Tribhuvan University
Institute of Engineering, Pulchowk Campus
Pulchowk, Lalitpur

A

Thesis Report on

URBAN AGRICULTURE CENTRE: AN INTEGRATED SPACE FOR URBAN FARMING, RESEARCH AND INTERACTION

Submitted by,
Salina Awal
074-BAE-229

Submitted in partial fulfillment of the requirement for the degree of Bachelor of Architecture in the Department of Architecture.

Department of Architecture
Pulchowk, Lalitpur, Nepal

Date: May, 2023

CERTIFICATE

This is to certify that this thesis entitled "URBAN AGRICULTURE CENTER" at Madhyapur Thimi, Bhaktapur, submitted by Salina Awal (074/BAE/229) has been examined and has been declared successful for the partial fulfillment of the academic requirement for the completion of the Degree of Bachelor of Architecture.

....
Asso. Prof. Surya Gyawali
(Thesis Supervisor)
Date: ....

Department of Architecture
Institute of Engineering
Pulchowk Campus
Tribhuvan University

DECLARATION

I declare that this dissertation has not been previously accepted in substance for any degree and is not being concurrently submitted in candidature for any degree. I state that this dissertation is the result of my own independent investigation/work, except where otherwise stated. I hereby give consent for my dissertation, if accepted to be available for photocopying and understand that any reference to or quotation from my thesis will receive an acknowledgement.

....

Salina Awal

(074/BAE/229)

Date: ....

ACKNOWLEDGEMENT

First and foremost, I would like to express my unequivocal gratitude and appreciation to my thesis supervisor, **Associate Prof. Surya Gyawali** for the perpetual support and guidance during the research. The boundless help from my friends and seniors encouraged me to work hard in each phase of the research. I am grateful for their continual assistance and guidance throughout my research and design journey.

My humble regards and gratitude must also be addressed towards Department of Architecture, Pulchowk Campus and all the faculty members for their help during the research and design phases.

Moreover, I would also like to convey my hearty gratitude to all the helping hands that helped me during this course of time to successfully complete the research, design and the report.

Salina Awal
074-BAE-229

ABSTRACT

Agriculture is an important key to human development. The social relation between human and agriculture, that was developed from initial phase of human development, is getting weaker. Everything around us has changed a lot including available natural resources, technological advancements, climatic conditions, population density and their demands. But, agriculture hasn't changed much in thousands of years. We are still going above acres of crop land, far from the people who eat it.

In Kathmandu valley, urban and peri-urban agriculture have been practiced from ancient time and is traditional way of life. Like many cities in the world, Kathmandu is pushing the agriculture and nature away from settlement. The current unsustainable system of agriculture including massive amount of food imports and malpractice of chemicals in food production have created severe threats to health, environment and economy of the valley. It is no longer economically viable because of population growth, crop failures, urbanization, and dealing with a changing external environment. Building a farm and a research unit close to the people it serves is the only option to deliver a sustainable approach to food crises and food security in the future. Considering drastic decrease in the available farm land and current demand of food, the better alternative to prevailing tradition system of agriculture can be vertical farming, indoor high-tech farming and roof farming. Promoting and extending the urban agriculture in the city through adoption of vertical farming is the major aim of the project. The project will also contribute to strengthen intricate relation between agriculture and people.

The concept is to design a hi-tech urban farm and necessary research and training units for the urban farm that provides theoretical and practical knowledge about various growing technologies of urban farming, along with the fresh, healthy and disease-free fruits and vegetables grown in the farm to people of the city. Therefore, the project emphasizes symbiosis of agriculture and architecture through modern agricultural systems to reconnect people with nature and solve major issues of food crisis at the same time.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

1. INTRODUCTION

1.1 BACKGROUND

Nepal has great agricultural potential due to its diverse climate and soil conditions. Majority of the people i.e. about 65.6 percent is directly involved in agriculture for livelihood, employment and income generation. The share of agriculture and forestry sector to national Gross Domestic Product (GDP) is about 28.89 percent. (Operation of Community Agriculture Extension Service Center and its Management, 2018) One of the fundamental factors of growth and development of the early towns in Kathmandu valley was the intensive agricultural system, which becomes clear from the construction of Rajkulos as the irrigation canal. The peri-urban agriculture was the basis for raising crops and the core for the residing, processing and sufficient in food production.

Until the 1990s, Nepal was a net exporter of grains and government programs have given agriculture a high priority for many decades. The country had a decade-long civil war (1996–2006), which killed over 10,000 people, destroyed major infrastructures, and hindered public services and development initiatives. Thousands of people fled to cities from war-torn countryside, abandoning their farmlands. Many of those left behind in rural areas have little access to farmland or extension services. (Ramjee Ghimire, 2021).Mainly in Kathmandu valley, the rapid conversion of fertile agricultural land into residential buildings, commercial complexes, industrial blocks and many urban infrastructures has resulted in shortage of food. The valley is now dependent on food imports from different corners of country and neighboring countries, India and china. Also use of chemical fertilizers, insecticides and pesticides to increase quantity of agricultural production has degraded the fertility of soil and resulted in slow poisoning of various produced food. In addition, at the times of road blockade due to covid-19 case or any other cases, there occurs serious issues like unusually high rise in food prices and food crisis. So, urban agriculture even though have small contribution to the GDP, its importance to city inhabitants is substantial especially in difficult time.

According to several research, urban green open space and left out spaces of various residential and service buildings have the potential to be used as urban farming land. Low-income citizens may be the most essential participants in the administration of urban agriculture, which generates food for both low-income inhabitants and their neighbors. (Hilmi, 2022) Urban agriculture with its household kitchen waste management as its origin is not a new concept. This method has several advantages, including food availability, nutrition security, and productive use of waste water, reduced pollution, and improved green cover, among others. This may be an efficient tool for attaining urban food security and leading to a bright future for Agriculture in cities (al., 2020).

1.2 RATIONALE

It is learnt that Kathmandu is facing loss of agricultural land, food inadequacy and environmental pollution. Importing produce is not a long-term solution because it creates a dependency on outside sources and is directly affected by rising oil prices due to the finite nature of fossil fuels. So that means if we want to grow food closer to its consumption and reduce the increasing effect of food transportation on environment, one best option is to grow food within the city. Thus, a strategy for the implementation of urban agriculture in an existing urban setting at the scale of the neighborhood is the proposal of this thesis. By incorporating nature into the community, the disturbed ecosystem can also be restored and maintain balance. The proposed project, “Urban Agriculture Centre” is an urban farm as a dynamic platform for research, innovation, education, interaction and recreation.

NARC, in theory, develops knowledge, while the extension office disseminates knowledge to the local community level of farmers. However, knowledge is not actually spreading to the farmers, because the recommendation made by National Agriculture Research center (NARC) was not formally supplying implementation or extension offices. Thus, in the research areas, Madhyapur Thimi and Kageshwori, none of the farmers queried had regular interaction with the extension service. In addition, stagnation of research by NARC and its research stations is another major issue. Some farmers in the country are experimenting with new techniques like as vertical farming, hydroponics, and drip irrigation, although they are in the minority. So, for the exploration of new techniques and design, a research station is required which designs prototypes of those instruments.

Considering the current scenario of Kathmandu valley and issues discussed above, the project mainly provides following services:

1. Urban farm (hydroponics farm, aquaponics farm, green houses, mushroom farm)
2. Research and training units
3. Interactive spaces (cafeteria, exhibition space, open green park, agro-market)

Kathmandu has high potentiality of application of urban agriculture with integration of urban planning for sustainable urban development. Advanced methods like biophonic, aquaponics, aeroponic and growing media farming can be adopted in small abandoned spaces of buildings and urban spaces to produce healthy fruits and vegetables that are free from chemical insecticides and pesticides. Thus, this project aims to study and aware urban farmers as well as new youths about various types of fruits and vegetables that can be grown using different systems of vertical farming by providing proper space for researches and trainings. Open interactive green space helps to attract young people. And exhibition space where researchers can exhibit their findings and entrepreneurs can advertise their new products and ideas will help to keep the farmers updated about the new products and technologies. At the same time, it also contributes to enlighten young people about agriculture as an important, innovative, respectful and profitable profession and hence attract new youths in the agriculture field.

1.3 PROBLEM STATEMENT

The cities of the world have been losing fertile green land and forests to build residential buildings, commercial complexes, industrial blocks and many urban infrastructures. The issue of sustainability already comes into play since there is already a threat in food supply and a threat to our environment due to the rapid consumption of natural resources that the earth has trouble keeping up to sustain our demands. The growing distance between cities and agricultural farms has resulted in more consumption of fuels for transportation and storage of agricultural products. In addition, people are getting disconnected with the nature. There are difficulties in finding open and green spaces for healthy breathing.

Like many other cities in the world, Kathmandu is facing these problems too. Agriculture land in urban areas is decreasing at an alarming rate. The agricultural area in the Valley is reported to have declined from 58.4 per cent to 47.4 per cent between 1990 and 2012. Moreover, agricultural lands in peri-urban areas are converted into buildable plots, leading to urban sprawl and loss of agricultural land that can fulfil food requirements of the city. (The Himalayan, 2017). Local farmers realized to have more profit from renting land to developers than from farming. Also, the outdated methods of farming and lack of proper knowledge have built the mentality among people that agriculture is done by uneducated people and the farming profession has become an un-respected profession in the society. Thus, decrease in number of farmers and agricultural land compelled the valley to be dependent on food imports from different corners of country and neighboring countries, India and china.

Diesel consumption for vegetable transportation in the valley in 2063 is 2176623.9 and the cost is Nrs.1,17,53,790, which is a huge amount that can be decreased to great extent through application of urban agriculture (Raut,2062). Also use of chemical fertilizers, insecticides and pesticides to increase quantity of agricultural production has degraded the fertility of soil and resulted in slow poisoning of various produced food.

The World Health Organization reported 30 million pesticide poisoning cases each year, with 220,000 deaths in underdeveloped nations. In Nepal, insecticide use is increasing by 10- 20% each year, indicating a prevailing dilemma in Nepalese agriculture not only in terms of economic losses but also of linked negative impacts. Some of the reported negative impacts of the chemical insecticides and pesticides are: -

- Pesticides also causes infertility, cancer in both the male and female reproductive systems, developmental toxicity, neurotoxicity, and immune toxicity (Sagar GC, 2019).
- Farmworkers who have been exposed to pesticides may experience headaches, sleepiness, disorientation, skin irritation, muscle twitching, respiratory discomfort, and other symptoms. According to reports, the estimated health cost of a pesticide user who has been exposed to pesticides is Nepalese Rupee (NPR) 287.
- Pesticide-induced health expenditures account for 0.2 percent of overall household expenditure and 10.32 percent of yearly health care expenditure.
- In addition, it is noted that intentional or attempted suicides by pesticide poisoning are frequent in Nepal. Methyl parathion, dichlorvos, aluminum phosphide, and zinc phosphide were the insecticides that were most usually used for self-pesticide poisoning (Nyaupane, 2021).

Similarly, at the times of road blockade due to covid-19 case or any other cases, there occurs serious issues like unusually high rise in food prices and food crisis. So, urban agriculture even though have small contribution to the GDP, its importance to city inhabitants is substantial especially in difficult time.

1.4 OBJECTIVES

- To learn about potential advantages and challenges of urban farming through research and experiments.
- To design an urban farm based on new technologies as an alternative to future food crisis.
- To re-create the intricate relation between urban farming and the community life.

1.5 METHODOLOGY

Methodology is the backbone of any research and design project. A systematic methodology is essential to find out the answer to research question and control variance. The methodology followed for this project consists of two phases: -

- Research Phase
- Design Phase

1.5.1 RESEARCH PHASE

Collection of data and information related to the project is the first step of the project. The research phase again is conducted in 2 stages: -

- Literature review
- Case-studies

1.5.1.1 LITERATURE REVIEW

A literature review is a detailed summary of past research on a certain issue. The literature review examines scholarly articles, books, and other sources that are related to a specific area of study. Building your study on existing knowledge and relating it to it is the foundation of all academic research activity, regardless of subject. (HannahSnyder, 2019)

There are a number of existing methods and guidelines for literature reviews. One of the methods that I will be using for the literature review consists of following procedures:

1. formulating the research question(s) and objective(s),
2. searching the extant literature,
3. screening for inclusion,
4. assessing the quality of primary studies,
5. extracting data, and
6. analyzing data

   (Kitsiou, 2017)

1.5.1.2 CASE-STUDIES

The case study approach is distinguished by the deliberate selection of the case to be studied and triangulation, which is commonly done using a variety of data gathering methods. The case study allows critical evaluations, interventions, policy changes, and program-based service improvements in depth based on real life context. (Musbau Bello Adewumi, 2020)

The term case study consists of two key words “case and study”. Therefore, the case study must have a “case” which is the object of study. The case could be:

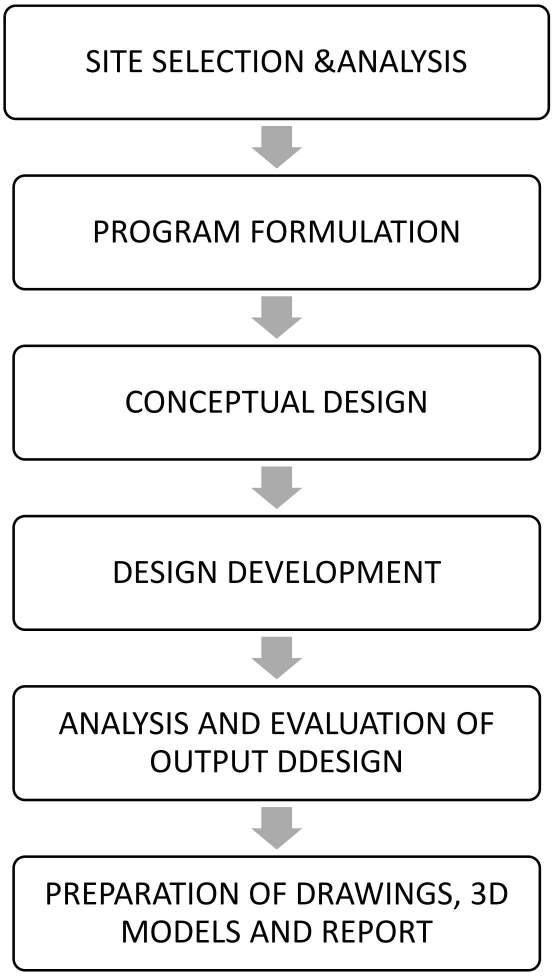
1. A complex functioning unit

2. Investigated in its natural context with a multitude of methods and

3. Contemporary. (NNAEMEKA, 2015)

1.1.1 DESIGN PHASE

This phase will focus on developing an appropriate design for the thesis topic chosen, where the combination of all knowledge collected during the research phase will be used. Design phase is generally carried out in following steps: -



2. LITERATURE REVIEW

2.1 URBAN AGRICULTURE

Urban agriculture may be defined as the cultivation of plants and the rearing of animals in and near cities. The most noticeable aspect that separates urban agriculture from rural agriculture is that it is integrated into the urban economic and ecological system: urban agriculture is immersed in - and interacts with - the urban ecosystem. Such connections include the use of urban residents as laborers, the use of common urban resources (such as organic waste as compost and urban wastewater for irrigation), direct links with urban consumers, direct impacts on urban ecology (both positive and negative), being part of the urban food system, competing for land with other urban functions, being influenced by urban policies and plans, and so on.

The current definition that is most widely accepted by international organizations like the United Nations Food and Agriculture Organization (FAO) is:

"Urban agriculture is an industry located within or on the fringe of a town, a city or a metropolis, which grows and raises, processes and distributes a diversity of food and non-food products, (re-)using largely human and material resources, products and services found in and around that urban area, and in turn supplying human and material resources, products and services largely to that urban area."

Urban Agriculture is practiced globally by people of all economic classes, cultures, ethnicities and situations as an informal sector activity as alternative livelihood strategy that the urban poor can use in combination with other strategies. It is estimated that roughly 15% of the world's food is produced through urban agriculture, with an estimated 800 million people involved in the early 1990s.

2.2 HISTORICAL ACCOUNT OF URBAN AGRICULTURE

"Ever since the First French geographical accounts of intra and peri-urban agriculture were published in central Africa in 1960s, a scattered and isolated urban agricultural survey by individual social scientists has gradually been giving way to institutional projects led by multidisciplinary teams." (Raut, 2008)

The concept of modernization in agriculture emerged in 1960s. Generally, the modernization of agriculture has been dominated by two major purposes. One has been the need for increased food production to meet the need of a growing population in the world. For attaining this goal, government has initiated plans and policies to encourage the use of varieties of crops and livestock together with incorporation of new agricultural techniques, technologies and other necessary external inputs. The second most important theme of the modernization process is to prevent the degradation of natural resources. For the protection of natural resources, governments have shown concern and encouraged adoption of soil and water conservation measures to control soil erosion. However, since 1945, modernization theory has been more concerned at dealing with poverty through the application and transfer of science and technology as understood in the developed countries (Sapkota, 2018).

Urban agriculture has been practiced throughout the world for thousands of years and is an integrated urban form in many places. Increasing rural-urban migration contributes to food insecurity, pollution, unequal distribution of resources, etc. Food provision is gaining importance but is neglected for a long period of time. Urban farming, which originated in the management of family kitchen waste, is not a new notion. However, as technology advances, this approach is gaining traction (al., 2020).

2.3 URBAN AGRICULTURE IN CONTEXT OF KATHMANDU

The traditional settlements in Kathmandu valley are characterized by compact urban settlements of small sizes located on ridges fallow and un-irrigable hill tops. Such compact settlement at core and top location must be for security purpose and for maximizing agricultural land on irrigable slopes and fertile plain lands along river banks. (Maharjan, 2022)

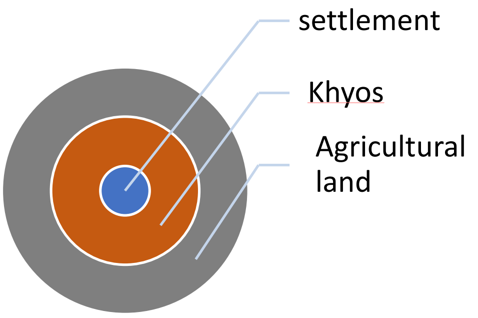


Figure 2. 1 – City pattern of Kathmandu valley at past

Agricultural development policies have mostly relied on Western technology solutions, with variable results. Farming Systems Research (FSR) was developed in order to improve the usage of indigenous crops and techniques of farming to make new technology more adaptive. It is found that use of local knowledge and modern technology provide a sound basis for promoting the productivity use of local resources and in enhancing the sustainable management of the resources. The local knowledge is the term often used today to recognize a form of knowledge, which is holistic, and orally transmitted within local communities, whereas according to Scoones and Thompson (1993), the scientific knowledge is seen as theoretically based and that can be generalized as well as propositional knowledge. The purpose of this study is to draw attention to difficulties concerning existing linkages between indigenous knowledge and contemporary technology (scientific knowledge) in the context of sustainable urban agriculture in Nepal. (Sapkota, 2018)

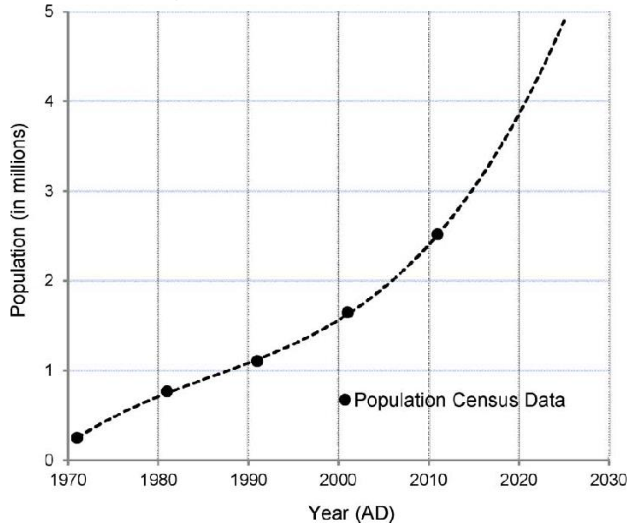
At present the growth of urbanization and industrialization is haphazard that it has broken all boundaries including the ecologically established social principle of building just in fallow land. Today all the agriculturally productive lands and river plains between Kathmandu are covered with concrete forest of residential and commercial buildings.

2.3.1 PROBLEMS IN CURRENT AGRICULTURAL PRACTICE

2.3.1.1 DECREASE IN FARMING LAND AND FARMERS

Rapid urbanization driven by Kathmandu's growing importance in Nepal's economy as the center of government, industry, and tourism, drawing an increasing number of migrants from rural areas resulted in decrease in farming land.

The agricultural area in the Valley is reported to have declined from 58.4 per cent to 47.4 per cent between 1990 and 2012. Moreover, agricultural lands in peri-urban areas are converted into buildable plots, leading to urban sprawl and loss of agricultural land that can fulfil food requirements of the city. (The Himalayan, 2017). Local farmers realized to have more profit from renting land to developers than from farming.



Source: CBS (2012). | Download scientific Diagram (researchgate.net)

Figure 2. 2 – Population data of Kathmandu valley

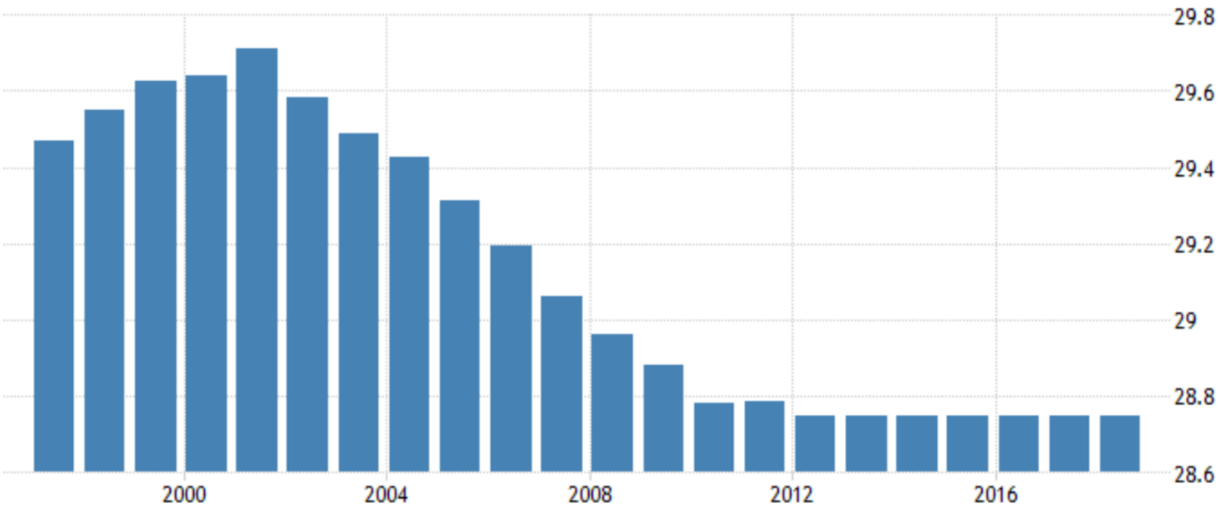


Figure 2. 3 - Agriculture land percentage in Nepal

Source: : Nepal - Agricultural Land (% Of Land Area) - 1961-2018 Data | 2021 Forecast (tradingeconomics.com)

Also, the outdated methods of farming and lack of proper knowledge have built the mentality among people that agriculture is done by uneducated people and the farming profession has become a disrespected profession in the society. Hence agricultural land and number of farmers are decreasing in an alarming rate.

2.3.1.2 WIDELY DEPENDENT ON FOOD IMPORT

According to Dr. Gyan Lal Shrestha, Nepal imports annually over rs.400 million worth of fresh vegetables from India which directly comes to the valley and distributed to other parts. The chart below shows the places from where vegetables in Kalimati market is brought.

