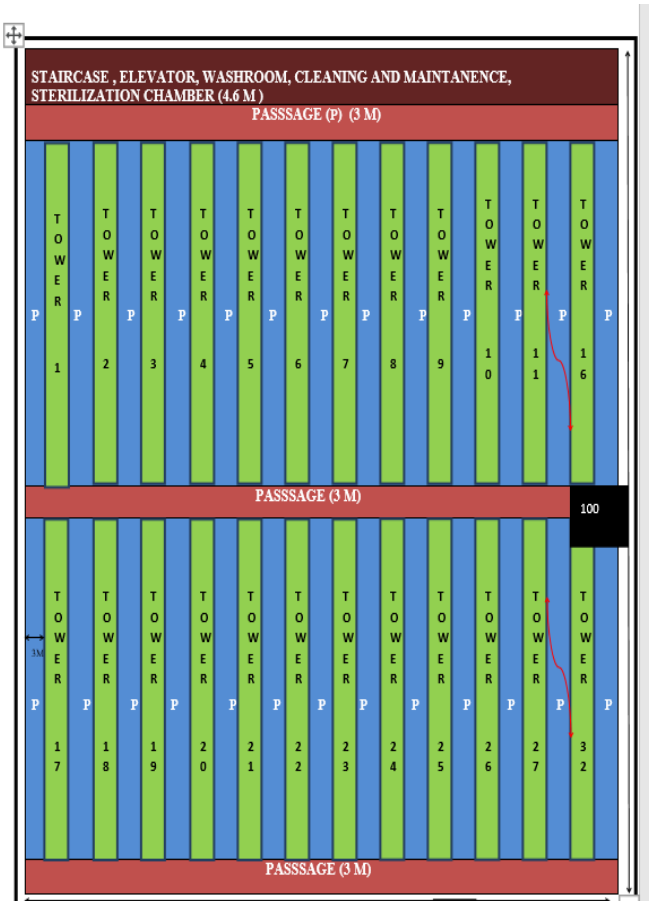


Figure 9. Site Layout

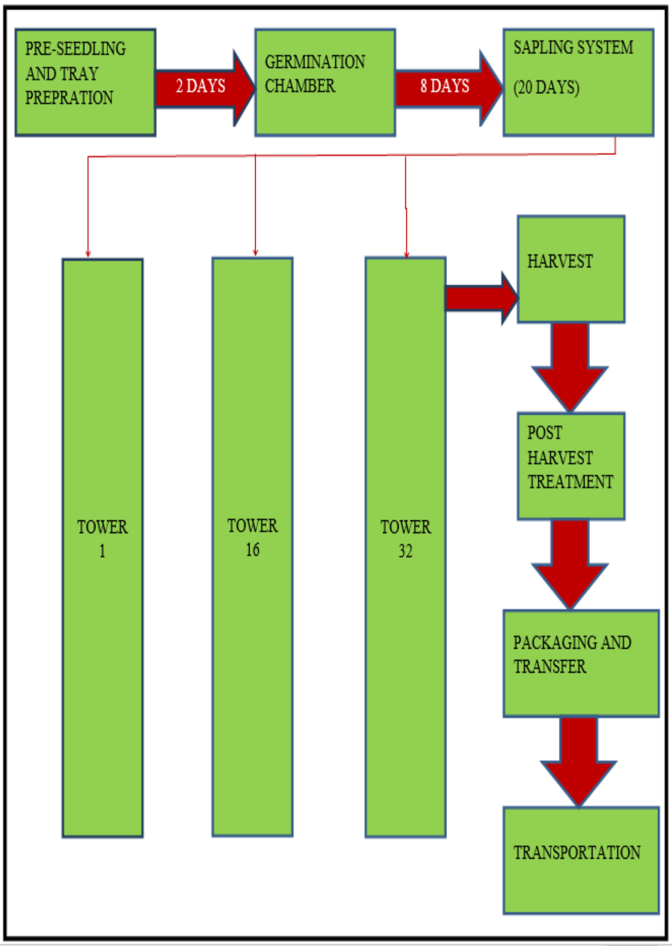
Figure 12. Tower

ALL DIMENSIONS ARE IN METER

Figure 12. Resembles the plan of individual tower where there are 32 towers and plan of single tower of dimension 43 x 3 is shown in the figure.

Figure 11. Resembles the orientation of 32 towers and also considering the passages, washrooms and many other rooms for conveyance. Floor size is of 100 x 100 m.