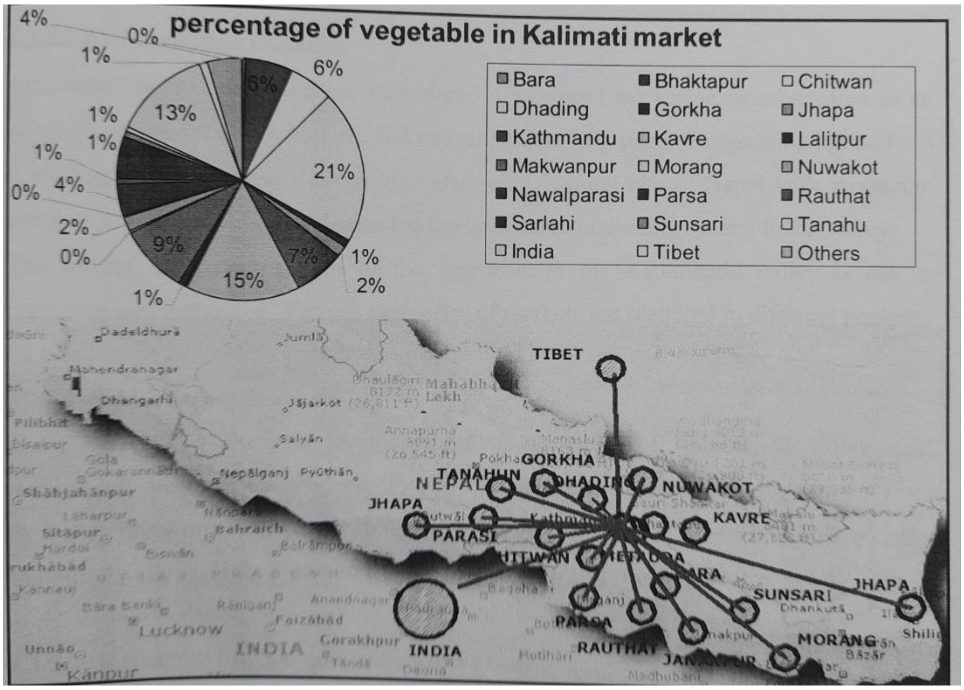


Figure 2. 4 – Percentage of vegetables import in Kalimati market (Raut,2008)

2.3.1.3 POOR LINKAGES BETWEEN TECHNOLOGY GENERATION AND DISSEMINATION

Ineffective linkages have hindered the development and transfer of technologies to improve the farming community's standard of living and stimulate the nation's agricultural growth. (Poudel, 2016) Around 47.7% of urban farmers of surveyed areas (Kupondole, Tinthana and Gothatar) acquired their knowledge from traditional experiences, other 47.7% got agricultural skill from their friends while only 5% got trained with some agricultural techniques (Raut, 2008).

The biggest institutional challenge to creating efficient technology development systems in the nation is bridging the gap between research and development organizations. As a result, commercialization of agriculture has been hampered in sectors where there is ample room for the production of the raw materials for agro-based industries like sugar factories, jute mills, tea industries, vegetable seed production, and many horticultural commodities such as flowers, fruits, and vegetables, as well as agro processing and post-harvest related industries. Technology to address this issue should work hand in hand with agro-based industrialization to promote (Poudel, 2016).

2.3.1.4 EXTENSIVE USE OF CHEMICAL INSECTICIDES AND PESTICIDES

In Nepal, insecticide use is increasing by 10-20% each year. Farmers' lack of awareness and education, a lack of alternatives to chemical pest management, and a lack of governmental oversight and monitoring policies and activities for pesticide usage are some of the reasons for incorrect and excessive insecticide use in Nepal. After the introduction of chemical fertilizers, pesticides and insecticides, some of the women’s works had been reduced but not noticeable change on the rhythm of everyday life. Before that, women were working for the preparation of homemade pesticides/insecticides and even put on the farm as well as they involve into collection of different plants and other things for the preparation of organic manure (Sagar GC, 2019).

2.4 METHODS OF URBAN FARMING

There are several agricultural techniques used in urban agriculture. Vertical farming, roof-top farming, controlled environment agriculture, empty lots, and guerrilla gardening are examples that can be integrate agriculture with architecture; making it as common in buildings as water, heating and natural lighting from the literature (ADAM GHANDAR).

2.4.1 ROOF FARMING

Rooftop farming is getting a traction in the urban areas because it is easy to handle, economic and has array of health and environmental benefits. It makes the city green, eases waste management, enhance the air quality, and easily provides unadulterated, fresh and nutritious food products.

Figure 2. 5 - Roof farming by Dilip Shrestha

Source: Dhungana, N. (2020, May 14). *Online khabar*. Retrieved from Online

- Enhance the urban landscape (and human wellbeing). By cultivating lettuces, kale, arugula, and other crops and vegetables literally makes cities greener. And studies have found that exposure to nature and vegetation provides an array of psychological benefits, from decreased anxiety to increased productivity.
- Makes cities eco-friendlier. Bare roofs in cities absorb and then radiate heat – a phenomenon known as the "heat island effect". This increases energy usage and as it travels fewer food miles, decreases transportation cost as well.
- Increase the availability of real, healthy food. When farmers grow inside – or better yet, on the top of – the concrete jungles and food deserts that many of us inhabit, more people have access to fresh, wholesome, and affordable food.

Example:

Dilip Shrestha of Ratopul, Kathmandu does roof farming where sponge gourd, black-eyed beans, spinach, garlic, onion to fruits like mango, kiwi, pomegranate, avocado, strawberry, lemon and dragon fruit are grown. He stated that kitchen and house waste as compost and old containers as pots to plant vegetables and fruits are enough for growing fruits and vegetables. (Dhungana,2020)

2.4.2 INDOOR FARMING

"Indoor farming is a relatively new method of growing vegetables and other plants under controlled environmental conditions. These farm systems are variously referred to as indoor farms, vertical farms, vfarms, zfarms, greenhouses, and controlled environment agriculture (CEA), and plant factories." (Stein, 2021)

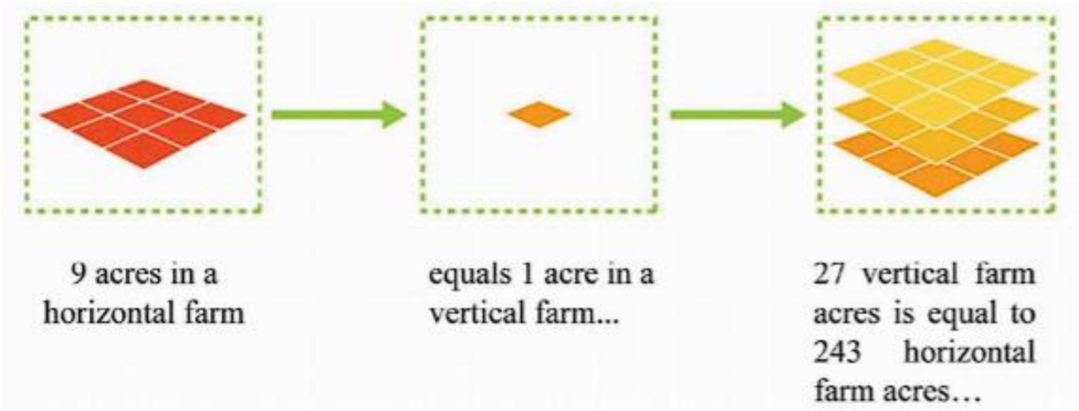


Figure 2. 6- Comparison of flat farming to vertical farming

For decades, greenhouses have been the workhorse of indoor gardeners, particularly in the production of flowers and decorative plants. Modern high-tech greenhouse designs were developed in the Netherlands and have since spread around the world. Several examples of these farms may be found around the United States, with the largest spanning hundreds of acres. Greenhouse Grower5 reports that Altman Plants (CA) has about 600 acres under glass, followed by Costa Farms (FL) with 345 acres. These are mostly employed in the cultivation of ornamental plants. For vegetables, greenhouses were originally designed for tomatoes, but now are used in the production of kale, microgreens, lettuces, herbs, squash, and other types of fresh produce. These greenhouses, formerly located in rural areas, are now being positioned near urban and peri-urban areas to bring operations closer to population centers to save money and reduce the carbon footprint associated with transportation miles. For example, Bright Farms has greenhouse operations located just outside of Philadelphia and Cincinnati to produce lettuces and other leafy greens. Gotham Greens situated its first greenhouse on top of a warehouse in Brooklyn, NY and has since expanded to other cities (Stein, 2021).

2.4.3 VERTICAL FARMING

Vertical farming is the method of cultivating plants in layers that are vertically stacked. This horticultural strategy aims to increase plant space use and productivity by scaling up off the ground, allowing for more plants to be grown in the same area. Furthermore, it may be applied to current horticultural methods ranging from small-scale hydroponics to large-scale controlled environmental agricultural operations, and it has the ability to create year-round production in virtually any region if combined with the appropriate techniques (Wallace-Springer, 2022).

Vertical farming = growing more with less, farming up rather than out.

Vertical farms are divided into three major components:

(1) the system structures

(2) the electrical structure and

(3) the plumbing structures

These three factors are critical to examine since they will determine where a system may be situated, what crops can be produced in them, and the resources needed to develop one. They should be taken into account before beginning a vertical farming enterprise (Wallace-Springer, 2022).

2.5 BUILDING STRUCTURES FOR VERTICAL FARM

2.5.1 BUILDING BASED VERTICAL FARMS

Urban abandoned buildings are a common location for building-based vertical farms, including Chicago's "The Facility" vertical farm, which was built within a former pork-packing plant. A new multistory vertical farm that is joined to an existing parking lot structure in downtown Jackson Hole, Wyoming is an example of a new building utilized in a vertical farm (Birkby, 2016).

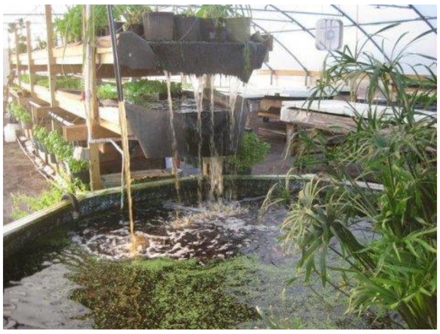


Figure 2.7- Urban farm in abandoned building

2.5.2 SHIPPING CONTAINER VERTICAL FARM

Vertical farms built within 40-foot shipping containers often transport commodities around the globe. The conversion of shipping containers into self-sufficient vertical farms includes adding LED lighting, drip irrigation, and vertically stacked shelves for beginning and cultivating a range of plants. These self-contained devices include growth management systems that are computer-controlled, allowing customers to remotely monitor every system from a smartphone or computer. (Maharjan, 2022)

Figure 2.8-Shipping container

Source: (1172) Pinterest

2.5.3 DESPOMMIER SKYSCRAPERS

Dickson Despommier, a microbiologist at Columbia University, believes that traditional farm practices, which are already using 41% of the planet’s land, will not be able to support the food requirements of the exponentially increasing population. So, he envisions skyscrapers where crops can be grown in vertically stacked shelves, mass produced within closed and controlled environments that are not influenced by the external climate. As a result, these skyscrapers can be built anywhere regardless of any agronomic constraint.

One school of thoughts claims that vertical farming requires less energy and causes less pollution than some those of traditional farming practices because vertical farms can be integrated with renewable energy technology. Solar panels, wind turbines and hydroelectric power can be used respectively or in combination with one another to satisfy energy requirements of these structures. Vertical farming

Figure 2.9- Despommier's skyscappers

Source: (Tim Heath, 2014)

has a scope to create huge employment opportunities as local inhabitants can work in these vertical farms to make a living (Gupta & Ganapuram, 2019).

2.6 TYPES OF URBAN FARMING TECHNOLOGIES

2.6.1 GREEN HOUSE

Green house is a technology to control and maintain favorable indoor environment for growing plants using a framed structure, covered with glasses or other transparent materials. Major function of a green house is to trap sunlight and maintain warm temperature in winter or in cold region. The operable ventilations of greenhouse facilitate natural air circulation to maintain indoor temperature and humidity when the temperature is too high.

In high-tech green house, there will be more controlling features through which farmers can

Figure 2. 10 - Green house of National Botanical Garden

freely adjust temperature, humidity, light intensity, concentration of carbon dioxide and nutrients for having better yields (Su, 2021).

2.6.2 HYDROPONICS

Plants are fed an aqueous solution containing all of the essential nutrients required for maximum plant development in hydroponic vertical farming. Modified hydroponics systems, such as nutrient film technology (Ex. A-Frame and vertical grow towers), deep water culture (DWC), and aeroponics are examples of this sort of vertical farming (Wallace-Springer, 2022).

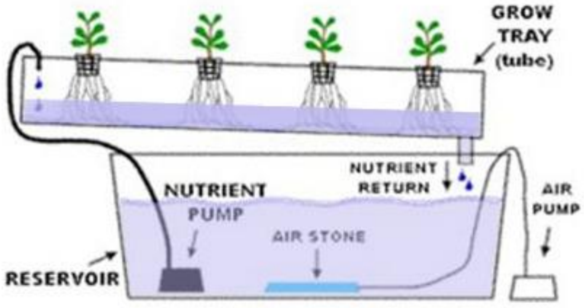


Figure 2.11- Hydroponics module

Source: (Heather, 2018)

2.6.3 AQUAPONICS

`Aquaponics farming, on the other hand, integrates fish production with plant production through the use of hydroponic system designs. Plants are alternatively nourished using nutrient-rich fish water that has been filtered, converted to nitrates, and supplied for limiting nutrients absent in aquaponics systems, rather than an aqueous solution containing all needed nutrients (Wallace-Springer, 2022).

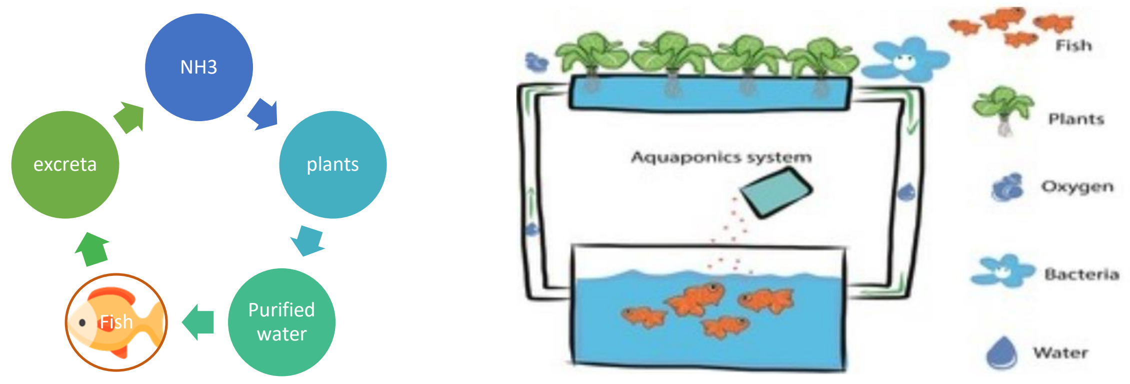


Figure 2.12- Working of aquaponics system

Source: (Heather, 2018)

2.6.4 AEROPONICS

In aeroponics system, the roots of the plants are completely liberating and allowing it to come into contact with pure air and hence resulting in 95 percent less water usage than field farming and 40 percent less than hydroponic growing. Aeroponic farming yields faster, fresher, cleaner produce with less risk of contamination. Crops grow two to three times their normal sizes. On top of that, aeroponic farming systems are not limited by season or weather and completely free from the threat of pests (Wallace-Springer, 2022).

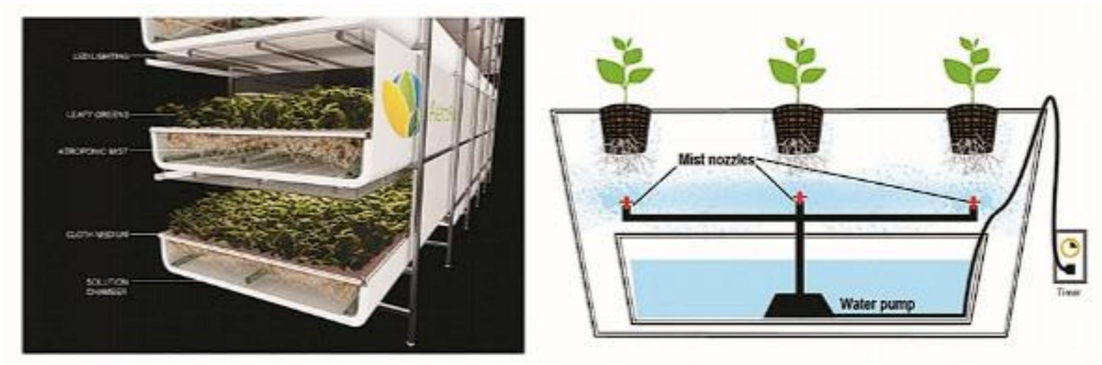


Figure 2. 13- Working of aeroponics system

Source: *Kohlstedt, 2017*

The National Aeronautical and Space Administration (NASA) is responsible for developing this innovative indoor growing technique. In the 1990s, NASA was interested in finding efficient ways to grow plants in space and coined the term "aeroponics," defined as "growing plants in an air/mist environment with no soil and very little water.

2.7 PLANTS REQUIREMENTS

In addition to vertical farming components and system types, it is necessary to consider how the plants will be cultivated as well as their specific requirements! Will they, for example, be cultivated outside or inside? Are the necessary systems in place if they are to be grown indoors? Is air circulation necessary? What effect does shade have on crop quality?

Plants require four essential things to grow properly: nutrients, carbon dioxide, water, and light. Before expanding a facility or opening a vertical farm, each of these concerns should be considered (Wallace-Springer, 2022).

2.8 DESIGN CONSIDERATIONS FOR A VERTICAL FARM

A high-rise vertical farm should possess following properties: -

- Few floors of same distribution should be used for controlling the internal environment of the farm. For Vertical farm size: 93 hectares (about the size of a city block), 37 levels, 25 of which are solely for crop production and 3 for aquaculture. Furthermore, three levels of the same distribution are utilized for environmental adjustments, and two are positioned underground for waste storage.
- Moreover, one level should be dedicated to the cleaning of growth trays, as well as the exhibiting and germination of seeds.
- One floor should be dedicated to the packing and processing of vegetables or fish.
- Another floor dedicated to the sale of underground products.
- The building should have a large elevator in the center that can accommodate a forklift truck. This aids in transporting the harvest to lower floors.
- The system requires huge amount of water each day. The water that is not absorbed by the veggies is subsequently recycled in a water recycling system. The loop is closed once it has been treated and sprayed once more.
- The ground floor of a vertical farm must be a grocery store or restaurant where the products are sold to the public (ToyokiKozai, 2016).

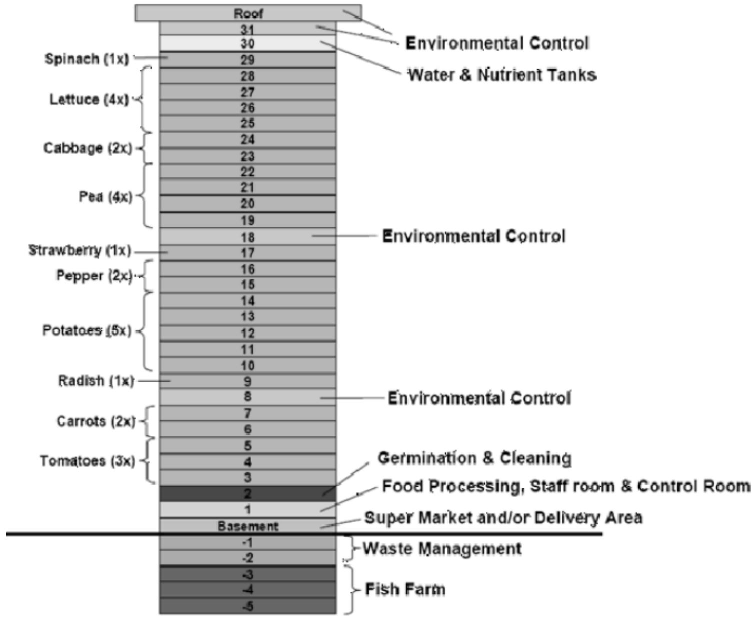


Figure 2. 14- Model for a vertical farm, (ToyokiKozai, 2016)

2.9 GROWING MODULES

Plants can grow on growing modules that have a vertical orientation because to the lightweight framing technology. There are various typologies applicable to indoor crop cultivation on a commercial scale. Each one has their own pros and cons which are described below (Szen, 2017).

2.9.1 A-FRAME TRELLIS

The frame is made of PVC pipes that may be arranged either vertically or horizontally to create a triangular extrusion of its footprint that is angled toward the light sources. This arrangement increases the growth surface without significantly diminishing the amount of light that is available. The main benefit of this module design is its simplicity, as it maximizes space efficiency while relying on equipment that has been widely used in the hydroponics sector for many years (Szen, 2017).

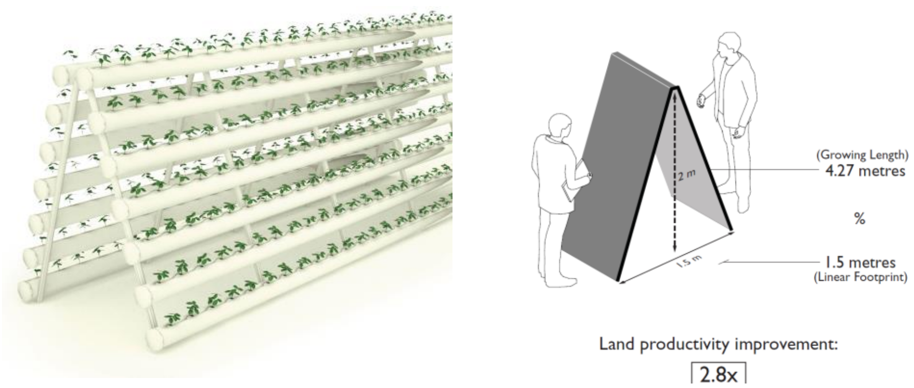


Figure 2. 15- A-Frame Trellis , (Szen, 2017)

2.9.2 STACKED BED

Simple in-line pipe beds are stacked to create this design. Due to its ability to provide more room for growing, this method has remained the option of choice for the majority of commercial vertical farms. However, the design's stacked layout prevents sunlight from penetrating each layer, necessitating artificial lighting. As a result, this expanding system accounted for a sizable share of the total energy utilized for illumination (Szen, 2017).

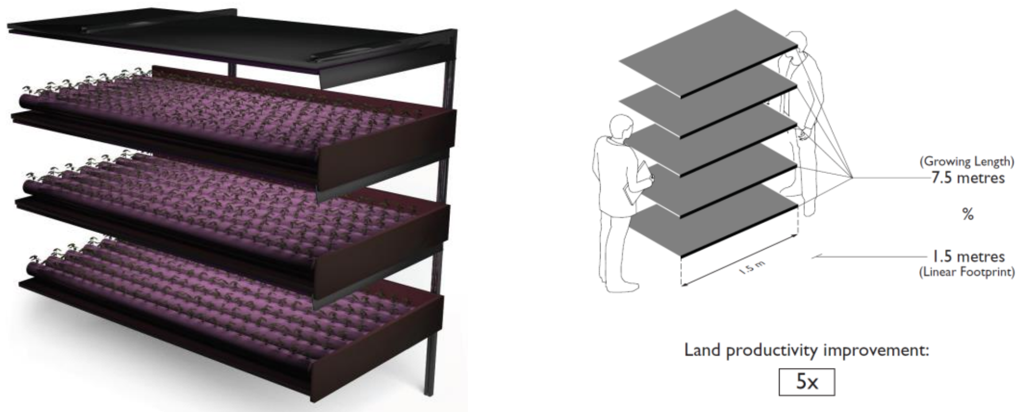


Figure 2. 16- Stack bed, (Szen, 2017)

2.9.3 COLUMNAR SYSTEM

To maximize light penetration, this VertiCrop design uses a number of stacked trays set up in a staggered way. The "columns" are then cycled along a conveyor track to a central device that displaces the trays for harvesting and provides nutrient solution. Compared to other sun-fed hydroponic systems now on the market, the design offers the maximum space efficiency. (Szen, 2017).

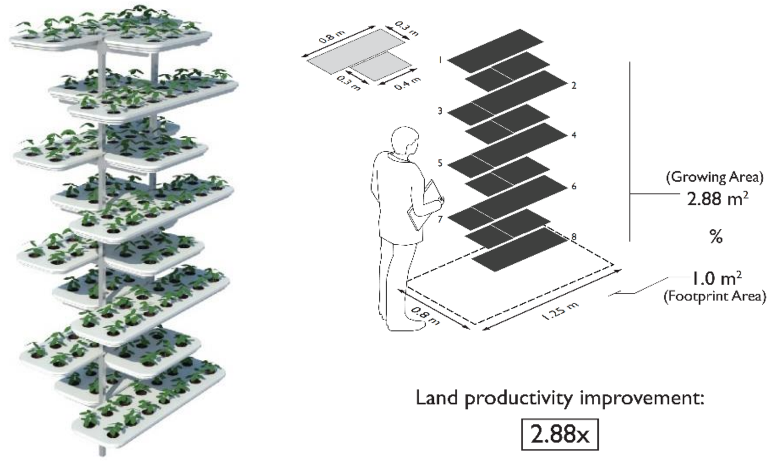
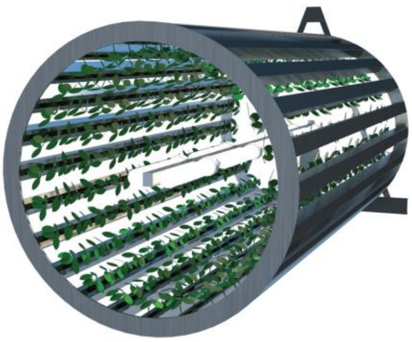


Figure 2. 17- Columnar module

Source: (James, n.d.)

2.9.4 STACK DRUM

Despite the fact that stack drum is the least common commercial cultivation module among



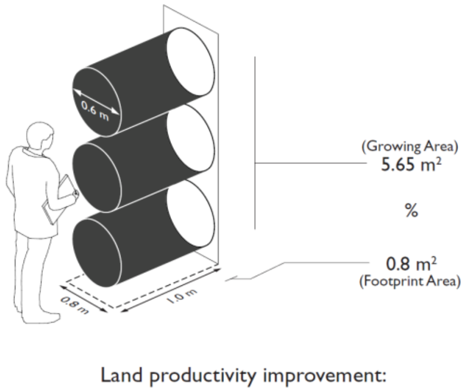


Figure 2. 18- Stack Drums

The drum design likely offers the most promising eventual fate of indoor agriculture. It compromises of growing plants within the interior of a drum structure located around a central artificial light source, resulting in a phenomenally low space and energy use par unit of production (Szen, 2017).

2.10 TECHNOLOGIES REQUIRED FOR INDOOR VERTICAL FARM

2.10.1 LIGHTING

Light is a vital ingredient for growth of any plants as photosynthesis occurs in presence of light. The intensity, light of different wave lengths and duration of light falling on the plant plays important role in growth rate and production rate of crops and vegetables. The range of light intensity needed for enhancing the growth of vegetation is contingent on the setting and time, product, heat and CO_2 content of the air around plants. Considering all of these factors, the typical range of light intensity used is 50-200 mol/m2/s, or around 4100-16400 lx when high-pressure sodium lamps are used. The amount of light necessary in a closed environment for vegetation growth is around 18 hours per day (Adhikari, 2019).

To control the production line, determine whether the vertical farm will use only artificial light or both artificial and natural light.

2.10.1.1 NATURAL LIGHTING

Daylight approaches rely on the availability of natural light, which is controlled by the latitude of the building site and the surrounding environment. Because day lighting strategies are also influenced by the weather, determining seasonal, predominant climate variables, particularly ambient temperatures and sunshine probability, is an important stage in daylight design. Building should be designed to have maximum amount of light penetration inside the building. Openings in wall and roof should be made as per the light requirements of the indoor plants. Orientation, shape and building angle to follow the sun can control the amount of solar gain. For example: - there is a preview of the dynamic construction program of Plantagon in Sweden. Its modern helix design helps in maximum light absorption and distribution (Adhikari, 2019).

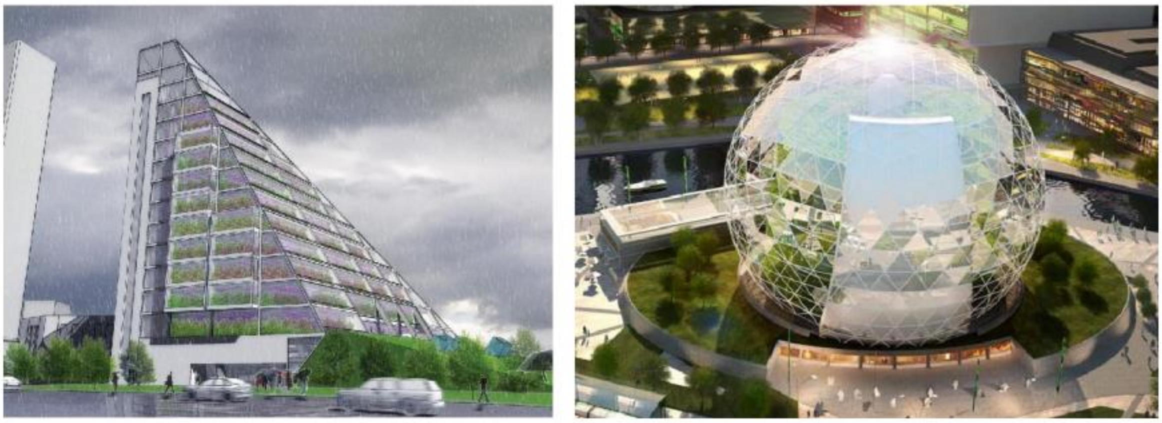


Figure 2.19-Building shapes for maximum solar, (ToyokiKozai, 2016)

Non-PAR waves (Photo-syntactically active radiation) should be filtered in vertical farms to maximize the use of solar energy because they are not absorbed by chlorophyll. These waves must be filtered by selected solar cells before being used to generate photovoltaic energy. Recently, many semi-transparent cells have been created. However, there have been fewer attempts to make such cells especially transparent for photo synthetically active wavelengths. Using red/purple colors with the highest absorption (535 nm) as the foundation of dye-sensitized solar cells can be a good technique to build chosen solar cells (ToyokiKozai, 2016).

In case of unavailability of direct sunlight or insufficiency of natural PAR, because the area of vegetation growth in VF is doubled by the number of stories, a network of reflectors can be used to as shown in the figure below to have required amount of light (ToyokiKozai, 2016).

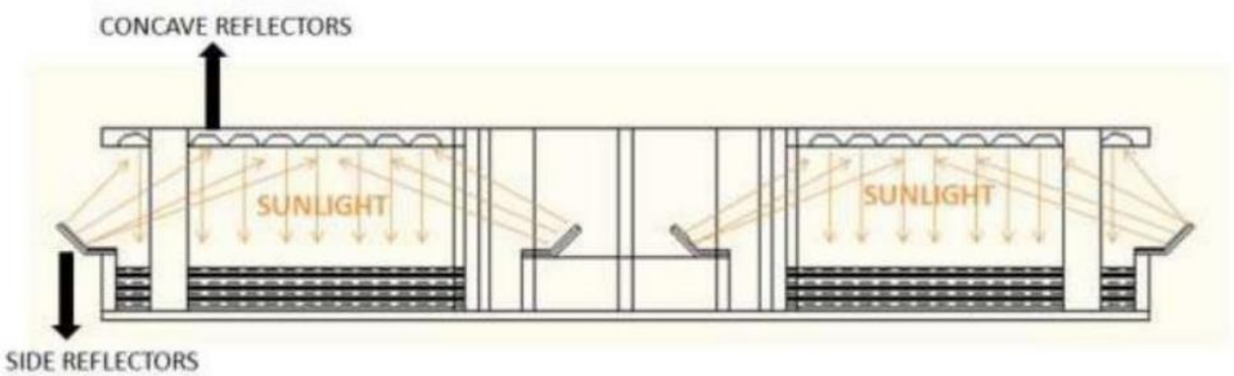


Figure 2.20- Use of network of reflectors

2.10.1.2 ARTIFICIAL LIGHTING

Based on the required illumination, intensity and color of lights to grow certain type of plants generally flowing types of artificial lightings are used: -

- Incandescent grow lights
  They have a red-yellowish tone and low color temperature (approx. 2700k). Such lights are not useful for plant growing but used to highlight indoor plant groupings. They have life span of around 750 hours.
- Fluorescent tube lights

These are either cool white colors in red range or warm white colors in blue range. Combination of cool and warm lights provides the most natural spectrum of light. Their life span is rated as 4 years but loses 85% of their intensity before they bum out.

- LED fixture

  LED lights have longer lifespan and consumes lesser electricity. LEDs are increasingly used as a source of light for plants because of their advantages of long life, efficiency in energy, feasibility to adjust particular light wavelengths for desired plant responses. Blue LED light can shorten the plant height which helps in easy transport of plants when needed. LEDs are low in heat radiant so, can be placed near to the plants.

2.10.2 EVAPORATIVE COOLING

Evaporative cooling is a natural process in which a liquid that has evaporated in the air comes into touch with a solid or liquid and cools it. The evaporative cooling effect increases with the temperature difference between the two devices called evaporative coolers use the evaporation of water to chill the air. By converting water to vapor utilizing the latent heat of evaporation, they are used to reduce the air's temperature. The air's heat is used to evaporate water, converting warm, dry air into chilly, wet air. When a greenhouse is built into a building, an evaporative cooling system in the greenhouse is very helpful for controlling the environment of the structure.

To expel exhausted air outside, coolers are positioned at the floor or ceiling margins of the greenhouse. To create cool air, the fan sucks stale air via the moist pad and vents. The pads are continuously re-damped to maintain the process as the heated air evaporates the water from them. Moist air is released through a vent from the roof or an exterior wall into the building when this air is cooled (Scott, 2009).

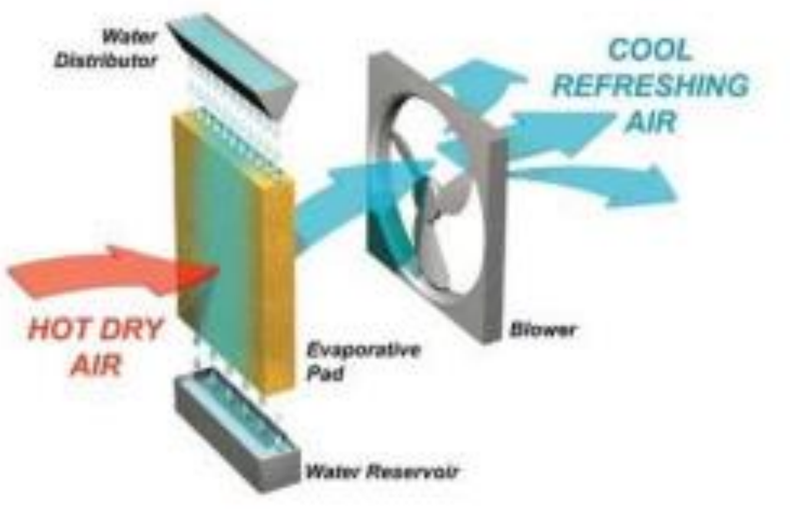


Figure 2.21-Evaporative Cooling illustration

A successful greenhouse environment necessitates strict temperature control. Within the greenhouses of the vertical farm, evaporative cooling, biogas heating, and natural draft ventilation are used to maintain optimal temperatures and relative humidity in the ranges of 18–24°C and 30-70%, respectively. In areas with a warm, dry Mediterranean climate, like Cape

Town, where humidity ranges from 30 to 70 percent and temperatures range from 18 to 24 degrees Celsius, evaporative cooling is efficient. (Scott, 2009).

2.10.3 WATER CONSERVATION

The amount of water provided is a key productivity constraint, thus how to regulate crops and soil to maximize water consumption and preserve it within soil is required to ensure enough products. There are several ways employed in VF to deal with a scarcity of water, which are discussed more below.

2.10.3.1 WATER RETRIEVAL BY MEANS OF RECYCLING

When city water waste is recycled, it becomes a good source of farm-specific water supply and helps farms become self-sustaining. Vertical farms can not only use rainwater, but they can also use gray water supply, which is water that is only used once, such as for showers or hand washing, or water collected from the roofs of buildings. This water can be purified and used to water plants both indoors and outdoors. The concept is to first direct the water into a cistern beneath the earth acquired from a city somewhere in the center. This water will then be pushed to the top of a tower, where it will fall and irrigate the crops using gravity. Water that has been processed only once and does not require further processing to be drinkable can also be used to water plants in farms. If water is recycled in this manner, no water will be wasted, and the water table will be less threatened.

2.10.3.2 WATER RETRIEVAL BY MEANS OF DEHUMIDIFICATION

Water that has evaporated and disappeared can be collected and reused. Water with all of its nutrients enters a plant through its roots. Solutes are absorbed, and the remaining water evaporates into the atmosphere via leaves. Once it exits the plant, the evaporated water contains no contaminants. This evaporated clean water can be reused in VF through dehumidification. There are specific machines for this purpose that, once installed on each floor, may recover this water. A natural method of purifying water has therefore been adopted. Every year, this approach collects 220000 m3 of water. Aero farms, a corporation that uses specialized irrigation technology, is one example of this. According to experience, this farming system can utilize 1.2 times the quantity of water as traditional farms to produce the same amount of crops. According to data, hydroponics can use up to 70% less water than traditional farming techniques, while geoponics uses even less water.

Water produced by this method can be used for drinking and watering plants. If achieved, this can indicate a closed loop in water use, which opens the prospect of self-sufficient cities in terms of water supply while also saving a significant amount of financial and environmental resources.

2.10.4 HVAC SYSTEM

Toxic chemicals, combustible compounds, flammable solvents, dangerous organisms, noxious fumes, and other substances are handled in laboratories. While designing and fitting out new laboratories, much effort is expended in incorporating proper engineering controls. This ensures security on three levels: laboratory users, the larger corporation, and the surrounding community. Understanding the nature of research/activities carried out and regulatory compliance sought by clients is a key step for lab designers in determining the type and level of ventilation required for their new facility.

Ventilation is crucial for both safety and economic reasons, as it requires significant capital and operational costs. Laboratories are energy-intensive settings, consuming 4-6 times more energy per square meter than ordinary office or commercial buildings, and the HVAC system accounts for more than 60% of a laboratory's energy usage (Manufacturing Chemist).

2.10.4.1 HVAC SYSTEM IN LABS

HVAC (Heating, ventilation and air conditioning) system is used in indoor vertical farming for controlling indoor quality of air, saving energy, consistency of moisture and heat in vertical farms provided by the shades of plants. The building which uses the least energy possible is highly efficient in saving energy. (Bulb laboratories, n.d.)

Air changes per hour (ACH) or air change rate (ACPH) is a measurement of the amount of air added to or withdrawn from an area (often a room or residence) divided by the volume of the space. If the air in the space is homogeneous or perfectly mixed, air changes per hour is a measurement of how frequently the air in a defined space is replaced. The amount of air changes required by different laboratory areas and rooms in the facility will vary from one another. Rooms with fume cupboards and higher containment require more air changes than a standard laboratory. (Bulb laboratories, n.d.)

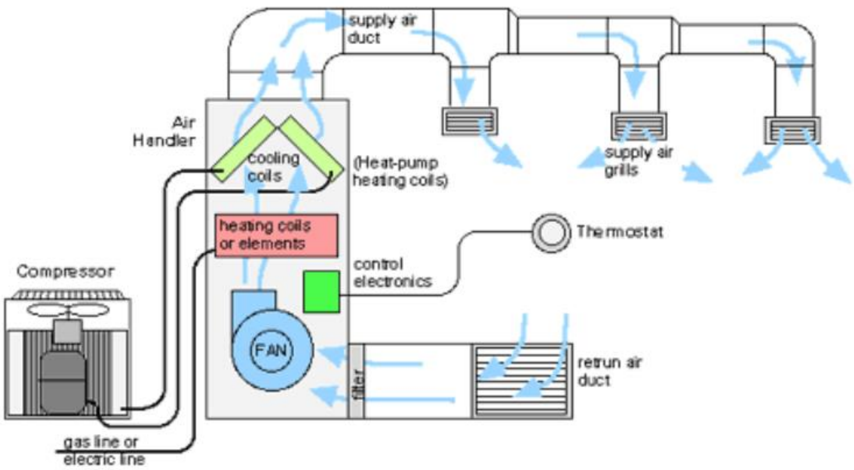


Figure 2.22-Lightfoot Mechanical, (Bulb laboratories, n.d.)

The type of material handled in the area will dictate whether the exhaust needs to be treated (e.g., HEPA (High Efficiency Particulate Absorption) filters, scrubbers) before being discharged into the atmosphere or re-circulated. For example, biology laboratories with BSL 1 through 4 will have rising hazard levels and filtration requirements. BSL1 is the simplest while BSL4 is the most complicated. (Bulb laboratories, n.d.)

Pharmaceutical clean rooms necessitate frequent air changes as well as HEPA filtering for supply and exhaust air.

Some or all of the following criteria can be used to determine what that looks like:

• Facility layout and workflow

• Temperature and relative humidity

• Air pressure differentials between rooms

• Number of air changes per room

• Air velocity and airflow pattern (Bulb laboratories, n.d.)

2.10.5 GLAZING

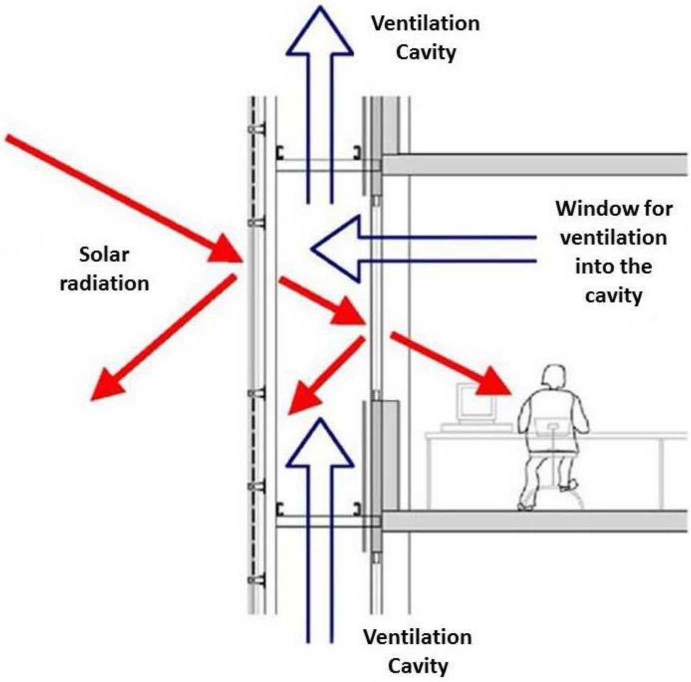


Figure 2.23- Two layers of glazing for maximum heat trap

Source: (Boni, 2017)

A laminated structural glass that satisfies the specifications for strength and transparency will be used as the outer layer in a double-glazing facade. Two exterior layers of heat-strengthened laminated glass panes are sandwiched between layers of Poly-Vinyi Butyral (PVB), which gives these goods their strength. A low E coating will be applied to the inner layer to control the incoming solar radiation.

A glass that combines LED (Light Emitted Dioxide) and solar panel technology has been created by Sharp Electronics and Shimizu. This glass can illuminate glass for 5 hours using electricity generated by the solar energy it captures at a rate of 7%(Scott, 2009).

2.10.6 ANAEROBIC DIGESTOR

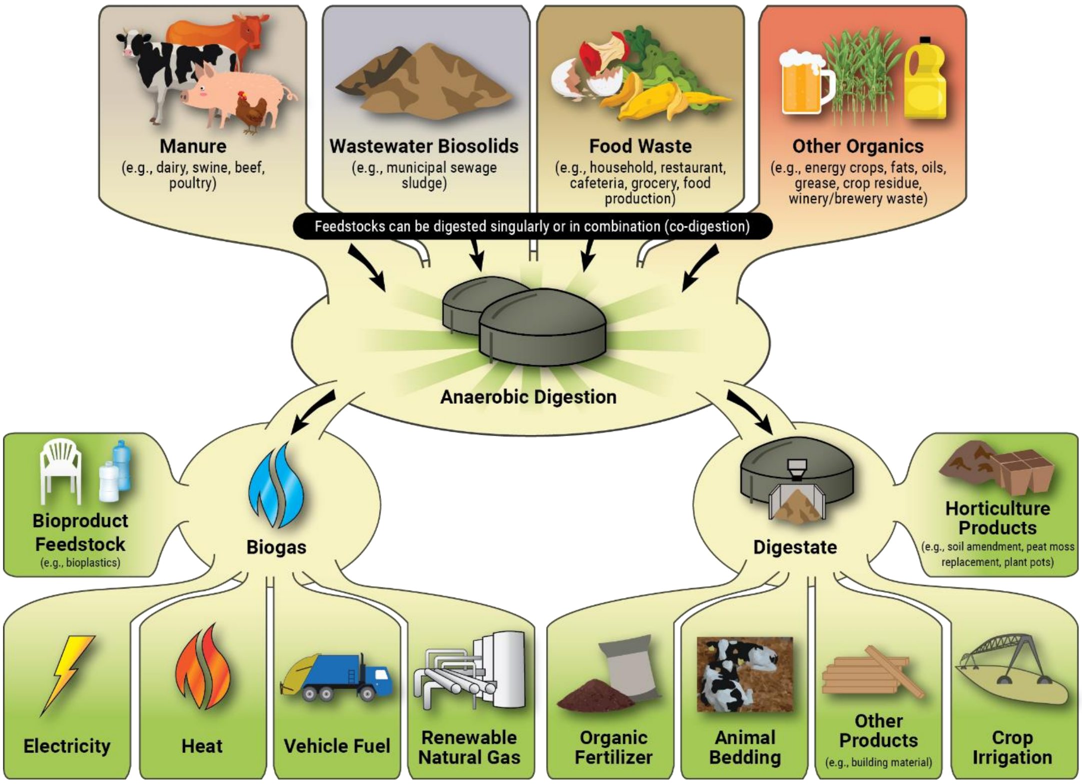


Figure 2. 24-Anaerobic digestion

An AD facilitates a number of procedures for decomposing organic waste: first, remove muck; heated and burned, secondly; and thirdly, crushed and digested without oxygen environment. In these procedures, air is removed. Derived from the trash and methane-rich Biogas is created, enabling green energy generation of energy. Sewage-related waste water in the AD, systems can also be handled. Despoiler (The Vertical Farm) claims Project 2008) a 1000-person Vertical Farm. 13,492 kg of biological waste are generated by people per week. This occurs in a methane digester. A certain amount of bio-waste would generate 1,123,931 kWh of power annually, providing. The electricity used by the vertical farm is much over half. Anaerobic digestion is used. Technologies can aid in lowering greenhouse gas emissions.

2.10.7 GREEN ROOF CONSTRUCTION

A green roof is a landscape covered in vegetation that is constructed from a number of layers that are loosely laid, fitted in modules on the roof one layer at a time, or prepared in trays. Depending on the design goals and the roof's weight capability, the growing media used for vegetation on green roofs can range in depth from 50 millimeters to more than a meter. Green roofs are constructed in layers, each of which serves a particular purpose (Taufani, 2017).

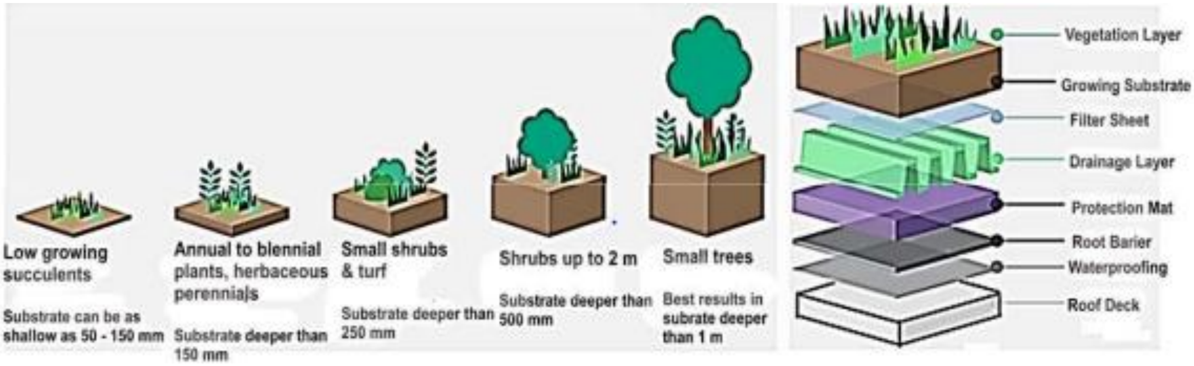


Figure 2.25-Green roof construction

Source: (Suparwoko, 2017)

2.10.8 GREEN WALL CONSTRUCTION

A green wall is made up of plants growing in supported vertical structures that are usually attached to an internal or external wall but can be freestanding in other situations. Green walls, like many green roofs, combine vegetation, growing media, irrigation, and drainage into a unified system (Taufani, 2017).

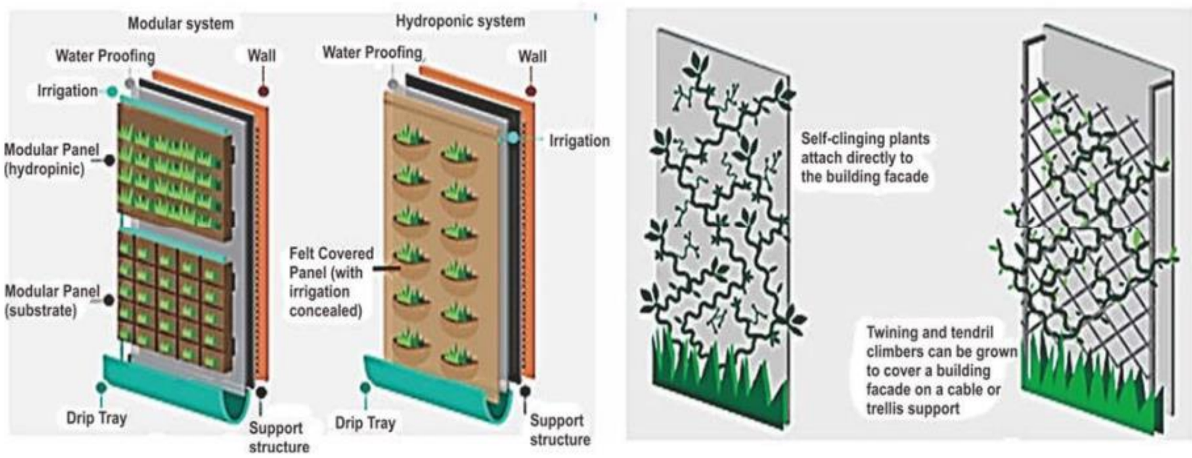
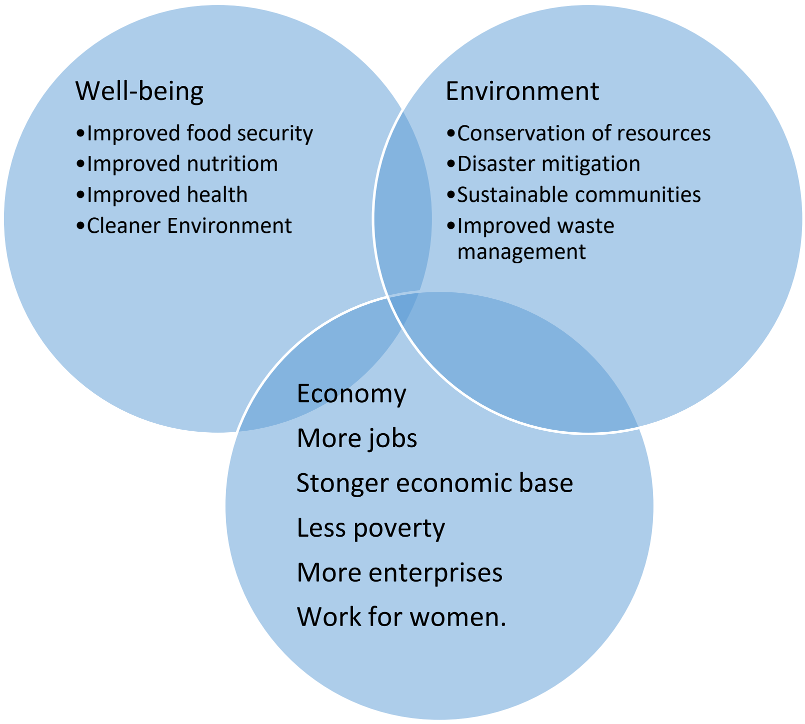


Figure 2.26-Green Wall and Facade Construction

Source: (Suparwoko, 2017)

2.11 BENEFITS OF INDOOR VERTICAL FARMING



2.11.1 WELL BEING

As urban food production becomes more accepted and understood again, urban planners can incorporate urban agriculture into a city's strategy to meet resident food security. It is important for planners to recognize that the rise of hunger is not only due to falling incomes and unemployment but also the availability of accessible foods. Food production is done close to humans which allows consumption of fresh and organic food. Urban food production improves in health factor of people as there will be less use of use of chemical fertilizers like insecticides and pesticides. Use of advanced technologies enhance more production and income which increases number of people involving in urban food production including youths.