4.3 Process Flowchart



5. Cost Analysis

Cost Analysis for ARSS 1 Unit

Fixed Cost	
One Time Cost	5,930
Installation for Plant Growth (Sq Mt)	1
Installation for Sapling (Sq Mt)	1

Yield : Leafy Vegetables Yield Analysis	
Yield / Sq Mt in 25 Days for Plants (Kg)	1
Yearly Cycle for Plants	15
Yield in 25 Days (Kg)	1
Yield in a Years (Kg)	15

Yield : Sapling	
Yield/Sq Mt Sapling in 20 Days (Nos)	10
Yearly Cycle for Saplings	18
Yield in 20 Days	10
Yield in a Year	180

Electricity: Lighting Consumpton Analysis for Leafy Vegetables	
Electricity Consumption for 1 Kg Yield (Units)	8
Cost of Electricity	8.75
Cost for 1 Kg Yield	70.00
Electricity: Lighting Bill for 15 Cycles	1,050

Electricity: Lighting Consumpton Analysis for Sapling	
Electricity: Lighting Consumption for 1 Sq Mt Sapling per Day (Units)	1.5
Electricity: Lighting Consumption Sapling Installation per day(Units)	2
Electricity: Lighting Consumption for 20 days (Units)	30
Electricity: Lighting Bill for 20 days (Sapling)	263
Electricity: Lighting Bill for 18 Cycles (Sapling)	4,725

Yearly Operating Cost	Amount
Electricity: Combined Lighting bill for a Years	5,775
Maintainenace Cost (Employed by Client@ 2%)	119
Air Conditionin/Heating System Cost	6,388
Management Cost & Labour Cost (15% of Investment)	890
Plant Propogation Material (Seeds, Nutrition & Growth Media /Sq Mt/Cycle)	1,800
Total Yearly Operating Cost	14,971

Monthly Operating Cost	Amount
Electricity: Combined Lighting bill	481
Maintainenace Cost	10
Air Conditioning/Heating System Cost	532
Management Cost & Labour Cost	74
Plant Propogation Material (Seeds, Nutrition & Growth Media @ Rs 50/Sq Mt/Cycle)	150
Total Montly Operating Cost	1,248

Sale Cost for Vegetables /Kg	150.00
Sale Cost for Sapling	8.00

Average Sale from 25 Days Cycle	Amount
Vegetable Sold in Wholesale Market	150
Sapling Income	80
Average Sale from 25 Days Cycle	230

Average Sale in One Year	Amount
Vegetable Sold in Wholesale Market (15 Cycles)	2,250
Sapling Income (18 Cycles)	1,440
Average Sale in 1 Year	3,690

Total Lighting Load (KW)	0.24
Connected Load (KW) (Operation is 2 Shifts)	0.12

Cost Analysis for ARSS 100 M X 100 M Area

Fixed Cost	
One Time Cost	7,969,327
Installation for Plant Growth (Sq Mt)	2752
Installation for Sapling (Sq Mt)	1376

Yield : Leafy Vegetables Yield Analysis	
Yield / Sq Mt in 25 Days for Plants (Kg)	5
Yearly Cycle for Plants	15
Yield in 25 Days (Kg)	13,760
Yield in a Years (Kg)	206,400

Yield : Sapling	
Yield/Sq Mt Sapling in 20 Days (Nos)	1,200
Yearly Cycle for Saplings	18
Yield in 20 Days	1,651,200
Yield in a Year	29,721,600

Electricity: Lighting Consumpton Analysis for Leafy Vegetables	
Electricity Consumption for 1 Kg Yield (Units)	8
Cost of Electricity	8.75
Cost for 1 Kg Yield	70.00
Electricity: Lighting Bill for 15 Cycles	14,448,000

Yearly Operating Cost	Amount
Electricity: Combined Lighting bill for a Years	20,949,600
Maintainenace Cost (Employed by Client@ 2%)	159,387
Air Conditionin/Heating System Cost	13,183,800
Management Cost & Labour Cost (15% of Investment)	1,195,399
Plant Propogation Material (Seeds, Nutrition & Growth Media /Sq Mt/Cycle)	3,715,200
Total Yearly Operating Cost	39,203,386

Monthly Operating Cost	Amount
Electricity: Combined Lighting bill	1,745,800
Maintainenace Cost	13,282
Air Conditioning/Heating System Cost	1,098,650
Management Cost & Labour Cost	99,617
Plant Propogation Material (Seeds, Nutrition & Growth Media @ Rs 50/Sq Mt/Cycle)	309,600
Total Montly Operating Cost	3,266,949