2.11.2 ECONOMY

It can be done even in abandoned space and do not require large space for production. It yields more production with use of advanced technologies and also leads to more income. Though the initial cost is high, the economic benefits from this system is more in compare to tradition system of farming in flat land. The system can be fitted in as small as 1sq.m area. So, more people who don't have enough space can do urban food production which strengthens economic base by providing employment opportunities within the valley and helps to minimize poverty.

2.11.3 ENVIRONMENT

Proper adoption of urban agriculture using above mentioned methods and systems of urban farming has lots of positive impacts on environment. Major effects of such systems are as follows:

a) **Water use**: Many indoor re-circulating vertical farms quote a 90%-95% reduction of water usage vs open-field farming. A more recent study by Barbosa et al found that conventional lettuce grown in southwestern Arizona required 250 ± 25 L/kg vs 20 ± 3.8 L/kg for lettuce grown hydroponically; ie, only about 8%. water use in this indoor farm was just 2.4 percent -4.8 percent of that necessary to grow lettuce in open fields, providing validity to claims made by many indoor farms.

b) **Water runoff**: Agriculture contributes to the nitrogen loading of freshwater bodies ranging from coastal aquifers to lakes to bays like the Chesapeake. Subsurface drainage transports to rivers. According to the United States Environmental Protection Agency44, excessive levels of nitrogen and phosphorus in water bodies can promote eutrophication, which can lead to hypoxia, resulting in fish deaths and a decline in aquatic life. Excess nutrients may also trigger dangerous algal blooms, which not only upset animals but also release chemicals that are harmful to people. According to the EPA, nitrogen loss not only impacts rivers but also air quality and climate change due to the production of gaseous nitrogen-based compounds (see also section "Effects on soil"). These results have been found to be improved by improved land use and management strategies. Indoor farming can be beneficial to avoid these hazards.

c) **Effects on soil**: Most indoor farming is soilless; ie, crops are grown without soil by seeding in inert materials such as stone-wool or peat and submerging the latter in water. Thus, the principal benefit of indoor farming regarding the land is the fact that no soil is used. This approach to food production has several positive consequences for land use and the environment.

d) **Agricultural soil as carbon sinks**: Many agricultural practices deplete the soil of carbon, thus adding to CO_2 emissions. Indoor farming provides the opportunity to reduce tillage and transition agricultural soils and arable lands back to forest or perennial species. By doing so, the capacity for carbon sequestration increases.

e) **Effects on air**: Opportunities to move from open field farming to indoor farming could potentially have significant impacts on air quality and the production of GHGs, especially through the conversion of open-field agriculture to forest.

2.12 CHALLENGES OF INDOOR VERTICAL FARMING

- Land and construction costs
  Urban settings for vertical farms can be fairly costly. Some existing vertical farms are located in abandoned warehouses, deserted regions, or Superfund sites, which are less expensive to build.
- Energy Consumption
  While transportation costs may be lower than in conventional agriculture, energy consumption for artificial lighting and climate control in a vertical farm can dramatically increase operating expenses.
- Limited Crop Species
  The current vertical farm crop model concentrates on high-value, fast-growing, small-footprint, and quick-turnover crops like lettuce, basil, and other salad products. In a commercial vertical farming system, slower-growing crops and grains are less profitable.
- Pollination requirements
  Crops that require insect pollination are at a disadvantage in a vertical farm since insects are typically not available.

2.13 AGRICULTURE RESEARCH CENTER

An agriculture research center provides platform for studies, experiment and training regarding agriculture priorities in economic and in ecosystem. The major aim of a research facility is improving productivity and quality of crops by their genetic improvement, better plant protection, irrigation, storage methods, farm mechanization, efficient marketing, and a better management of resources.

Research center can be categorized as 2 types based on following 2 kinds of research conducted by the research center: -

- Strictly agriculture research: - gathers agricultural methods developed in various parts of world and test them experimentally under given conditions.

- Scientific research: - does research on sciences which have direct bearing on and help to develop agriculture and agricultural methods.

A research center of laboratory basically consists of the following spaces

- Laboratory
- Laboratory support Spaces
- Offices for Researchers
- Administration
- Support Spaces (Cafeteria, auditorium etc.)

2.13.1 HISTORY

History has a significant impact on human history and dates back thousands of years. Different climatic conditions, civilizations, and technology have tremendously influenced and characterized development. agricultural methods changing as a result of new technology the "Rothamsted Experiment Station," John Bennet Lawes, in the United Kingdom in 1843, sought to determine how inorganic and organic agricultural yields and fertilizers.

The first agriculture research facility in the SAARC region was established in India as the Agricultural Research Institute (ARI), which was renamed the Imperial Institute of Agricultural Research in 1911 and then again in 1919 as the Imperial Agricultural Research Institute. Nepal has an agrarian economy, with more than 80% of the population still engaged in agriculture. It currently accounts for one-third of GDP. It has enormous social and cultural importance in addition to economic worth. (Adhikari, 2019)

A research center of laboratory basically consists of the following spaces

- Laboratory
- Laboratory support Spaces
- Offices for Researchers
- Administration
- Support Spaces (Cafeteria, auditorium etc.)

2.13.2 GENERAL TYPES OF LABORATORY

2.13.2.1 WET LABORATORY

These laboratories require a piped supply of water as well as the storage and use of reagents and chemicals in liquid form. If laboratories are not properly designed and have stringent safety requirements, they might be dangerous. They also feature dedicated safety equipment such as fume hoods for mixing reagents that emit poisonous gases, as well as a safety shower and eye wash in case of an emergency. This industry has a significant energy requirement. (Adhikari, 2019)

2.13.2.2 DRY LABORATORY

Dry laboratories are those that do not require utilities such as water or gases. Dry labs are commonly used to describe instrument laboratories. Reagents are not kept here. The amount of energy utilized is comparable to that of a typical office building. Dry labs are also computer spaces where virtual experiments are performed.

2.13.3 RESEARCH DIVISIONS

The agriculture research laboratory consists of six main divisions. They are as follows: -

- Tissue Culture Lab

- Agronomy
- Plant Protection Entomology
- Plant pathology
- Seed laboratory and Genetics Research
- Laboratory for Soil, Water and Plant Tissue Analysis

2.13.3.1 TISSUE CULTURE LAB

Any laboratory that performs tissue culture procedures, regardless of the specific aim, must have a number of fundamental facilities. Typically, these are as follows:

- A general washing zones
- A media preparation, sterilization, and storage area
- An aseptic transfer area
- Environmentally controlled incubators or culture rooms
- An observation/data collection area.

2.13.3.2 AGRONOMY

Agronomy is the application of biology, chemistry, economics, ecology, soil science, water science, pest control, and genetics to the improvement and management of the world's principal food crops. The required agronomy lab area is as follows:

- Offices
- Senior Scientists
- Sterile Room
- Laboratories
- Storage

2.13.3.3 PLANT PROTECTION ENTOMOLOGY

Entomology is the study of insects. The plant protection entomology lab consists of:

- Laboratories
- Insect Rearing Room
- Food Preparation Area
- Sterile Room
- Collection
- Storage
- Offices

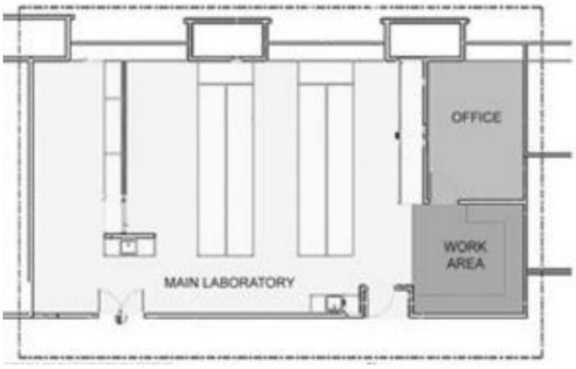


Figure 2.27-Typical layout plan of entomology lab

Source: (Neufert, p. 1980)

2.13.3.4 PLANT PATHOLOGY

Experiments with fungi, bacteria, viruses, nematodes, and parasitic higher plants will be part of the lab work. The plant pathology lab is made up of the following sections:

- Material receiving area

- Laboratories
- Media Preparation
- Growth Room Light and Dark
- Growth Room
- Sterile Room
- Storage
- Office Spaces

2.13.4 AREA DISTRIBUTION

The typical rule of thumb for first program area distribution is as follows. The following data is based on averages obtained by aggregating data from laboratories registered with the National Institute of Health (NIH) in the United States and should not be used as a planning standard. As laboratories should be generic rather than specific by default because they are very susceptible to change, this table should be used as a guide for initial programming and care should be taken that the spaces designed are not too specific and open to future adjustments. As a result, these rules of thumb begin as a helpful guide in planning flexible laboratory environments. The percentage distribution is depicted in the chart below. The US Department of Health and Human Services' utilization rate for laboratories is 200 to 460 net square feet (NSF) per person.

Space	Area(sq.m)	Ratio
Laboratory space	16.5	53
Laboratory support	8.25	26
Research staff office	2.79	9
Ancillary space	0.84	3
Laboratory administration	2.88	9
Optimal Area per Researcher	31.26	

Table 2. 1- Area Requirements, Thumb rule

Source: NIH biomedical lab design guide

2.13.5 LABORATORY MODULE

Laboratory module is an important unit of any lab that must be considered while designing engineering and architectural systems of the research laboratory. A modular planned laboratory is used for the following purposes and benefits.

2.13.5.1 BASIC LAB MODULE

A typical laboratory module is roughly 10'-6" wide but can range in depth from 20' to 33'. The depth is determined by the size of the lab and the cost-effectiveness of the structural system. The 10'-6" size is based on two rows of casework and equipment (each row 2'-6" deep) on each wall, a 5' aisle, and a wall thickness of 6" between labs. The standard basic lab module is 10'-6" X 30'.

The 5' aisle width should be considered a minimum because it not only offers adequate space for a wheelchair to turn, thus conforming to universal design; it also allows two researchers to operate on opposite benches at the same time.

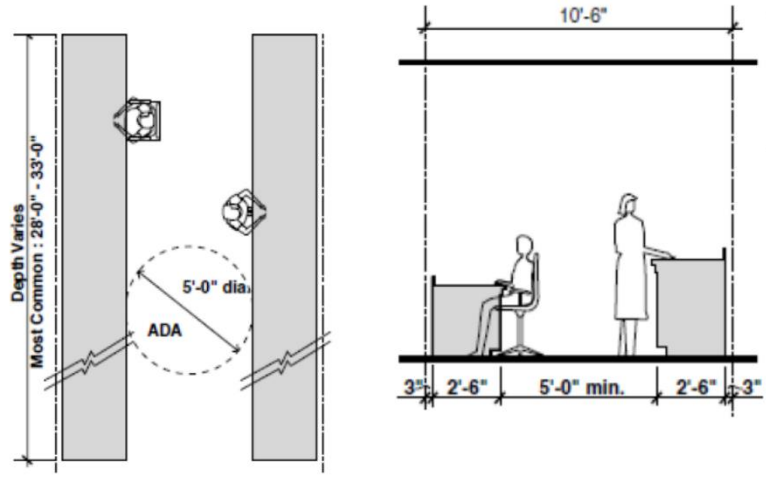


Figure 2. 28-Aisle width requirement, (Neufert, 2002)

Multiples of the basic module are used to represent the various sorts of laboratory spaces, such as labs, lab support spaces, and offices. If brick is utilized in the design of the laboratory, the module should be based on the dimensions of the masonry units.

2.13.5.2 TWO DIRECTIONAL MODULES

A two-directional module is one that has a length that is twice as long as it is wide. This module provides increased flexibility because the casework can now be positioned in any direction, i.e. perpendicular or parallel. This concept is easier to use than the standard lab module concept, although it may take up more space.

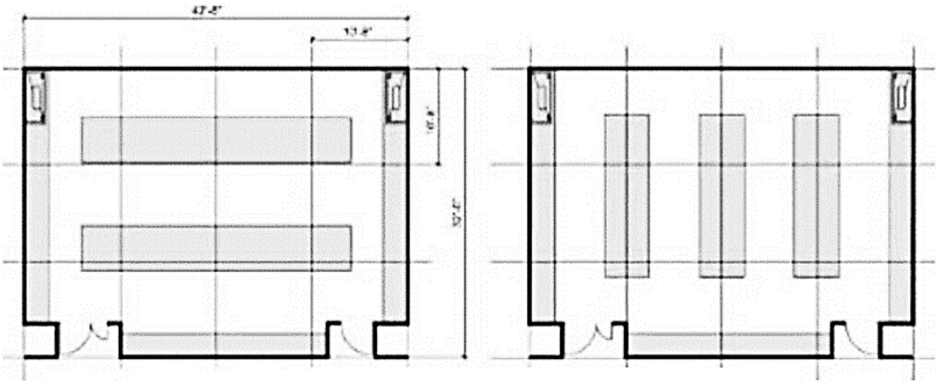


Figure 2. 29-Plan of 2 directional module, (Neufert, 2002)

2.13.5.3 THREE-DIMENSIONAL MODULE

This concept is easier to use than the standard lab module concept, although it may take up more space. It entails basic lab modules or two-directional module floor layouts that are vertically coordinated, i.e. the vertical stairways and various engineering systems must be vertically coordinated with the floors above or below it. This style of planning is highly recommended for all research centers because it saves money.

2.13.6 OFFICE SPACES

2.13.6.1 LAB RELATED OFFICE

Around half of the time that researchers spend is in the lab and the other half is in their offices. Every single member of the permanent core staff, such as scientists, is an expert and professor in their respective fields; as a result, they each need a dedicated office room for a single staff, in addition to desk space for storage and a place to receive guests. The placement of temporary employees, such as contractual researchers and students undertaking research, in office space is sufficient because they only need a desk, and such open-plan workplaces also stimulate more social interaction. Offices of 12 feet by 14 feet (3.65 meters by 4.26 meters) are adequate, and there is a growing trend for smaller offices. Most offices are between 100 and 200 net square feet in size. A workspace divided into cubicles needs about 50 square feet (4.64 square meters) per employee.

Space	Area per person
Laboratory Chief's office	15 sq. m.
Section Chief'	12 sq. m.
Investigator's office	12 sq. m.
Scientist's office	12 sq. m.
Receptionist Workstation	8 sq. m.
Clerical Workstation	8 sq. m.
Technical Engineering's office	12 sq. m.
Lockers	0.3 sq. m.

Table 2. 2- Space requirement for lab related office spaces

2.12.6.2 GENERAL RELATED OFFICE

The biggest grid module available for offices is 1.875 meters. For this center distance, beam spacing that adheres to the standard measurements of 625mm or 1.25m is likewise suitable, and every third beam will coincide with the façade column.

A room of around 12 square meters is needed for one senior staff member who needs privacy when discussing clients or social services or who needs to focus. Moreover, a conference table for around four persons and two senior staff members require about 18 square meters of space.

The depth of a room is determined by how much personal space is needed in a multi-occupancy, open space, group, or office area. Office spaces typically have a depth of 4.5 to 6 meters. Workstations are illuminated during the day to a depth of 4.5 meters from the window (depending on the location of the office building). D=1.5HW is a general rule of thumb, where D stands for the depth of light penetration and HW for window head height.

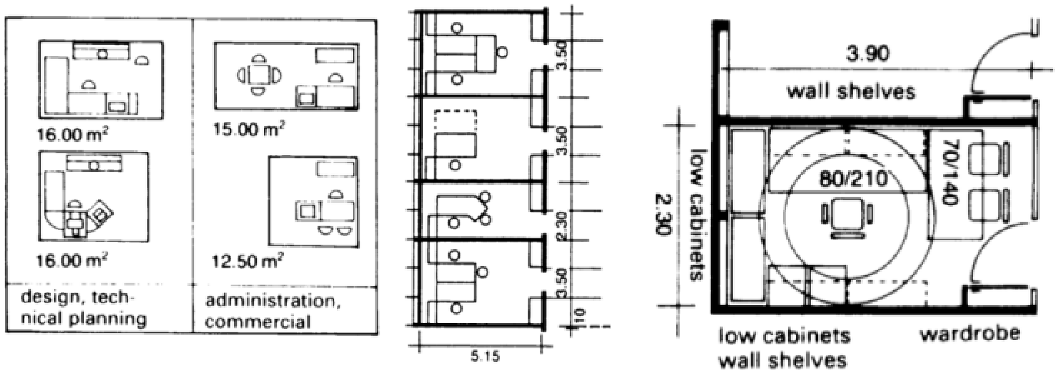


Figure 2. 30- Standard office layouts, (Neufert, 2002)

The amount of space occupied and the amount of room needed to move equipment determine the corridor's width. In general, it ought to be possible for two persons to pass one another (Neufret, 2002).

2.12.6.3 GENERAL OFFICE SUPPORT ROOMS

A. CONFERENCE ROOM

For conference and seminar rooms, 150 Net Square Feet (NSF) is enough for groups of six or less, 20 NSF per person for groups of six to twenty, and 18 NSF per person for groups of twenty to three hundred. If rooms are being used for large audiovisual presentations, room sizes might need to be raised. For a research institute with a staff of 200 employees, 3 conference rooms with a capacity for 8–10 people, ideally on each floor, were found to be sufficient in the majority of cases.

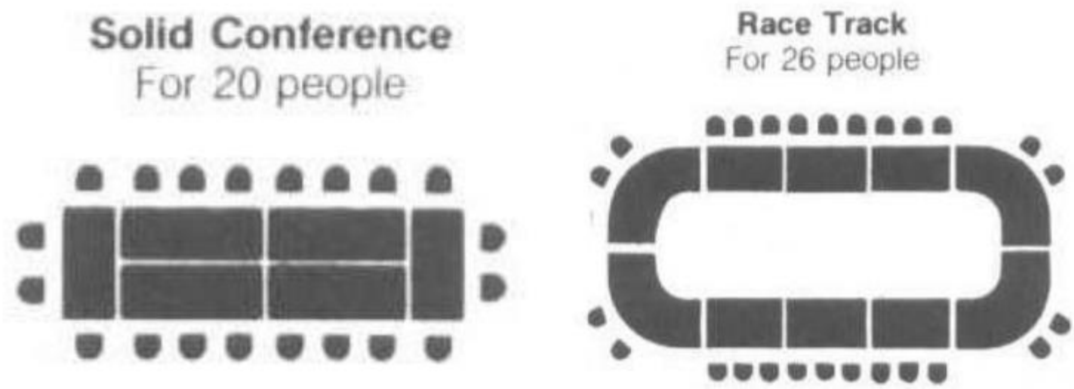


Figure 2. 31- Conference table layouts

The ideal size for a conference room for 12 people is 7.0m x 4.2m (23ft x 14ft), although for practical circulation, a conference room of 8.5m x 5.7m (28ft x 19ft) is more than adequate (Chiara, Panero, & Zelnik, 1992).

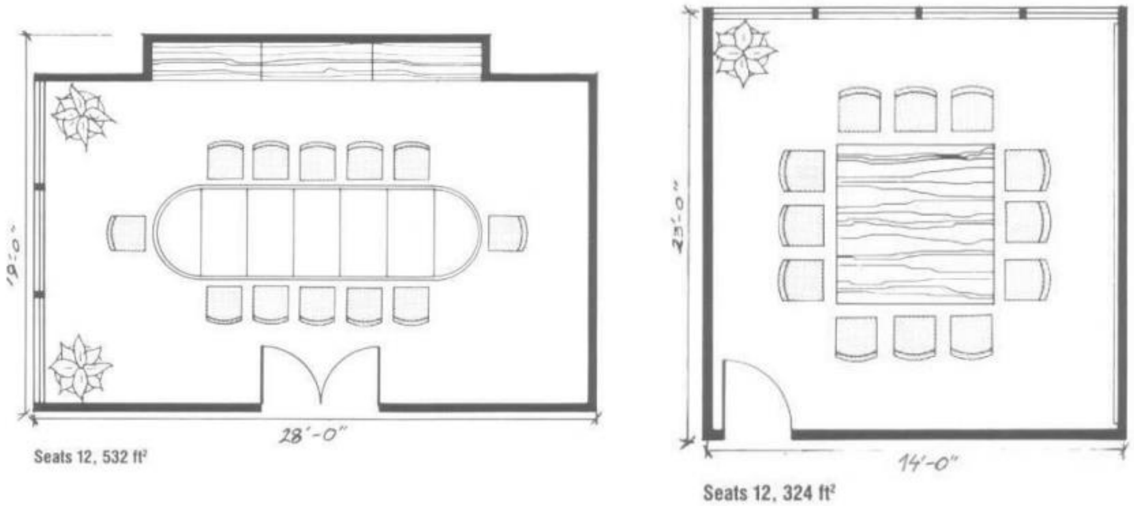


Figure 2. 32- Conference table layouts, (Neufert, 2002)

B. ARCHIVE ROOM

The documents must be organized in a system with clear labels, a condensed path of travel, and effective use of available space. Archival space should be accessible as well. Deep file cabinets are less expensive. The link between the needed aisle space and furniture floor area for a vertical filing system using big archival shelves is shown in Figure. A vertical filing system requires 5.2 square meters of floor space and 4.6 square meters of aisle space.

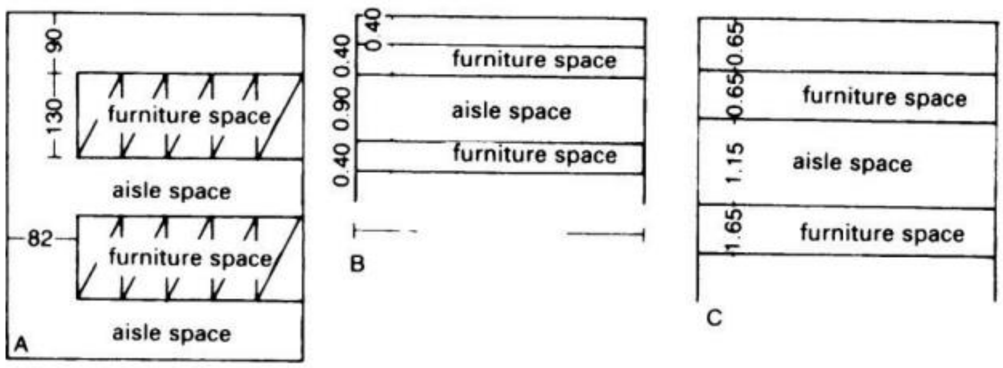


Figure 2. 33- Furniture layout for archive room, (Neufert, 2002)

The optimal window grid module is between 2.25 and 2.5 meters, and the filing room should be situated centrally. Three stories of file might fit into a space that would only accommodate two stories in typical workplaces because only a clear height of 2.10m is necessary. Attics and basements are inappropriate since dry storage spaces are required. By removing intermediate sections, a moving filing system significantly reduces space usage (Chiara, Panero, & Zelnik, 1992).

2.12.6.4 ADMINISTRATIVE OFFICE

One of the key components of a research institute is administration. Without management that can coordinate the organization, a complex institution like a research institute could not function. The administration's primary responsibilities include accounting, hiring and managing qualified people, purchasing equipment or research materials for the lab, and maintaining the intricate engineering of the system.

Support Space	Functional Area
Filing Cabinet	1 sq. m. per filing cabinet
Storage Rooms	1 sq. m. per shelving unit
General Work Area	5 sq. m.
Photocopier Area	5 sq. m.
Computer Room	Space determined on a case by case
First Aid Room	Provided under the regulation of the Safety Act
Reception Area	Based on functional needs, visitors, security, etc.
Meeting Room	4-5 people: 11.15 sq. m. 6 – 7 people: 13.90 sq.m. 12 people: 22.3 sq.m.
Coffee Counter	1.16 sq. m. per department

Table 2. 3- Components of administrative office

2.12.7 TRAINING UNIT

In order to create a learning environment for new researchers and students, a training unit is an essential component of the research center. Buildings used for academic research serve as living labs that promote, facilitate, excite, and inform everyone nearby. They consist of labs for both teaching and research. While teaching laboratories are specific to the academic sector, academic research labs can be very comparable to those in the commercial and public sectors (Watch, Tolat, & McNay, Academic Laboratory, 2017).

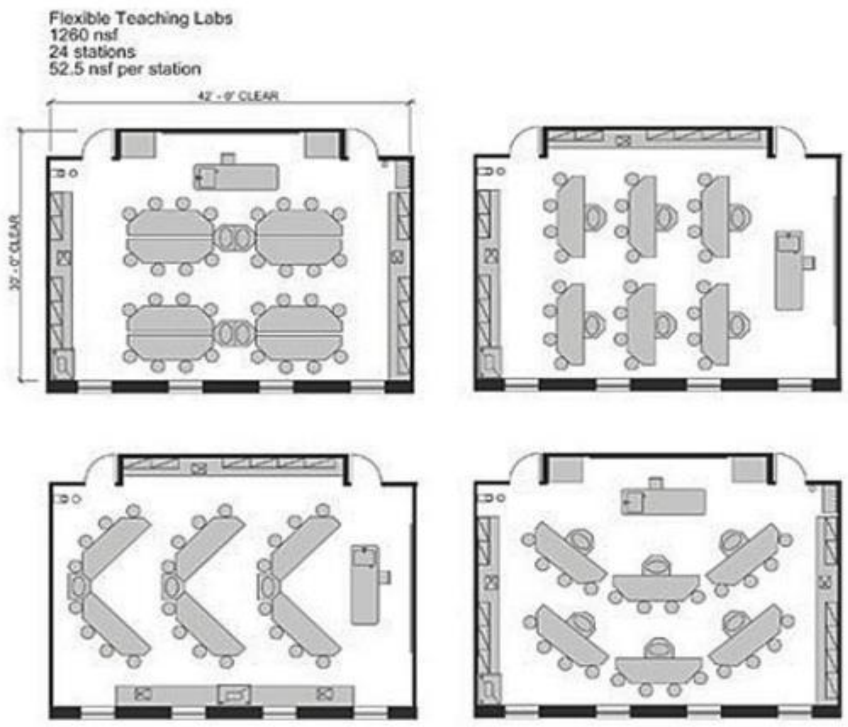


Table 2. 4- Various layouts for training room, (Neufert, 2002)

Space distribution and equipment requirements are the biggest differences between training and research labs. In order to account for these variations, certain new facilities have been built with increased adaptability to boost lab space productivity. There are homogenous lab facilities available so that equipment, support areas, storage areas, and instrument rooms can all be shared (Watch, Tolat, & McNay, Academic Laboratory, 2017).

It is preferable to provide a single theoretical room and neighboring practical rooms since this type of planning helps to maintain an efficient flow of users and allows for the sharing of numerous support spaces.

2.12.8 LIBRARY

2.12.8.1 PLANNING

The following fundamental guidelines are included in library planning (Chiara, Panero, & Zelnik, 1992):

• User-clear adjacencies between collections, reader sitting, and personnel; simplicity of the design concept

• Convenience of library staff monitoring.

• A welcoming reading area.

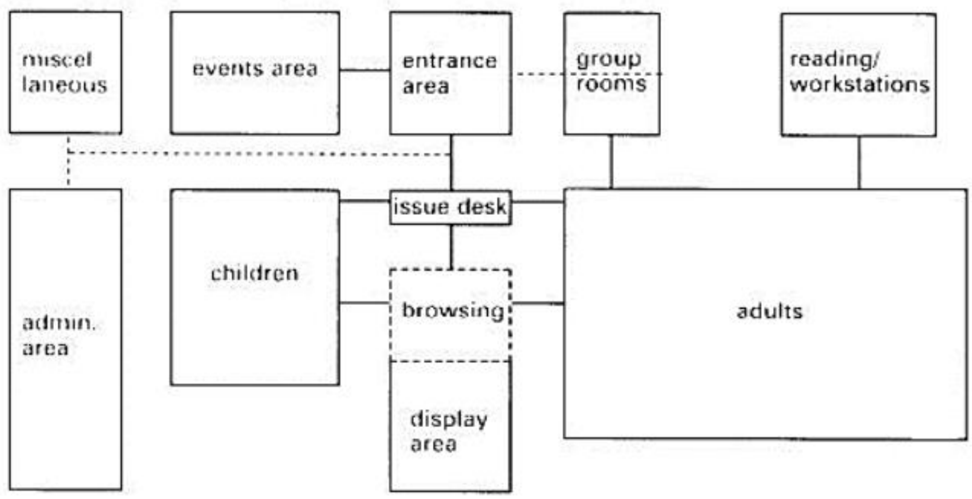


Figure 2. 34- General programs of a library, (Neufert, 2002)

2.12.8.2 SPACE REQUIREMENTS

Space for books: 15 books per sq. ft. (~160 books per sq. m.)

Space for staffs: 100 sq. ft. (~9.5 sq. m.) per staff member.

Space for group meetings: this space can be used for conference, audiovisual equipment: 7-10 sq. ft. (0.65 – 0.9 sq. m.) per seat.

Space for readers: min 30 sq. ft (~2.75 sq. m.) per adult and min. 20 sq. ft (!1.85 sq. m.) per child.

2.12.8.3 SHELVING

When arranging shelves in a space, there are several factors to take into account. The dimensions of the shelves, their arrangement, and the clearance areas between the shelves must all be carefully considered when designing a library environment.

36" (0.91m) is the standard length from the slab. Normal height: ranges from counter height at 42” to 48” (1.06m to 1.21m), medium height at 60” to 66” (1.5m to 1.67m), and intermediate height at 72” to 78” (1.8m to 1.98”). Too tall is defined as 84” to 90”. (2.13m to 2.26m).

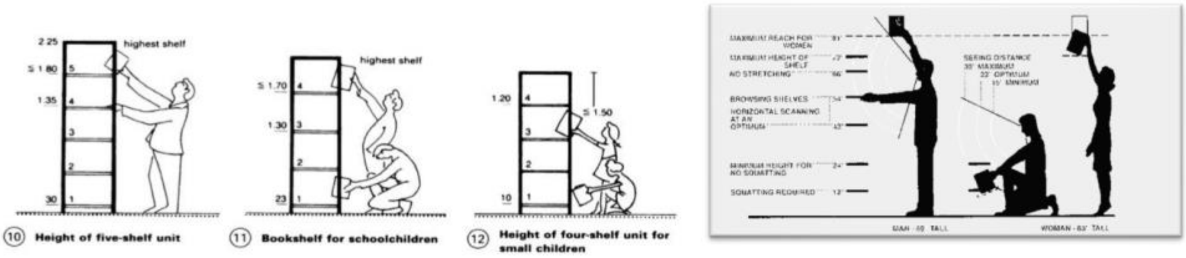


Figure 2.35- Anthropometric data for shelving, (Neufert, 2002)

Standard depth: Actual depths are one inch shorter than the nominal shelf depths, which are typically 8, 10, or 12 inches (0.2 to 0.3 meters). Between the uprights in the back of the shelf is where there is a "lost inch." Canopies' shelf tops are typically put on counter-height shelving. Every shelving should include backstops to stop books from falling in between the uprights.

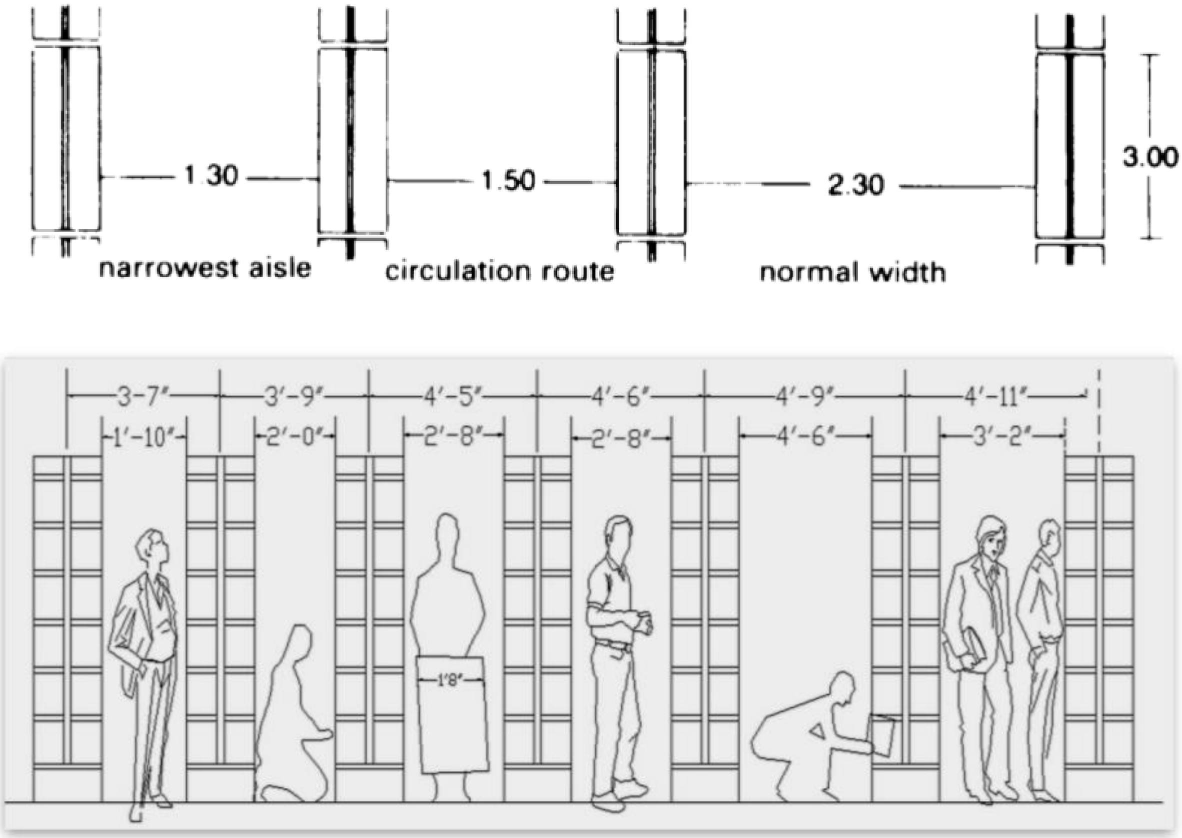


Figure 2. 36-Aisle dimensions between shelves, (Neufert, 2002)

2.12.8.4 SEATING SPACE

Seating options include lounge seating, which is preferable for reading periodicals, small group study tables, big group study tables, and single reader study tables.

The footprint of a table for four people is 4' by 6', with 3' between each chair and 2' on either end, for a total assignable square footage of 100 square feet (10' x 10'). There should be at least 5' between tables.

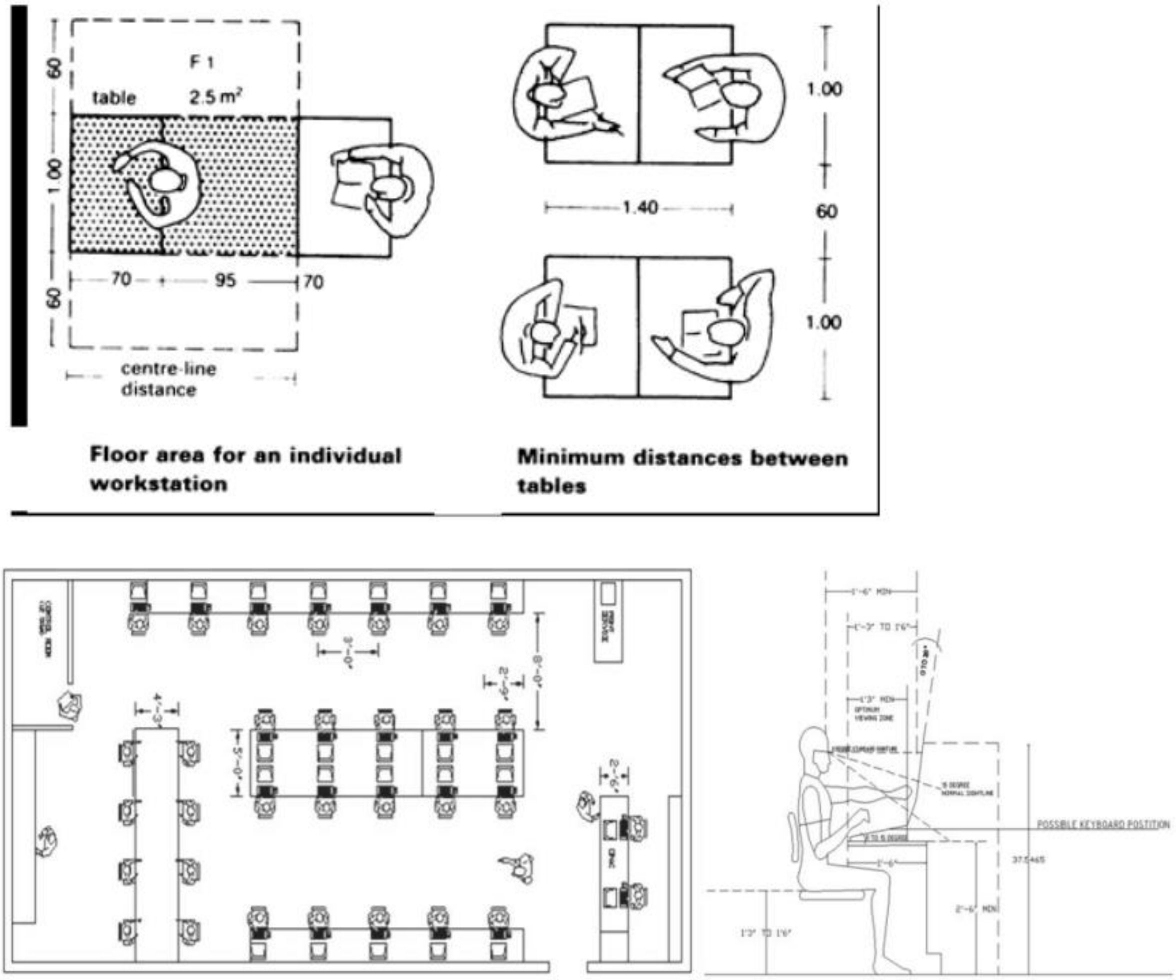


Figure 2. 37- Standard dimensions for reading table, (Neufert, 2002)

2.12.9 LIGHTING DESIGN

Spaces	Illumination Level (Foot candles)
Most Labs	75-100
Tissue & Culture	150-200
Offices	50-75

Table 2. 5- Illumination requirements

Lighting design is essential in determining not just the working conditions for a certain task, but also the level of comfort for building occupants. There is a common assumption that lighting quality is just concerned with minimizing glare and/or producing a specific amount of light. Without a doubt, both are critical. However, these are only two of many things to consider. Others are light direction, light-source color, color rendering accuracy, contrast, homogeneity, and surface reflectance. The following are the recommended lighting levels:

2.12.10 CAFETERIA

Cafeteria planning guidelines are 12-15 square feet per seat for dining rooms. Other kitchen space is distributed as follows. The kitchen area accounts for approximately 30% of the total cafeteria space. The service aisle is 3' to 4.5' wide. The needed lighting intensity is 50-200 lux in the dining room and 215 lux in the kitchen. (Neufert, 2002)

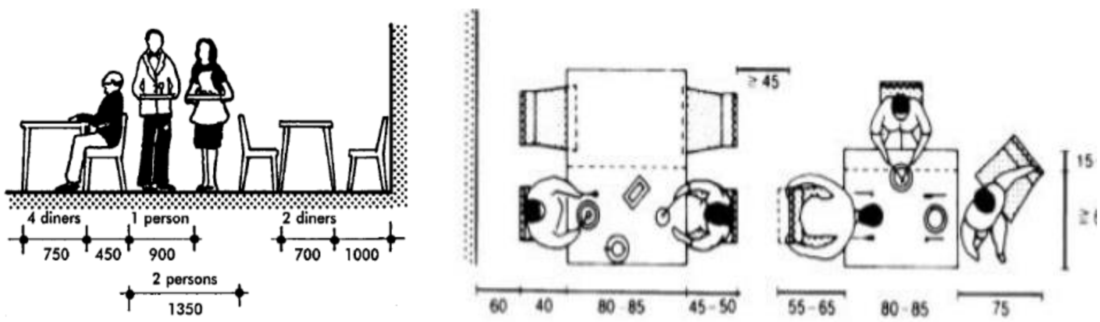


Figure 2. 38- Anthropometric data of dining space, (Neufert, 2002)

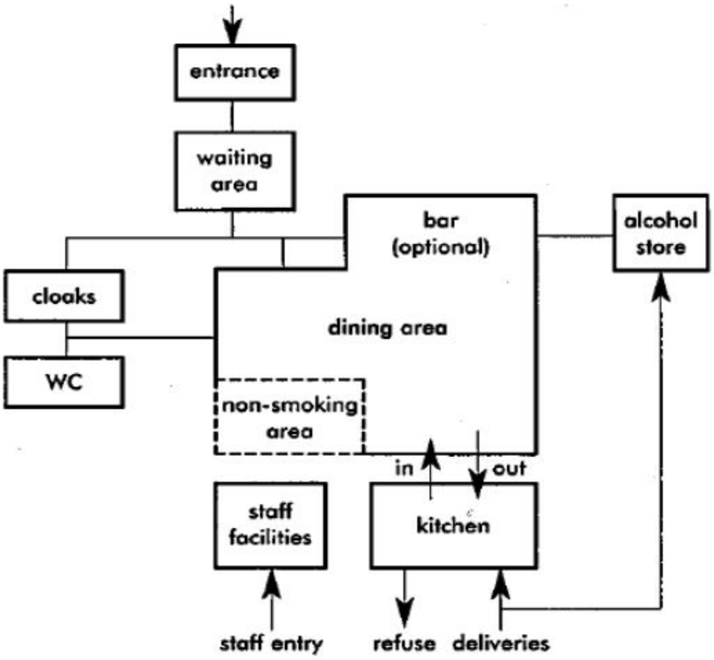
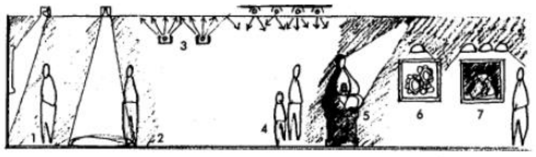


Figure 2. 39-General space connection of cafeteria

2.12.11 EXHIBITION HALL AND GALLERY

In general, museums and galleries are concerned with collecting, recording, maintaining, investigating, interpreting, and displaying some type of tangible evidence. Many persons with diverse skills are needed for this objective. However, there are significant differences between museums and galleries. To exhibit works of art and cultural and scientific interest, the institution should provide protection against damage, theft, humidity, aridity, sunlight, and dust, as well as display the works in the greatest possible light (in both senses of the term). Exhibits should be displayed in such a way that the general public can easily view them. This necessitates a variety of properly chosen, roomy layouts in rooms of appropriate shape and, particularly in museums, in an engaging and logical succession. The normal human angle of vision begins 27 degrees above eye level. This means that well-lit pictures should be hung 10m away with the top not more than 4.90m above eye level and the bottom about 70cm below, for a standing viewer. The best hanging position for smaller pictures is with the point of emphasis (the level of the horizon ¡n the picture) at eye level. It is necessary to allow 3-5 m2 hanging surface per picture, 6-10m2 ground surface per sculpture, and 1m2 cabinet space per 400 coins. Galleries need side rooms for packing, dispatch, administration, a slide section, conservation workshops and lecture theatres. Disused castles, palaces and monasteries are usually suitable for housing museums. (Neufert, 2002)



Recommended lighting levels (lux)
- office: 300 ambient, 500 task
- demonstration theatre: seating area 300, demonstration area 600
- exhibition hall: 500/300/100

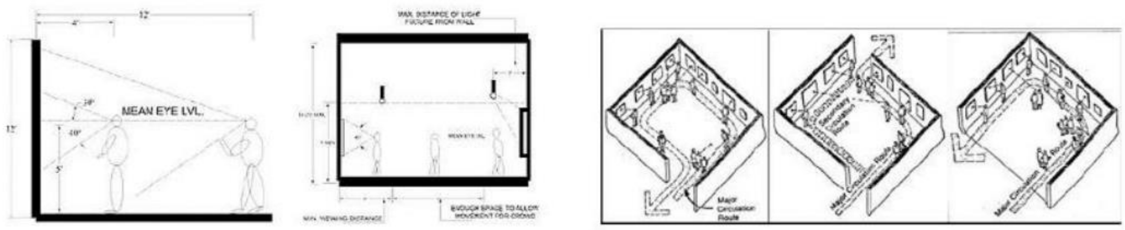


Figure 2. 40-Lighting design considerations, (Neufert, 2002)

2.13 PARKING

Type of Vehicle	Length	Breadth	Height	Turning Radius
Motorcycle	2.2m	0.7m	1m	1m
Standard Car	4.7m	1.75m	1.5m	5.75m
Fire Engine	6.8m	2.5m	2.8m	9.25m
Standard Bus	11m	2.5m	2.95m	10.25m

Figure 1 – Vehicle size and dimension

A. General Design Consideration:

Parking Spaces for Car: 1.80m x 4.6m to 2.5m x 6m

Space required for 90-degree car parking: 20-22 sq. m. per car

Space required for 45-degree car parking: 23-26 sq. m. per car

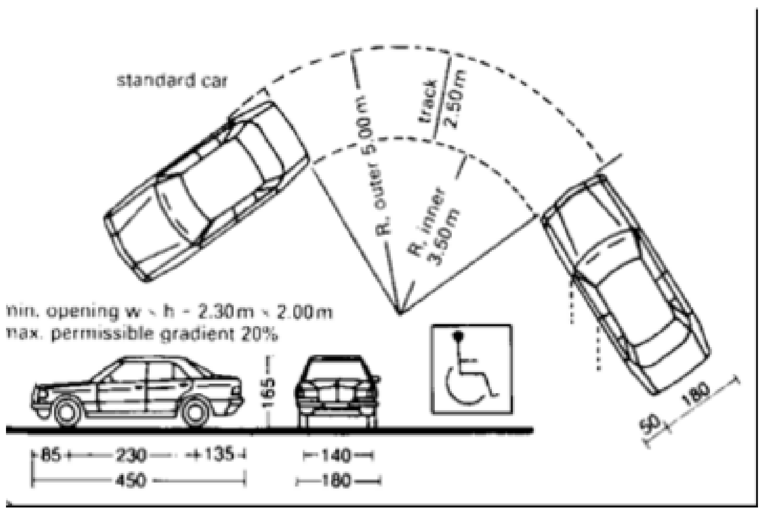


Figure 2. 41 -Turning radius of car (Neufert, 2002)

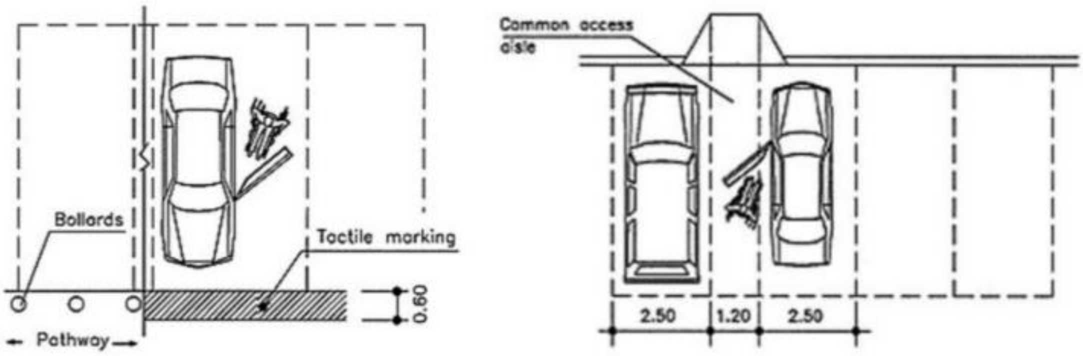


Figure 2.42-Consideration for universal access (Neufert, 2002)

The general accessible parking guidelines apply to both above- and below-ground parking. At least one level of multi-story indoor parking garages shall be served by an accessible elevator.

B. Number:

There should be at least one accessible parking place available in every parking facility, even those with less than 50 vehicles. There should be at least 1:50 accessible parking spaces available for parking facilities with a maximum of 400 spaces (one accessible space for every 50 spaces). At least 8 accessible parking spots plus one space for every additional 100 automobiles over 400 should be available in parking complexes with more than 400 spaces (Neufret, 2002).

c. Location:

Accessible parking spaces for outdoor parking should be placed no more than 50 meters from accessible building entrances. Accessible parking spaces for indoor parking should be placed as close as feasible to exits or right next to accessible elevators. Vans with lifts for wheelchair users should park at the ends of rows (Neufret, 2002).

d. Dimension:

An accessible parking place must be at least 3.60 meters wide. The suggested width is 3.90 meters. There is a 1.20 m wide access aisle that can be found between two regular parking spaces. When parking spaces are angled and indoors, the minimum height clearance for vans with hydraulic lifts is 2.40. The extra space at the end of a row can be used as a parking aisle for people with disabilities.