Sale Cost for Vegetables /Kg	150.00
Sale Cost for Sapling	10.00

Average Sale from 25 Days Cycle	Amount
Vegetable Sold in Wholesale Market	2,064,000
Sapling Income	16,512,000
Average Sale from 25 Days Cycle	18,576,000

Average Sale in One Year	Amount
Vegetable Sold in Wholesale Market (15 Cycles)	30,960,000
Sapling Income (18 Cycles)	297,216,000
Average Sale in 1 Year	328,176,000

Total Lighting Load (KW)	495.36
Connected Load (KW) (Operation is 2 Shifts)	247.68

6. Crops that can be Cultivated

Leafy vegetables, especially the high-value ones like lettuce, celery, and cucurbits with export potential, tomato, capsicum, bottle brinjal, fruits like strawberry, and flowers like gerbera, carnation and anthurium were considered to be more relevant in the Indian context. *(CURRENT SCIENCE, VOL. 110, NO. 11, 10 JUNE 2016)*

7. Results

Benefit Analysis for ARSS 1 Unit Growth Light

Investment	5,930

Year	Revenue From Sales	Operational Cost	Depreciation	Total
Year 1	3,690	14,971	847	(10,433)
Year 2	3,875	15,719	847	(10,997)
Year 3	4,068	16,505	847	(11,590)
Year 4	4,272	17,330	847	(12,212)
Year 5	4,485	18,197	847	(12,864)
Year 6	4,709	19,107	847	(13,550)
Year 7	4,945	20,062	847	(14,270)
Total				(85,917)

* Assumption: 5% Increment in operational Cost and sales every year

Investment	▯ 5,930 (80%) IRR
Year 1	▯ 10,433
Year 2	▯ 10,997
Year 3	▯ 11,590
Year 4	▯ 12,212
Year 5	▯ 12,864
Year 6	▯ 13,550
Year 7	▯ 14,270

Benefit Analysis for ARSS Growth Light 100 M X 100 M

Investment	7,969,327

Year	Revenue From Sales	Operational Cost	Depreciation	Total
Year 1	328,176,000	39,203,386	1,138,475	290,111,090
Year 2	344,584,800	41,163,555	1,138,475	304,559,720
Year 3	361,814,040	43,221,733	1,138,475	319,730,783
Year 4	379,904,742	45,382,819	1,138,475	335,660,398
Year 5	398,899,979	47,651,960	1,138,475	352,386,494
Year 6	418,844,978	50,034,558	1,138,475	369,948,895
Year 7	439,787,227	52,536,286	1,138,475	388,389,416
Total				2,360,786,796

* Assumption: 5% Increment in operational Cost and sales every year

Investment	⍰ 7,969,327 (3,645%) IRR
Year 1	⍰ 290,111,090
Year 2	⍰ 304,559,720
Year 3	⍰ 319,730,783
Year 4	⍰ 335,660,398
Year 5	⍰ 352,386,494
Year 6	⍰ 369,948,895
Year 7	⍰ 388,389,416

Cost Comparison Between Horizontal Farming and Vertical Farming

FOR 100 M X 100 M AREA			
		HORIZONTAL FARMING	VERTICAL FARMING
INVESTMENT IN RS		1,61,400	79,69,327
OUTPUT IN RS	YEAR 1	10,38,600	29,01,11,090
	YEAR 2	10,38,600	30,45,99,720
	YEAR 7	10,38,600	38,83,99,416
PROFIT (%)	YEAR 1	644	3640
	YEAR 2	644	3822
	YEAR 7	644	4874

8. Conclusion

1. The Project concludes the study of existing setup based on vertical farming in India.
2. It proposes a vertical farming structure in Metropolitan cities
3. A model is constructed based on hydroponics technique.
4. Cost benefit of vertical farming over horizontal farming is done.

ABBREVATIONS

CEA	: Controlled Environment Area
cm	: Centimeter
CO2	: Carbon Dioxide
DO	: Dissolved Oxygen
KH	: Hardness
LED	: Light Emitting Diode
mm	: Millimeter
NFT	: Nutrient Film Technique
NH3	: Ammonia
N.P.K.	: Nitrogen, Phosphorous, Potassium
ppm	: Parts per million
Pvt Ltd.	: Private Limited
TDS	: Total Dissolved Solids

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