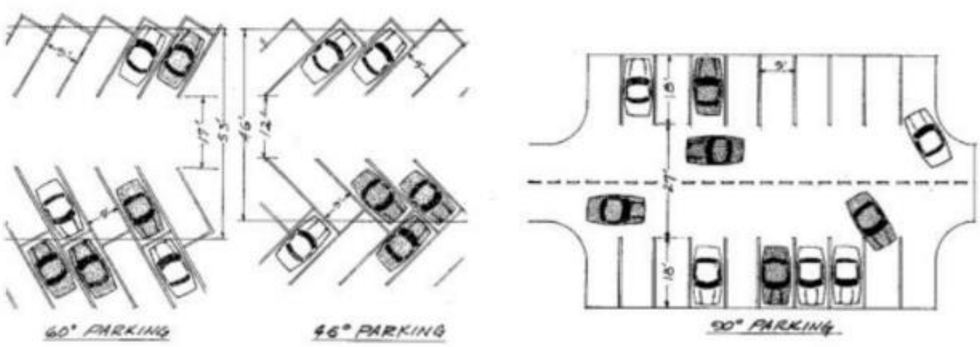


Figure 2. 43-Various parking layouts with respective dimension, (Neufert, 2002)

e. Gradients and ramps:

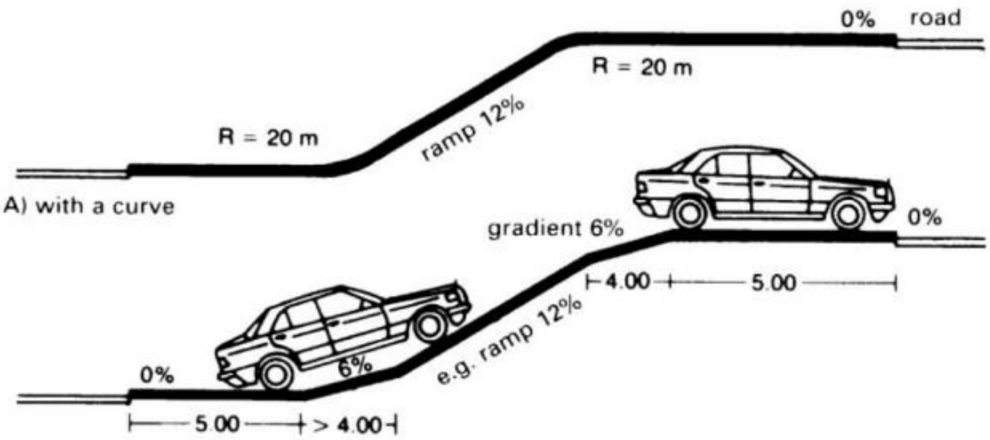


Figure 2. 44-Gradients and ramps requirements (Neufert, 2002)

2.14 UNIVERSAL DESIGN

a. Ramp

To facilitate access inside the building and throughout the property, ramps must be constructed next to the building's outside staircases. The minimum width of a ramp is 1.7 meters, while the maximum length of a flight is six meters. The rap can be angled up to a maximum of 6 degrees.

b. Restrooms

Most people can use a 5' by 5' (1.52m x 1.52m) stall if it meets the following conditions:

• The center line of the toilet is 1'6" (0.45m) from the side wall.

• 32-inch (0.81-meter) door directly across from the restroom.

In front of the restroom, the handrail reaches 1' 6" (0.45m).

• Requirements for partition toe clearance.

There should be at least one toilet with a basin that is configured to meet the needs of individuals with disabilities.

A single WC cabin must be at least 850mm x 1500mm, with 300mm left over for ductwork. For regular users, the toilet cabin's door opens inward; for wheelchair users, it opens outward.

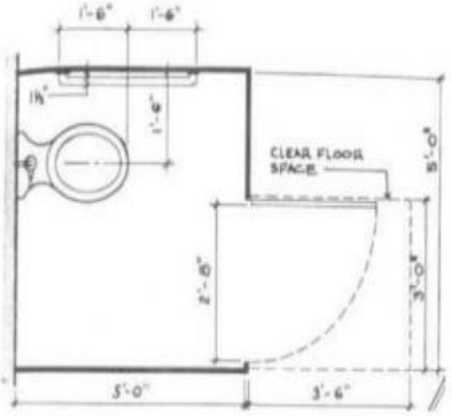


Figure 2.45- Differently-abled toilet dimensions (Neufert, 2002)

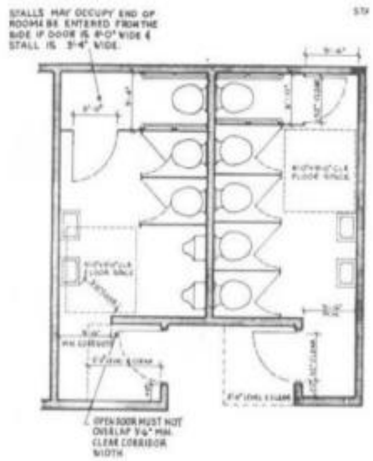


Figure 2.46 - Typical restroom layout for male and female (Neufert, 2002)

c. General circulation

The table below provides the minimal space required for circulation based on the wheelchair's 5 foot turning radius (1.52m).

Space	Dimensions
Door	32 inches (0.81m)
Aisles	48 inches (1.21m)
Turn Clearance	60 inches (1.52m)

Table 2. 6-Clearance space for wheelchair users (Neufert, 2002)

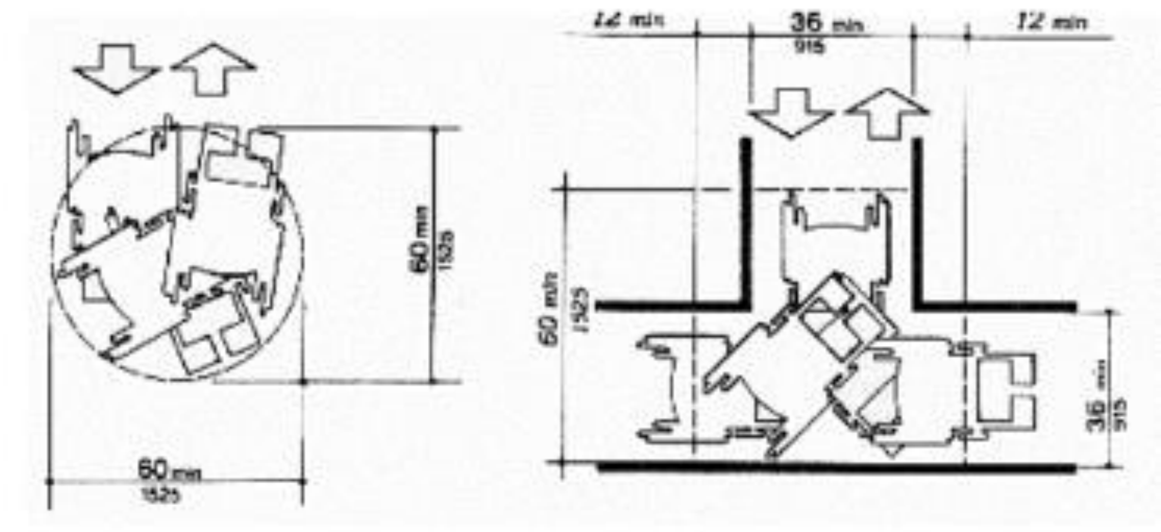
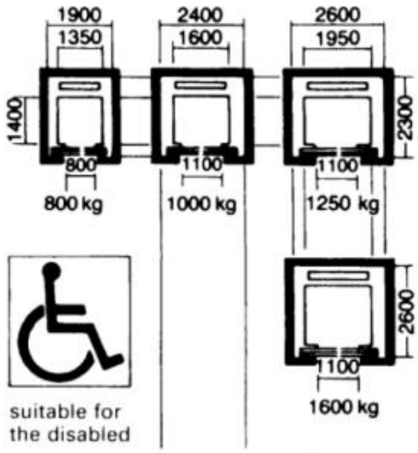


Figure 2. 47– Turning for wheelchair user (Neufert, 2002)

The Universal Design principles must also be followed in areas like stairways and elevators.



Door Location	Door Clear Width	Inside Car, Side to Side	Inside Car, Back Wall to Front Return	Inside Car, Back Wall to Inside Face of Door
Centered	42 inches (1065 mm)	80 inches (2030 mm)	51 inches (1295 mm)	54 inches (1370 mm)
Side (off-centered)	36 inches (915 mm)[1]	68 inches (1725 mm)	51 inches (1295 mm)	54 inches (1370 mm)
Any	36 inches (915 mm)[1]	54 inches (1370 mm)	80 inches (2030 mm)	80 inches (2030 mm)
Any	36 inches (915 mm)[1]	60 inches (1525 mm)[2]	60 inches (1525 mm)[2]	60 inches (1525 mm)[2]

1. A tolerance of minus 5/8 inch (16 mm) is permitted.
2. Other car configurations that provide a turning space complying with 304 with the door closed shall be permitted.

Figure 2. 48-Elevator standard dimension

A wheelchair user and a companion can fit comfortably within an eight-person lift, however reversing out will be required. If there will likely be a lot of foot and wheeled traffic, larger lift sizes may be preferable. Some lift users might require assistance from grab rails or perching seats. While using a passenger lift to transfer items may be okay, the opposite is never permitted (Pickard, 2002).

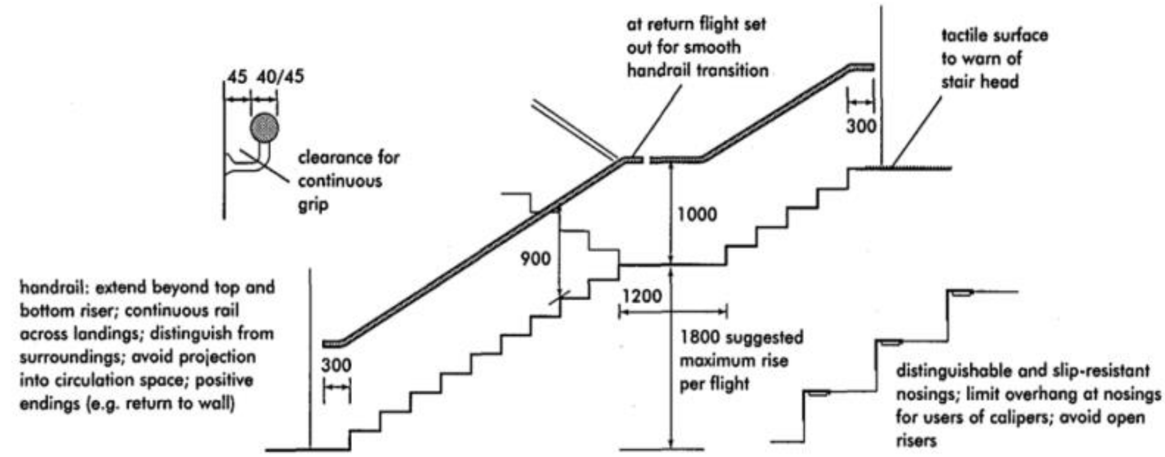


Figure 2.49-Staircase with details

Stairs must be carefully designed with a focus on lighting, contrast between surfaces, handrails and support, and nosing because they can be dangerous for many users. The aim for a spectacular appearance shouldn't take precedence over such factors, especially in entrance areas (Pickard, 2002).

2.15 INFERENCE

- Urban agriculture has the potential to improve community well-being. Urban farming has socio-cultural, environmental, health, economic, and educational benefits.
- Indoor farming cuts water consumption by 70%. Growing systems can produce 5 times or more corps or vegetables in the same agricultural field.
- Despite of the clear environmental, economic and health benefits of urban farming systems like hydroponics, aquaponics and aeroponics, farmers are still dependent solely on conventional methods of land farming.
- Vertical farms require a lot of energy, so they must be built in a sustainable manner.
- There is lack of interaction among farmers, agro-entrepreneurs and researchers. Farmers are unknown about the hazards of the chemical insecticides, pesticides and fertilizers, they are using.
- Few people having knowledge about advance farming systems like hydroponics, are also afraid of adopting such system because of high initial cost and high prices of output products.
- There is lack of governmental inputs for conducting research, providing trainings and dissemination of these new technologies.
- There need to have two type of labs, wet and dry lab in agriculture research center. Wet labs need to be air tight with mechanical ventilation, dry lab need to have at least wire mesh window.

3 CASE-STUDIES

3.12 HYDROPONICS NEPAL PVT. LTD.

3.12.8 OBJECTIVES

- To study different growing technologies of urban farming.
- To understand the challenges and feasibilities of hydroponics in context of Kathmandu.
- To know the crops and vegetations that can be grown in hydroponics system.
- To know the services related to hydroponics farming provided by the company.

3.12.9 PROJECT BRIEF

Location of corporate office: Lekhepati Marg, Dhumbarahi

Location of Farms: Samakhushi & Tokha

Category: Private Business Company

Aim: to introduce simple and affordable hydroponic farming to every Nepali household and help them increase production, income as well as improve their health conditions all at once.

Hydroponics Nepal Pvt. Ltd. is pioneer initiator of integrated soilless technology, hydroponics, aquaponics and fogponics methods with a vision of creating more agile and resilient food system in Nepal. The specialized fields of the firm are consultation, manufacturing, installation and marketing of customized hydroponic fodder and vegetable systems to help small and medium holder farmers, ensuring that they have access to a high quality and cost-effective way of farming sustainably. (Hydroponincs Nepal)

3.12.10 SERVICES

a) Consulting

- For Household & Small-scale Farmers

The service includes a free of charge consultancy as an extended training package for the first two years of purchase, of a hydroponic unit from this company. (Hydroponincs Nepal)

- For Commercial and Medium-scale Farmers

Our consultation service for commercial Hydroponics, Aeroponics, Aquaponics and Coco coir Growing system are as follows,

Figure 3. 1-Consulting/discussion session

Source: Hydroponics Nepal

- Simulating start-ups with detailed Soilless system knowledge.
- Suggesting best plants and vegetables as per current market trends.
- Designing/estimating of proposed project as a whole; including greenhouse.
- All farm input and output calculation.
- Financial analysis of your proposed farm.
- Preparing proposal to the Bank/Government office to get your project financed.
- Real time production guidance/supervision.
- Marketing of the product.
- Connecting to the sales outlet (Physical/Online). (Hydroponincs Nepal)

b) Training

There is provisions of training service to every farmers from beginner's level. The session varies from two to four hours and includes all elements of the innovative farming technology: from the chemistry, to the technical and business aspects of hydroponic farming, our training sessions will enable you to become an expert in hydroponic farming. (Hydroponincs Nepal)

Figure 3. 2- One day training program

Source: Hydroponics Nepal

<u>Introductory level training- one day</u>

Training Fees: Rs.5000

Course includes: introduction, hydroponic crops, nutrient and water quality parameters, system operation and economic analysis of hydroponics

Figure 3. 3- Tokha farm

Source: Hydroponics Nepal

<u>Tokha Farm visit</u>

Visit Fees: Rs.800

Visit includes:

- Tea/coffee
- Short description of farm and production
- Some farm products to taste

c) Supply and installation

Figure 3. 4-installation of hydroponics

Source: Hydroponics Nepal

Installation service is provided as part of the hydroponic farming package. The professional team, familiar with hi-tech greenhouses as well as fully automated all soilless systems consists of civil, electrical and mechanical engineers and technicians who can work on EPC based contract as per requirements.

3.12.11 CHARACTERISTISTICS OF THE FARM

a) Site features

- Total site area: around 14 ropanies
- Climate: Temperate
- Orientation: E-W Orientated land
- Water resources: boring and rainwater collected from roofs
- Area for expansion: the southern area is left unbuilt for future expansion.
- The area is in construction phase for the expansion of the farm.
- Surroundings: agricultural land and residential buildings
- Socio-economic background of people of the area: mostly people from newar community with agriculture as their secondary profession (Sunar, 2022)

Figure 3. 5-Top view of farm site

b) Site planning and zoning

<u>Farm, Tokha</u>

The agricultural farm is planned and designed to make it a training, demonstrating and recreational hub with following programs zoned as shown in figure below.

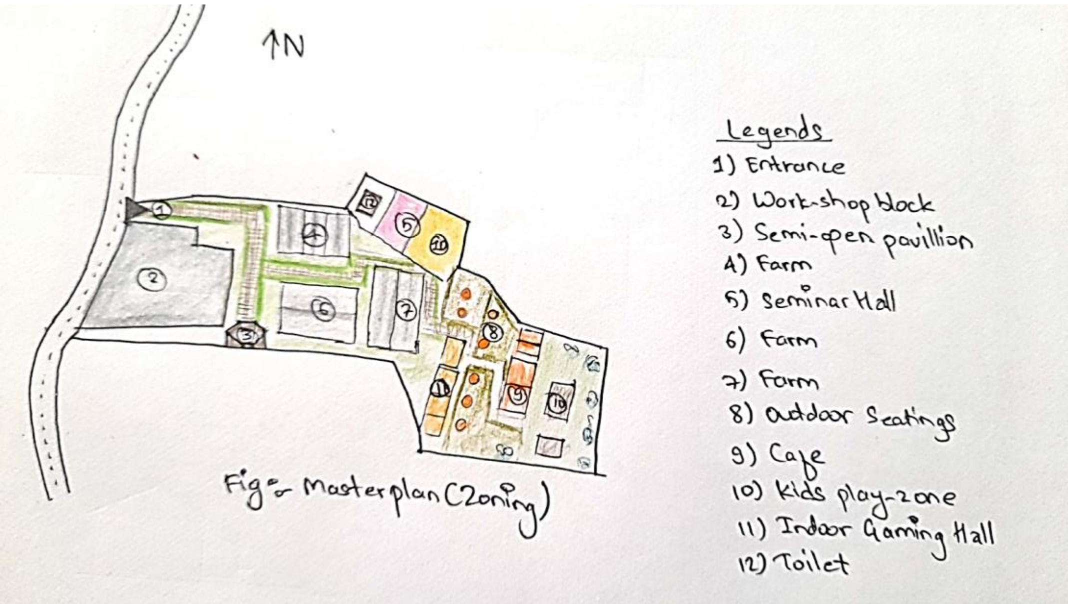


Figure 3. 6- Zoning shown in master plan

Figure 3. 8- side view of greenhouse structure

Figure 3. 7- Interior of farm

c) Materials used

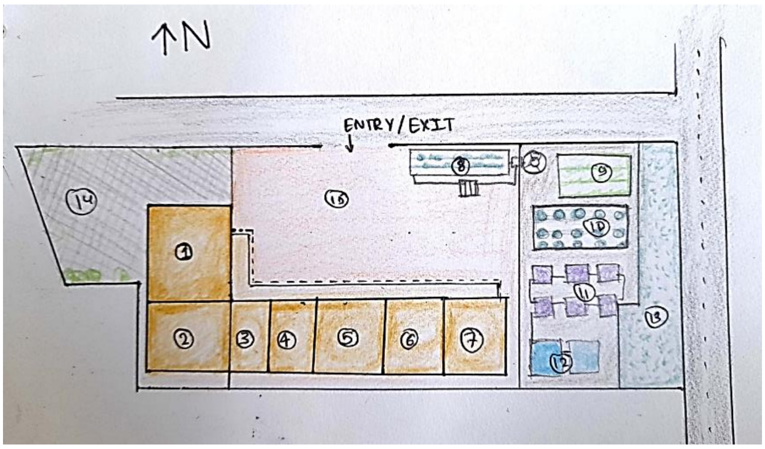
Green house = iron and steel structures, Bamboo structures

Hydroponics modules = food grade UPVC pipe

Other buildings = steel frame structure with brick walls

3.12.12 CORPORATE OFFICE

Corporate office, Dhumbarahi



Administration

1. Account room
2. CEO-office
3. Toilet(male & female)
4. Pantry
5. Director’s room
6. Staff room
7. Engineer/architect's room

Demonstration field

8. Nutrient film technique
9. Farming in UPVC Protected bags
10. Dutch bucket hydroponics system
11. Plant media of aquaponics system
12. Fish tank of aquaponics

Figure 3. 9- Masterplan of corporate office

Admin block

Figure 3. 10- corporate office block

Figure 3. 11- Rainwater collected through gutter

Demonstration modules

9. UVPC Protection

11, 12. Aquaponics system

10. Dutch bucket hydroponics

8. Nutrient film technique

3.12.13 GROWING TECHNOLOGIES

The company owns and sells complete hydroponic and aquaponics products systems to suit the needs of each individual or community. A garden can be set up in spaces as small as 1m². Most family hydroponic gardens are any size between 10 to 20m², but one can establish a bigger garden for commercial operations.

Different types of hydroponics systems used and sold by the company:

3.12.13.1 NUTRIENT FILM TECHNIQUE

In order to prevent the roots from drowning and to ensure that they have access to enough oxygen in the atmosphere, a thin coating of the solution is continuously sprayed over them, in this system. Plants that are lightweight, swiftly growing, require little support, and can be harvested quickly can be grown using this approach. In this method, lettuce, basil, kale, and other types of green salad, for example, can be cultivated. (Hydroponincs Nepal)

3.12.13.2 WICK SYSTEM

Figure 3. 12-wick system module

It is a passive system since it doesn't need any moving parts, such as motors or pumps. Direct nutrient delivery to the plant root is accomplished by the system via the capillary action of water. The type of wick being used affects how the liquid flows since certain wicks may quickly absorb liquid and some can be less efficient because they can grow mold or decay over time. As a result, it is necessary to frequently inspect the ropes used as a wick. Because the fertilizer solution in the reservoir gets diluted as the nutrients are taken up by the plants, it has to be replaced every week or so. Aeration is accomplished with air stones. To keep the water's oxygen level stable, they are put in the reservoir and attached to the air pump. It is only effective for small, fast growing plants and herbs such as lettuces, rosemary that do not need lots of water.

3.12.13.3 EBB AND FLOW

One of the typical hydroponic systems, it circulates the nutrient solution through the root zone in cycles before draining back into the reservoir. This allows you to reuse the feeding solution until it becomes diluted and has to be replaced with nutrients, which may save you a ton of water. Additionally, it occupies less space than the DWC system, allowing for installation in smaller spaces. (Hydroponincs Nepal)

3.12.13.4 DEEP WATER CULTURE

In this technique, plant roots constantly dangle in nutrient solution without periodic cycling of the nutrient solution. It is the most straightforward kind of system, requiring an air pump and air stones to maintain oxygen flow to the roots and preventing your plant from drowning. (Hydroponincs Nepal)

3.12.13.5 DRIP SYSTEM

Drip irrigation systems, sometimes referred to as trickling or micro irrigation systems, are the best option for individuals looking for a straightforward setup and maintenance process. It is also reasonably priced. As implied by the name, this system uses tiny emitters to gradually drip nutritional solution into your plants. It aids in water conservation as well. (Hydroponincs Nepal)

3.12.13.6 AQUAPONICS

The company has modules of aquaponics for production and sale of vegetables and fishes along with set-up modules for sale. (Hydroponincs Nepal)

Figure 3. 13-aquaponics system of Tokha

Testimonials from consumers of the company

Agri studio Pvt. Ltd, "Although my site is far away from the city, I must thank hydroponics Nepal and team for their coordination and dedication for making this happen. We are very happy to learn and connect with them."

Dhan Bahadur Tamang (taekwando player), "Hydroponics fruits and vegetables are fresh, healthy and nutritious. I am feeling healthier and more energetic after I started daily consumption of hydroponic salads." (Hydroponincs Nepal)

Conclusions

Hydroponics Nepal is promoting urban agriculture through following ways: -

- Providing knowledge, technologies and trainings on hydroponics system.
- Being an example of profitable hydroponics farm, producing healthy, fresh and nutritious food in environment friendly way.
- Providing job opportunities to many skilled and semi-skilled people.
- Attracting and encouraging youth to involve in agriculture field.

3.13 NATIONAL AGRICULTURE RESEARCH CENTER(NARC)

3.13.8 OBJECTIVES

- To know about the different programs of an agricultural research center
- To know the general design requirements of various programs of the research center

3.13.9 PROJECT BRIEF

Location: Khumaltar, Lalitpur
Client: Government
Total Site Area: 214288.42 sq. m (21.43 ha)
Ground coverage: 11,574.94 sq. m (5.4%)
Shape of land: Irregular
Construction type: Load bearing and framed

NARC is a research-based body that conducts numerous agricultural-related research activities. NARC develops novel technology and collaborates with national and international organizations.

3.13.10 SITE AND SURROUNDING

- Approach Road: -
  : 8m wide black topped road on the NE
  : 6m wide black topped road to the west
  : 3m wide black topped road on the east
- Proximity to transport hub: micro-bus Park on the immediate north
- Parking: Near main entry gate, East side Approx.: 2268.13 Sq. m

3.13.11 ADMINISTRATIVE BUILDING

Figure 3. 14-NARI building

The administrative unit, as well as other supportive units such as a library, storage, conference room, and museum, are housed within the Nepal Agriculture Research Institute (NARI).

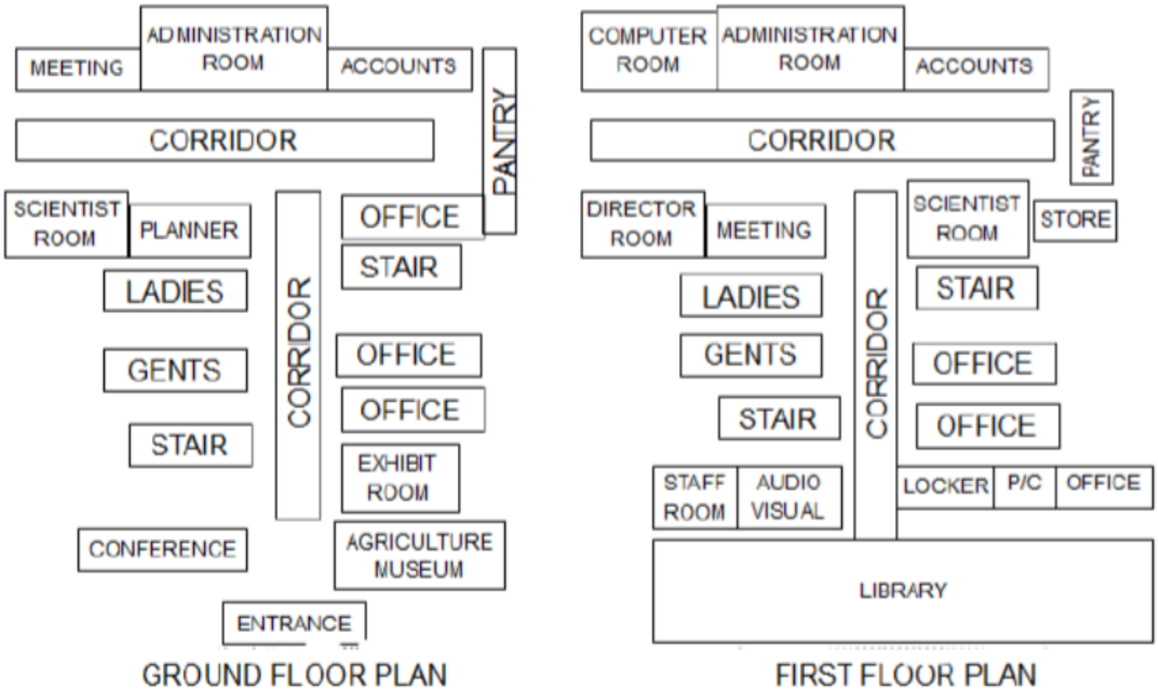


Figure 3. 15-Space connection of Admin Block

3.13.11.1 AGRICULTURE MUSEUM

The museum of area around 70sq.m consists of display racks for exhibiting agricultural systems of Nepal along with seeds and crops of Nepal.

Insufficient natural light and light glares due to reflection of light on by display glass are some issues found in the museum.

Figure 3. 16-Display racks of Museum

3.13.11.2 CONFERENCE HALL

Figure 3. 17-General test lab

Capacity - 100 Nos.

Florescent tube - 13 x 2 Nos.

2 air conditioning & 6 fans.

Two entry/ exit.

3.13.11.3 LIBRARY

Figure 3. 18-conference hall view

Central Library.

Area = 425 Sq. m.

Sufficient Natural light.

Reading Space acc. To types.

3.2.3 HORTICULTURE DIVISION

Figure 3. 19-Library

Functions: vegetables and fruits production process & education, seed production & distribution, organic farming, gap practices and conducting training programs in collaboration with extension services.

3.2.3.1 GENERAL TEST LAB

In this lab, general tests of hybrid crops and produced fruits and vegetables are conducted. The test includes: -

Figure 3. 20- Horticulture Division building

- Total soluble solid test
- Titratable acidity test
- Beta-carotene test
- Water content test

Tests are done for tomato, potato, papaya, carrot, pine-apple, cabbage, etc.

The room is well lit and ventilated with windows on west and northern sides of the building. (Kharal,2022)

3.2.3.2 STORE ROOM

A well-ventilated room on the northern side is provided to store produced fruits and vegetables that can be stored for few weeks in normal room temperature.

Figure 3. 22-Store room

Figure 3. 21-Cool-bot

3.2.3.3 COOL BOT

Cool bot is an insulated room for storage of fruits and vegetables with air conditioner and sprinkler to maintain desire room temperature and humidity. (Kharal,2022)

3.2.3.4 NET HOUSE

Net house is steel or bamboo framed structure used for breeding of crops. The function of net is to keep insects and flies out of the structure and avoid cross pollination, maintaining required air and heat circulation. (Rawal,2022)

Figure 3. 23- Net house

3.2.3.5 HYDROPONICS GREEN HOUSE

This horticulture division have started experimenting in hi-tech indoor farming using hydroponic modules and advance technologies to control room environment since last year.

Figure 3.24- Hydroponics module setup

3.2.3.6 ZERO-ENERGY DRIER

Zero-energy drier is traditional method of storing food harvesting and storing. (Rawal,2022)

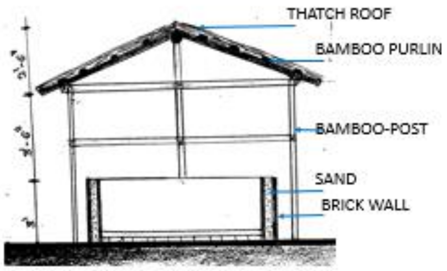


Figure 3. 25-Zero Energy drier

3.2.4 ENTOMOLOGY DIVISION

The Entomology Division is involved with insects that are either beneficial or harmful to crops. It creates environmentally friendly and appropriate technology to reduce losses caused by insects. The Entomology Division's general lab area is 360 sq.ft. Table 1 shows the General Labs of the Entomology Division.

Space	Description
Toxicology Lab	Rearing of insects Dark room using curtain Cupboard for wooden box
Pesticides Lab	Test for the amount of Pesticides Wet laboratory
Bio-Assay Lab	Located at north side
Entomology Museum	Display of different insects Located on north side
Insect rearing Lab	Insect rearing in controlled temp.
Temperature controlled room	Temp. Controlled as per need

Table 3. 1- General labs of Entomology Division

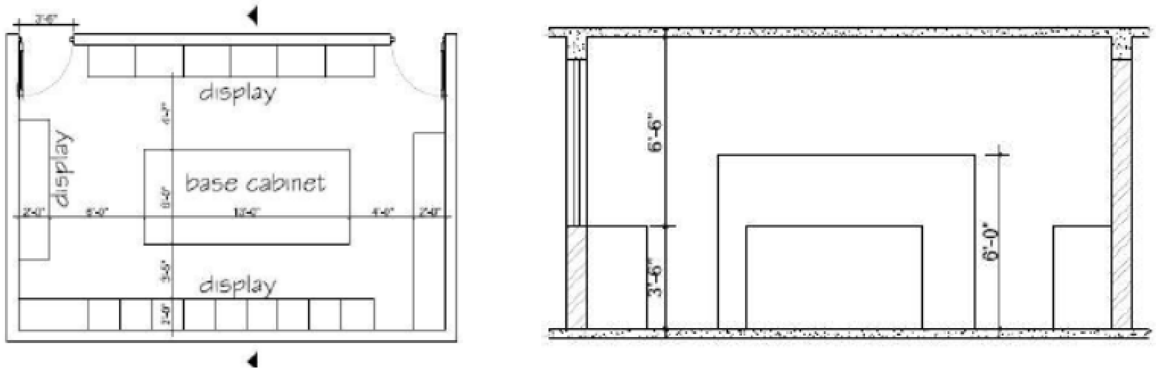


Figure 3. 26- Typical lab layout

Besides laboratories and office rooms, the division consist of insect museum where various beneficial and hazardous insects from all over Nepal are exhibited.

Figure 3. 27-Insect museum

3.2.5 PLANT PATHOLOGY DIVISION

Pathology is a division that conducts research on plant diseases. This division conducts surveys and monitoring of diseases, infections, and diseases, as well as offering services for identifying and resolving diseases connected to significant crop species. The Plant Pathology Division's General Laboratories are classified in the Table.

3.2.5.1 LABORATORIES

The Plant Pathology Division's General Laboratories are classified in the Table.

Space	Description	Area (m^2)
Mycology Lab	Fungus related disease in plants	6.35 X 5.63
Virology Lab	Research on viruses in plants	6.88 X 5.54
Bacteriology Lab	Various bacteria present in plants	6.00 X 5.63
Nematology Lab	Disease on plants by Nematodes	5.63 X 4.57

Table 3. 2- General Laboratories

3.2.5.2 LAB SUPPORT ROOMS

Incubation room

- Pathogen growth requires a special lab with a controlled temperature.
- The ceiling is insulated to reduce heat loss.
- UV rays are used to kill microorganisms.
- Although a window is provided, it should be sealed.

Routine Room

Also known as Lab Support area. It consists of following equipment: -

- Additional Lab Equipment.
- Hot Air ovens for drying process.
- Distillation plant.
- Growth chamber.
- Cooler

Write Up Area

- Adjacent to the Lab.
- Away from the Fume Hoods.
- Near Window.
- View to Outside.

Office Space

- Separate offices for researcher are given.
- Adjacent to the Laboratory.
- Oriented to the South East direction.
- Area = Approx. 12m^2

3.2.6 CONCLUSIONS

- The structure was constructed as an office building to provide the lab with the necessary space.
- Some laboratory features are offered, but laboratory safety standards are not observed as as there is absence of Safety Shower, eye wash, Biological Safety Cabinets, sprinklers, fire hose and freight elevator to move equipment.
- The majority of the laboratories are oriented south.
- It is not suggested to provide a single entrance that opens inwards toward the lab.
- The circulation is quite low due to non-modular planning.
- Improper finishing material selection, which is difficult to clean and maintain.
- Due to non-modular planning and inflexible utility distribution, flexibility is severely constrained.

3.14 NATIONAL BOTANICAL GARDEN

3.14.8 OBJECTIVES

- To study indoor and outdoor exhibition spaces for exhibiting plants.
- To learn about green houses that are used to preserve various exotic plants.
- To understand benefits of integrating recreational hub in a research and conservation center.

3.14.9 PROJECT BRIEF

Location: Godawari, Lalitpur (foothill of Mt. Phulchowki (2765 m), the highest peak of the Kathmandu valley)

Inaugurated by King Mahendra in 1962 AD (2019 BS)

Category: center of plant conservation, education, research, display and recreation

Landscape designer: British architects, Geoffrey Herklots and Tony Schilling

Total site area: 82 hectares (40 hectares of which have been transformed into various thematic garden units)

Figure 3. 28- Entry gate of National Botanical Garden

(National Botanical Garden , n.d.)

This is the oldest and largest botanical garden of the nation, well-known as a center of plant conservation, education, research, display and recreation. It is also an internationally recognized botanical garden and a member of Botanic Gardens Conservation International (BGCI) since 2015 AD.

- **Mission: "*Exploration and conservation of plant resources for a better future*"**

3.14.10 PROGRAMS

3.14.10.1 BOTANICAL INFORMATION AND EXHIBITION CENTER

A museum for teaching, research, and presentation that is situated next to the garden's main entry gate. This floral garden receives roughly 70 000 students each year. Mainly, plant researchers and students on educational trips visit this exhibition center to view live plants.



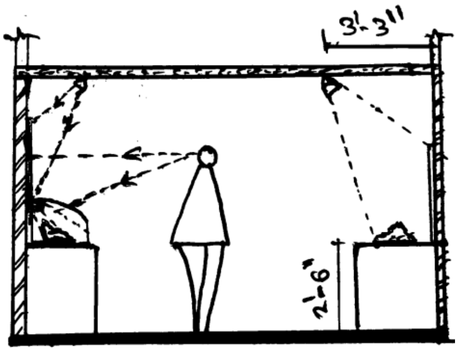


Figure 3. 29- Interiors of exhibition center

3.14.10.2 PRINCIPAL RESEARCH ACTIVITIES

- Preservation and multiplication of Nepalese endemic, native, endangered, and indigenous plants; and
- Ex-situ plant preservation through seed germplasm preservation in the seed gene bank.

The National Botanical Garden in Godawari, Nepal, is also conducting and supporting research on a number of different topics, including

- Taxonomic study of Ensete (Musaceae) in Nepal,
- Growth rate of Lichen species in Nepal,
- Air pollution tolerance index of Kathmandu Valley (Master's Thesis), and
- Floral preferences of Butterflies in Godawari.



Figure 3. 30-Green houses to support various important endangered plants of other regions of country

3.14.10.3 THEMATIC PLANT AND LANDSCAPE GARDENS

Arboretum, Biodiversity education garden, Canna path, Conservation and education garden, Coronation pond (aquatic plant garden), Ethno-botanical garden, Fern garden, Japanese style garden, Lily garden, Nepalensis-Historic Garden, Orchid garden, Physic garden, Plant production and research area, Rock garden, Rose garden, Sand Garden, Special garden, Taxonomic family garden (Bentham and Hooker's classification system), Terrace garden, Threatened plants garden, Tropical garden, VVIP plantation garden, and Wetland garden.

Figure 3. 31-Thematic Gardens and landscapes

3.14.10.4 RECREATIONAL HUB

The peaceful green environment with beautiful landscapes of the garden made it a perfect recreational and refreshing hub. Naturalists come here to observe birds and appreciate the beauty and flora, families and friends come here to rest and unwind distant from the monotony of city life, and film crews come here to shoot movies and films.

Conclusions

Therefore, the botanical garden has been a popular place for botanists, plant conservationist, students and common people. A fresh, green and beautiful place to chill around is an important aspect of every city which can be testified through the data of number of people visiting the place every year. Case study of National Botanical Garden helped in learning the benefits of integrating research, educational, conservational and recreational aspects in one center.

3.15 NATIONAL HERBARIUM AND PLANT LABORATORY

3.15.8 PROJECT BRIEF

The National Herbarium and Plant Laboratory is a research institute that is dedicated to the study and documentation of plant species. This article provides an overview of the institute's location, establishment, and the various sections that exist within the facility.

- Location: Godawari, Lalitpur
- Established: 1961
- Type: Governmental Building
- Building shapes: Combination of circular and rectangular shape
- Main entry: North-East

Figure 3. 32- National Herbarium and Plant Laboratory

3.15.9 PLANNING

The atrium serves as the main connecting element in the building, and workspaces are distributed from this central location. Effective lighting is incorporated into the design of the building, with windows being allocated in three directions to allow for natural light and cross ventilation.

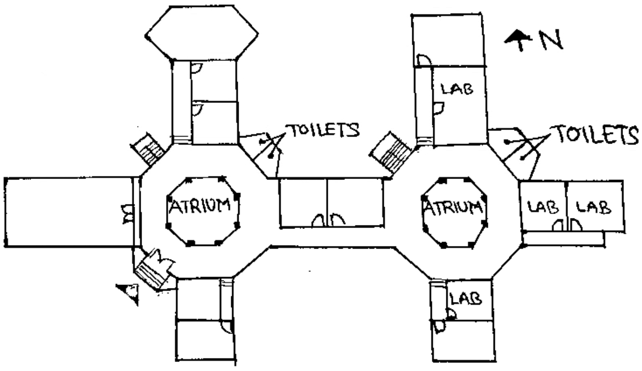


Figure 3.34- Plan

Figure 3. 33- Central Atrium

3.15.10 ARCHITECTURAL CHARACTERS

- **Atrium as a Main Connecting Element:**

The atrium serves as a hub for the different sections within the institute, connecting the workspaces and allowing for easy access to different areas of the facility.

- **Distribution of Workspaces from the Atrium:**

The workspaces within the institute are distributed from the atrium, with each section having its own dedicated space for research and documentation.

➢ **Effective Lighting in the Building:**

The building incorporates effective lighting design to provide natural light and cross ventilation, which is essential for plant research.

➢ **Allocation of Windows in Three Directions:**

Windows are allocated in three directions to provide natural light and to promote cross ventilation, which is important for maintaining a healthy environment for the plants.

➢ **Atrium as a Source of Day Lighting and Cross Ventilation:**

The atrium serves as a source of natural light and cross ventilation, which is essential for plant research and the preservation of plant specimens.

3.15.11 PROGRAMS

The various sections within the institute each have their own focus and purpose. The Mycology Section is dedicated to the documentation of fungi, while the Anatomy Section focuses on the identification of wood and timber. The Tissue Culture Laboratory is responsible for the propagation of rare and endangered plants, and the Medical Plant Section focuses on the domestication of wild herbs and research on their medicinal value. Finally, the Herbarium is responsible for the documentation and preservation of plant specimens.

➢ **Mycology Section:**

The Mycology Section is responsible for the documentation of mushrooms found in Nepal. The lab is equipped with specialized equipment and lighting to facilitate research and documentation.

Figure 3. 36- Mycology section

Figure 3. 36- Anatomy section

➢ **Anatomy Section:**

The Anatomy Section is dedicated to the identification of wood and timber. The room is allocated for this purpose, and activities such as microscopy and sectioning are performed in the room.

➢ **Tissue Culture Laboratory:**

The Tissue Culture Laboratory is responsible for the propagation of different plant species. The lab is equipped with specialized equipment and requires strict protocols for maintaining a sterile environment.

Figure 3. 38- Growth room

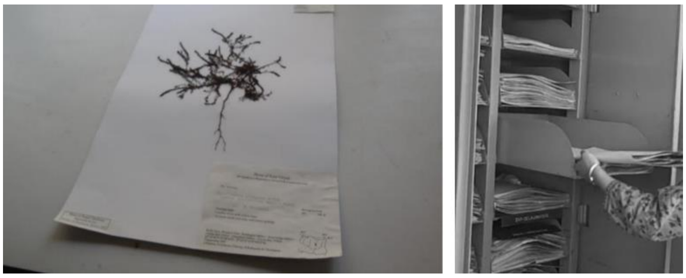


Figure 3. 38- preserved plant specimen

- **Herbarium:**

The Herbarium is responsible for the documentation and preservation of plant specimens. The process of compressing and storing plant specimens is carefully carried out, and archives and storage cabinets are used to preserve the specimens.

- **Medical Plant Section:**

The Medical Plant Section is focused on the documentation and domestication of wild herbs, and research on the medicinal value of plants. The section also incorporates agro technology for species development.

- **Library:**

The Library within the institute houses a collection of books and journals on botanical information, which are available to researchers and visitors.

Figure 3. 39- Library

- **Botanical Garden:** The institute has a botanical garden that houses a wide range of plant species, including those that are rare and endangered. The garden serves as a living laboratory and provides researchers with access to different plant species for their studies.
- **Plant Pathology Section:** This section is responsible for the identification and diagnosis of plant diseases. The lab is equipped with the latest technology and facilities to aid in research and diagnosis.
- **Seed Bank:** The seed bank within the institute is responsible for the conservation and storage of seeds of different plant species. This is important for the preservation of genetic diversity and the conservation of plant species.
- **Plant Taxonomy Section:** This section is responsible for the classification and naming of plant species. The section uses the latest taxonomic methods to identify and classify plant species.

3.15.12 RESEARCH AND OUTREACH

The National Herbarium and Plant Laboratory is not only involved in research and documentation but also actively engaged in outreach activities to promote the conservation and preservation of plant species. The outreach activities include:

- **Workshops and training programs:** The institute organizes workshops and training programs for students, researchers, and farmers to promote awareness about the conservation and preservation of plant species.
- **Public lectures:** The institute also conducts public lectures to educate the general public about the importance of plant species and the need for their conservation.
- **Collaboration with international organizations:** The National Herbarium and Plant Laboratory collaborates with international organizations to exchange knowledge and resources for the conservation and preservation of plant species.

3.15.13 CONCLUSIONS

The National Herbarium and Plant Laboratory is an important research institute that is dedicated to the documentation and preservation of plant species. With its various sections and dedicated workspaces, the institute is well-equipped to carry out research and preserve plant specimens for future generations. The key inferences of this study are: -

- Central atrium connecting different wings, makes flow of people easy and every room well lit and ventilated.
- Labs and office are in same building which provides sense of neighborhood.
- White & red color creates contrast with green surrounding

3.16 PLANT CONSERVATION SCIENCE CENTER

3.16.8 OBJECTIVES

- To study energy efficient and green building technologies used in this research building.
- To learn design and plan of the research building maintaining public interaction
- To study lighting and ventilation design for different laboratories.

3.16.9 PROJECT BRIEF

Location: Glencoe, Chicago, Illinois, USA

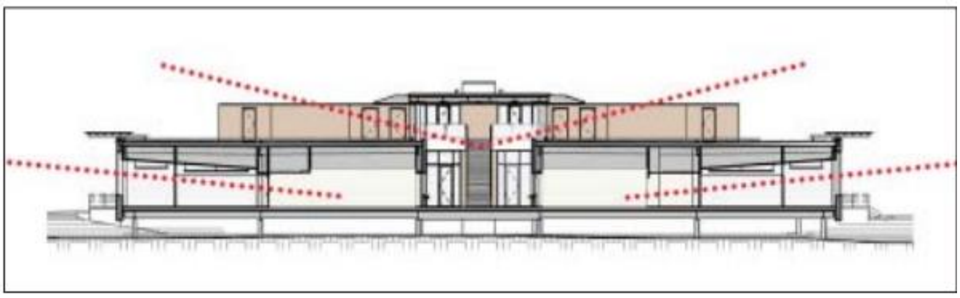
Category: Research Center

Area: 3,530.3 sq. m. (37,700 sq. ft.)

Project Year: 2008-2009 A.D.

Architect: Booth Hansen Ten laboratories, herbarium, an enlarged seed vault facility, seminar and conference rooms, and a plant science library.

A world-class laboratory to service plant conservation science research and to educate the public about this research within a new one-story 37,700 gross masonry and glass building. One of the most critical design objectives of the Chicago Botanic Garden was to make the science of plant research accessible to the public. The building is designed from the "inside-out" around a central public viewing gallery. (HANSEN, 2010)



Section diagram shows how natural light filters into the building

3.16.10 SITE AND BUILDING PLANNING

Because of its location on an existing floodplain and the Garden's intention for minimal site impact, the entire building is raised above the flood level to prevent floods, retain an undisturbed slope, and provide for a rain garden for site runoff. The building design was intended to have two simple identical "bars" of offices and laboratories divided by a central atrium allowing the public (almost 800,000 visitors each year) to witness the Garden's research operations. The “bars” consist of private offices of principal investigators on the exterior wall and laboratories fronting the public atrium. (HANSEN, 2010)

Figure 3. 40- Ground floor

Source: *(HANSEN, 2010)*

3.16.11 BUILDING MATERIALS

The materials utilized in the Plant Science Center complement the Garden's general defined palette. Natural brick, glass, wood, and steel allow the building to interact with its environment in harmony. Materials used inside the building, such as recycled rubber flooring, exposed concrete floors, and recycled slate countertops, were chosen for their durability and functionality, as well as to produce an easily maintainable, low-off-gassing atmosphere. Brise-soleil roof overhangs made of photovoltaic cell panels, along with the green roof, make sustainable design more evident to visitors. The buildings are smoke-free zones that are open to the public and workers alike. (HANSEN, 2010)

3.16.12 LABORATORIES

The laboratories were designed with the following planning principles:

- Interaction, Flexibility, Safety
- Establish the “Lab Module” to allow for flexibility
- Provide access to natural light
- Foster key adjacencies: office to lab, lab with views, lab to public, progression of low to high hazard

3.16.12.1 LABORATORY CLASSIFICATION

Laboratories are classified on the basis of process, chemical use and fume hood requirements into: -

- Wet labs (with hoods)
- Dry labs (without hoods)

The building is divided into two laboratory blocks based on the research's programmatic requirements. The west lab building is mostly made up of "dry labs," with fume hoods restricted to key support rooms. The biology/chemistry laboratories are located in the east block. Mechanical rooms, AHUs, and utilities are devoted to each laboratory block. Each block is considered self-sufficient, with minimum utility or program cross-over. (HANSEN, 2010)

3.16.12.2 LABORATORY MODULES

The Plants Conservation Science Center's basic planning module measures 9.75m × 9.75m with a 3.25m midline between benches. The modules are designed to provide for "plug-and-play" flexibility anywhere in the lab block. Walls can be placed anywhere on the 3.25m module to combine or enclose labs as needed. As a planning philosophy, labs were meant to be "open" by default, and "closed" only when function or safety needed (HANSEN, 2010).

3.16.13 SUSTAINABLE DESIGNS

3.16.13.1 ELECTRICAL AND LIGHTING SYSTEM

Most outside wall spaces have photocells that allow for maximum daylight and reduced energy use for illumination. High-efficiency lighting with occupancy sensors throughout the building

Figure 3. 42Green roof

Figure 3. 42- Solar panels as shading device

increases the efficiency of the electrical system architecture. Twenty-three electrical panels are being metered to allow for future monitoring and verification of the expected energy savings. 288 photovoltaic panels on the roof overhangs "brise-soleil" supply about 6% percent of the building's energy needs through the 54.7Kw. The design of the solar panel installation also provides for shading on the windows, reducing glare and heat gain. (HANSEN, 2010)

3.16.13.2 GREEN ROOF

Light-colored roofing and a green roof garden (approx. 1,500 sq. m.) cover over 50 percent of the roof area, reducing the heat island effect. The green roof system reduces storm water run-off and naturally filters any remaining stormwater. This roof garden tremendously maintains the environment below for the office rooms and research labs. The roof garden also has a sitting space for a peaceful environment to enjoy the nature in front. (HANSEN, 2010)

3.16.13.3 AIR SYSTEMS

a) Natural ventilation of the central atrium viewing gallery using fans: The allowable temperature range in the central atrium viewing gallery has been enlarged; it will be initially set at 60F to 80F. When the outside air temperature is between 55F and 85F, no supply air will be given by the AHUs. If the temperature in the space goes above a predetermined threshold, an exhaust fan will activate (approximately 70F to 75F).
b) Low velocity AHUs: Choosing air handling units with low velocity coils and filters (between 350 and 400 fpm to full flow) decreases pressure loss across the filters and coils, resulting in a lower fan power demand when compared to the normal 500 fpm face velocity.
c) VAV laboratory systems: Variable air volume laboratory supply and exhaust.
d) Heat recovery: The process of pre-heating/pre-cooling outside air using a heat pipe heat recovery system that recovers heat from the laboratory exhaust systems. (HANSEN, 2010)

3.16.13.4 PREVENTION OF POLLUTION AND WASTE

More than 75% of the building debris was saved from landfill. An erosion and sedimentation plan comprise silt fencing, sediment traps, and basins to prevent construction run-off from polluting the surrounding land. (HANSEN, 2010)

3.16.14 CONCLUSIONS

- Therefore, building of Plant Conservation Science Center is simple and efficient building with sustainable design. Proper orientation and planning of spaces based on the site context and functions of the project can minimize energy consumption by the building. Use of re-usable, recyclable and disposable building materials made the project environment friendly. The transparency of the central gallery allows the researchers to receive indirect natural light and provides a sense of connection to the other laboratories. The clerestories, cantilevered projections on roof, roof garden and photovoltaic cells are the other energy efficient technologies that made the project sustainable.

3.17 SKY-GREEN

3.17.8 OBJECTIVES

- To know the hydraulic nature of vertical farming
- To know about sustainable approach to Vertical farming

3.17.9 PROJECT BRIEF

Location: Singapore
Category: Commercial farm
Area: 600 sq. m. (37,700 sq. ft.)
Built by: Sky Greens Farm

Sky Greens is the world's first hydraulically powered, low-carbon vertical farm. Green urban solutions are used to produce healthy, fresh, and delicious veggies while using little land, water, and energy resources. (Rashmi Maria Royston, 2018)

3.17.10 FARM FEATURES

- Sky Greens' four-story rotating greenhouse produces one ton of leafy greens every other day, thanks to a hydraulic-driven system that rotates and feeds sunshine to the growing troughs.
- 38 growth troughs rotate around an A-shaped water-pulley system.
- An aluminum tower around 9 meters (30 feet) tall.
- Because the plants are irrigated and fertilized by floods, there is no need for a sprinkler system, which eliminates both electricity and water waste due to run-offs.
- The 1.7-ton vertical structure can be rotated using only 0.5 liters of water.
- The water is contained in an underground reservoir system and is recycled and reused.
- The plantation has 1,000 vertical towers and produces 800 kg of Chinese Cabbage, spinach, kai lan, and other greens vegetables.
- 40W electricity, or the equivalent of one light bulb, is needed to power a single 9-meter tower.

Figure 3. 43-top view of sky green, (Rashmi Maria Royston,

- Array of tower along N-S, tower length E-W
- Rotation of tower gives each tray sufficient sunlight throughout the day. Watering is done 3 times a day. (Adhikari, 2019)

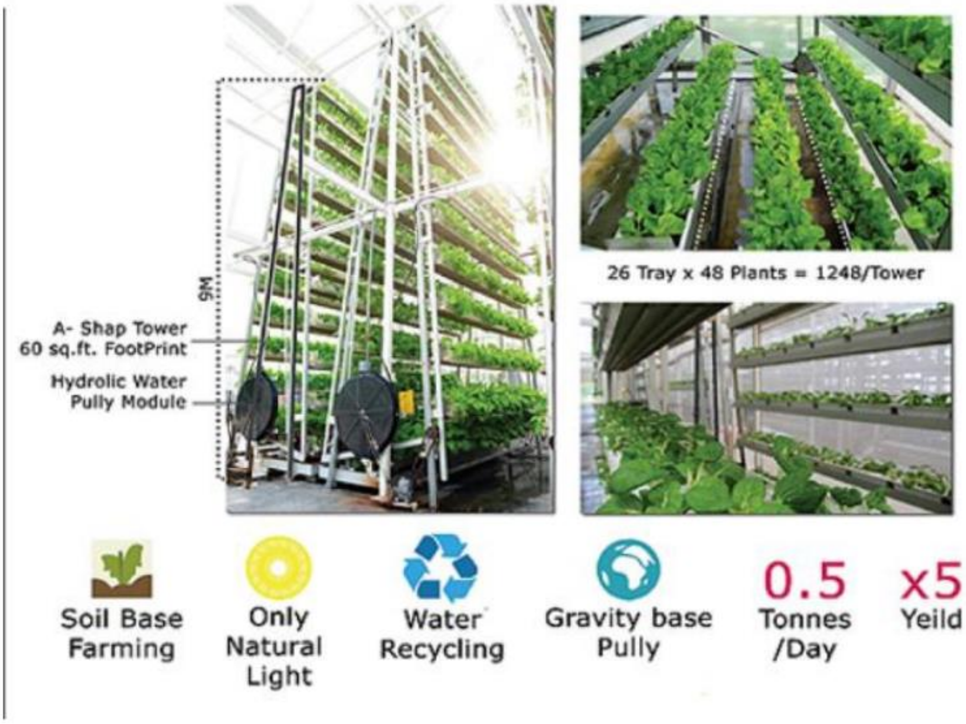


Figure 3. 44- Growing modules of sky green, (Rashmi Maria Royston,

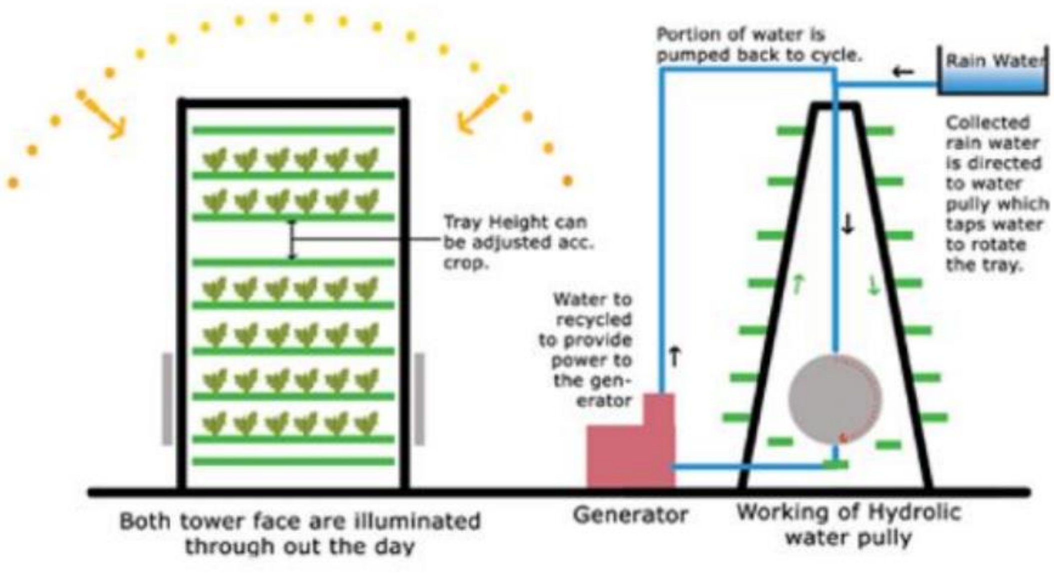


Figure 3. 45- Rotating tower through Hydraulic force

3.17.11 CONCLUSIONS

- Aeroponic System Used
- Low carbon Hydraulic Water-driven
- Natural Sun energy

3.18 SUNQIAO URBAN AGRICULTURAL DISTRICT

3.18.8 OBJECTIVES

- To study benefits of having multiple technologies in a farm
- To learn about interactive spaces to design an urban farm as educational and innovative space.

3.18.9 PROJECT BRIEF

Location: Sunqiao, shanghai
Category: Commercial farm
Area:250-acre
Designed by: Sasaki Associates

Figure 3. 46- Public oriented farm

With over 24 million people to feed in Shanghai, the Sunqiao Urban Agricultural District is intended to bring large-scale vertical farming to the city center. While the goal of this project is to meet the region's expanding agricultural demand, Sasaki Associates is also attempting to broaden its vision by utilizing this urban farm as a dynamic laboratory for innovation, engagement, and education.

3.18.10 FARMING TECHNIQUES

The urban farm carries out a number of urban friendly farming techniques such as algae farms, floating greenhouses, green walls, and vertical seed libraries to cater the demand for leafy vegetables in the Shanghainese diet. The growing systems used in the farm are hydroponics and aquaponics systems. (Walsh, 2017)

3.18.11 PROGRAMS AND SPACES

- Commercial production farm

- aquaponics showcase
- science museum
- sky garden, and
- interactive greenhouse

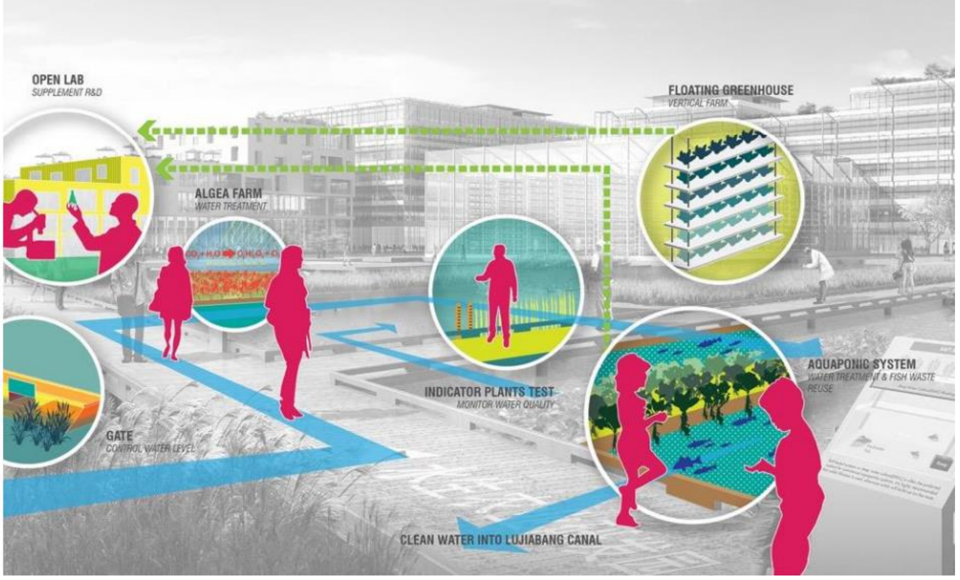


Figure 3. 47- Sunqiao Urban Agricultural District – Features 1

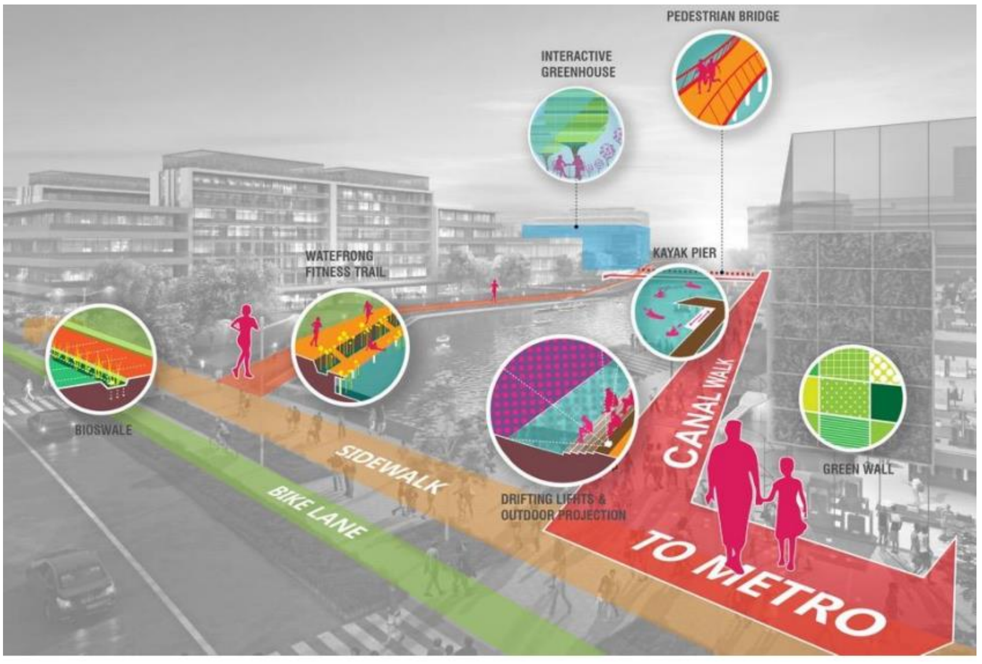


Figure 3. 48-Sunqiao Urban Agricultural District – Features 2

The major production area is segregated from the south's public-focused production areas, which include the aquaponics showcase, science museum, sky garden, and interactive greenhouse. This allows public visitors to immerse themselves in the agricultural area without harming the growing environment. (Walsh, 2017)

This technique promotes a more sustainable food supply, which improves city livability. With the planned growth of restaurants, markets, culinary academy, and pick-your-own experience in the future, it will even push itself to a new level of integrating agricultural into urban life. (Walsh, 2017)

3.18.12 SUSTAINABLE APPROACH

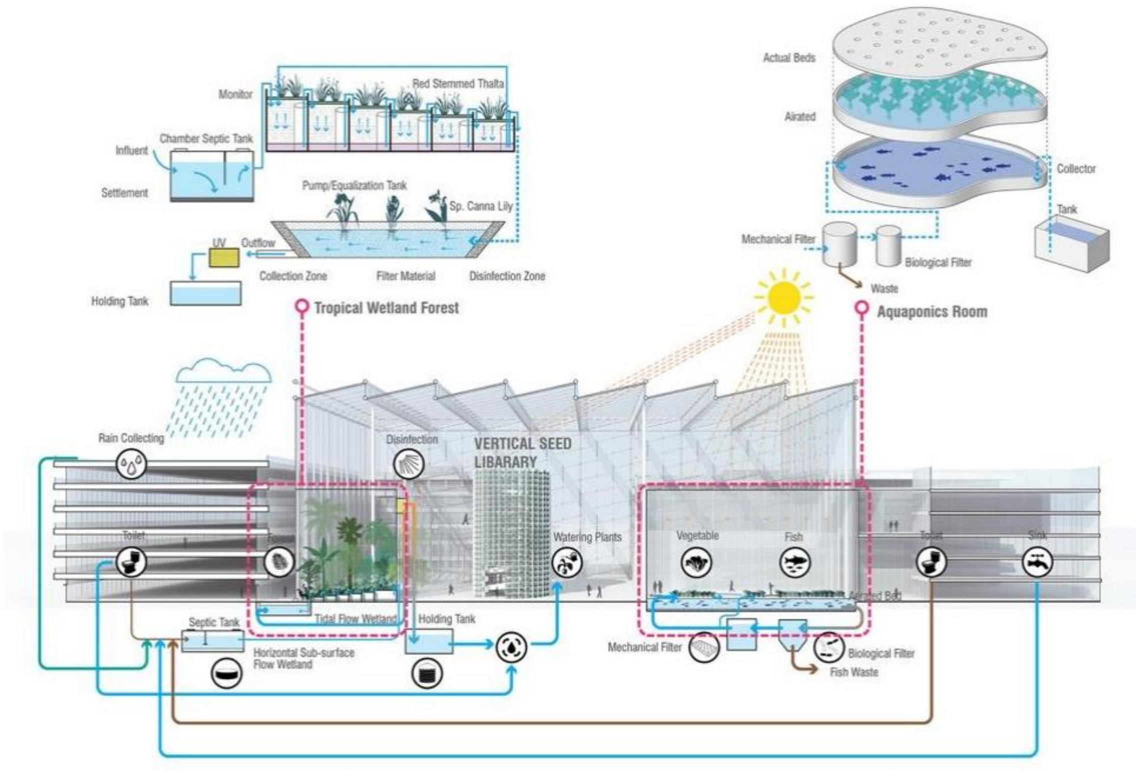


Figure 3. 49- Water circulation details in buildings, seed library and aquaponics

Source: (Walsh, 2017)

3.18.13 CONCLUSIONS

- Therefore, using multiple technologies and methods not only provides healthy crop diversity but also generates a venue for people to discover more about the way the food on our tables every day comes.
- The entire project has evolved into an educational and recreational facility where neighbors can come and spend their afternoons connecting with agriculture and environment along with a healthy food production facility,
- With the complexity of several systems, integration can be important. Water resources, for example, some used water we want to gather and some we don't; some water needs to be filtered before use, while others don't. All of these factors might have an impact on the layout designer's work and must be carefully examined throughout the preliminary design phase.

3.19 THE FARMHOUSE

3.19.8 OBJECTIVES

- ➢ To study ideas to incorporate nature into our buildings.
- ➢ To know about CLT Construction as a better alternative to concrete construction.

3.19.9 PROJECT BRIEF

The Farmhouse is a unique concept for a modular skyscraper designed by Precht Studio. The building aims to address two major issues faced by modern cities - housing and food scarcity - by combining urban farming and modular housing in one structure. The building's unique triangular shape and use of cross-laminated timber (CLT) panels create a striking and sustainable addition to the urban environment. (2023 Forest and Wood Products Australia Ltd, n.d.)

Figure 3. 50-Exterior view of The Farmhouse

- Architects: Precht Studio
- Location: Urban environment
- Type: Residential and agricultural
- Building materials: Cross-laminated timber (CLT), glass, metal
- Size: Modular structure, can be customised to various heights and sizes Features: Vertical farming, customizable living spaces, exposed CLT structure

3.19.10 STRUCTURE

The primary building material of The Farmhouse is CLT, which is a derivative of trees and a sustainable resource. CLT panels were used to create the modular structure, finishes, and vertical farm planters. The structural system combines both diagrid frameworks and traditional A-frame construction to create a rigid frame with low material use and structural clarity. The wall systems consist of three layers for electrical and residential water needs, insulation, and gardening supplies and water use. The modular system can be built offsite and assembled on location, reducing costs and time. (2023 Forest and Wood Products Australia Ltd, n.d.)

3.19.11 EXTERIOR

The Farmhouse features a rectilinear envelope with a patterned facade created by the triangular modules inside. The faceted glass panels allow maximum light into the vertical farms and apartments, which are set back behind balconies to avoid direct glare. The vertical farms are visible from the street, creating a lush garden profile for passersby. The v-shaped garden in between units acts as a buffer zone between apartment buildings, eliminating the need for overhanging balconies. (2023 Forest and Wood Products Australia Ltd, n.d.)

3.19.12 INTERIOR

The interior spaces of The Farmhouse take on the geometry of the triangulated form, with pitched walls creating unique spaces. The exposed CLT panels provide a warm and bright interior lining that complements the garden spaces. Views through to the vertical garden are evident in most rooms, providing an unprecedented floral setting in an urban environment. The gardens consist of an exposed timber structure, including planters for the crops. The customizable living spaces can be expanded to double A-frames to accommodate families.

Figure 3. 51- Interiors

Overall, The Farmhouse represents a modern and sustainable solution to the issues of housing and food scarcity in urban environments. Its unique triangular shape, use of sustainable materials, and integration of urban farming create a striking and functional addition to any city. (2023 Forest and Wood Products Australia Ltd, n.d.)

3.19.13 CONCLUSIONS

- Organic loops within a building.
- Spaces that really connects to all our senses.
- Traditional A-frame construction of CLT.
- 3 layers of wall system: one for electrical and water supply lines, middle one for insulation and exterior one for plantation.

3.20 COMPARATIVE ANALYSIS

BASIS	HYDROPONICS NEPAL	NARC	NATIONAL BOTANICAL GARDEN	PLANT CONSERVATION SCIENCE CNETER	SKY GREEN	SUNQIAO URBAN AGRICULTURAL DISTRICT	INFERENCE
STRUCTURE	IN GROUND INSIDE GREEN HOUSE	LOW-RISE	LOW-RISE	LOW=RISE	MD-RISE	MID-RISE	MID-RISE
MATERISAL	STEELSTRUCTURE GREENHOUSE POLYSHEET	BRICK, CEMENT MOTAR	STEEL, WOOD, BRICK	BRICK, GLASS, WOOD, STEEL	STEEL, GLASS	STEEL, GALSS	BRICK, GLASS, WOOD, STEEL
LIGHTING	GROW LIGHT, LED, PURPLE	FLUROESCENT LIGHT, LED, SUNLIGHT	FLUROESCENT LIGHT, LED, SUNLIGHT	LED, SUNLIGHT	SUNLIGHT	SUNLIGHT, LED, HALIDE.GROW LIGHTS	SUNLIGHT, LED, HALIDE.GROW LIGHTS
WATER	1 PLANT= 200ML 1SQ, FT = 9 PLANTS 1 SQ.FT.= 1.8 LT.	DRIP IRRIGATION	DRIP IRRIGATION, MANNUAL IRRIGATION	RECYCLED RAINWATER	WATER RECYCLED	RECYCLED	DRIP IRRIGATION, RAINWATER RECYCLING
RENEWABLE ENERGY		SOLAR PANELS		PHOTO VOLTAIC CELLS	FULLY ON SOLAR RADIATION		PHOTO VOLTAIC CELLS
FARMING	HYDROPONICS, AEROPONICS, AQUAPONICS	ON LAND, HYDROPONICSGREEN HOUSE	GREEN HOUSE, ON LAND		HYDROPONICS	HYDROPONICS, AQUAPONICS,	HYDROPONICS, AEROPONICS, AQUAPONICS
WASTE MANAGEMENT		COPOSTING INTO MANURE					COPOSTING INTO MANURE

4 PROGRAM FORMULATION

Major programs

1. Urban farm (hydroponics farm, aquaponics farm, green houses, mushroom farm)
2. Research and training units
3. Interactive spaces (cafeteria, exhibition space, open green park, agro-market)

4.12 PROPOSED PROGRAMS

ADMINISTRATION					
S.NO.	**DESCRIPTION**	**AREA/PERSON**	**NO. OF USERS**	**NO.S**	**AREA(SQ.M.)**
1	**EXECUTIVE HEAD OFFICE**	**20**	**1**	**1**	**20**
2	**DIRECTOR'S OFFICE**	**15**	**1**	**1**	**15**
3	**CHIEF MANAGER'S ROOM**	**15**	**1**	**1**	**15**
4	**ASSISTANT MANAGER'S ROOM**	**15**	**1**	**1**	**15**
5	**STAFF ROOM**	**6**	**4**	**1**	**24**
6	**SALES DEPARTMENT**	**6**	**3**	**1**	**18**
7	**MAINTENANCE DEPARTMENT**	**6**	**3**	**1**	**18**
8	**ACCOUNT SECTION**	**6**	**4**	**1**	**24**
9	**RECEPTION & FOYER**			**1**	**60**
10	**CONFERENCE HALL**	**2.5**	**100**		**250**
11	**STORE ROOM**		**1**	**1**	**10**
12	**TOILETS**				
	MALE		**4**		**20**
	FEMALE		**4**		**20**
13	**CONTROL ROOM**				**30**
14	**PRINTING ROOM**			**1**	**12**
	TOTAL				**491**

RESEARCH FACILITIES				
S.NO.	**DESCRIPTION**	**AREA**	**UNITS**	**AREA**
1	**GENERAL DRY LAB**	**30**	**1**	**30**
2	**MICROBIOLOGY LAB**	**30**	**1**	**30**

3	VIROLOGY LAB	30	1	30
4	BACTERIA TEST LAB	30	1	30
5	NEMATALOGY LAB	30	1	30
6	INSECTICIDE &PESTICIDE LAB	30	1	30
7	GROWTH ROOM	40	1	40
8	COOLBOTS	20	3	60
9	UTILITY ROOM	30	1	30
10	PHYTOCHEMISTRY LAB	40	1	40
12	AGRONOMY	50	1	50
13	GENETICS RESEARCH LAB	80	2	160
15	RECEPTION, FOYER	50	1	50
16	LAB HELPERS' ROOM	12	1	12
12	CHANGING ROOM			54
13	LABORATORY CHIEF	15	1	15
14	SCIENTIST'S OFFICES	12	10	120
15	MEETING ROOM	36	1	36
16	AHU	30	1	30
	TOTAL			877
17	ANCILLIARY SPACE	3%		26.31
	TOTAL			903.31

TRAINING FACILITIES					
S.NO.	DESCRIPTION	AREA/PERSON	NO. OF USERS	NO.S	AREA(SQ.M)
1	THEORY ROOM	2.4	30	3	216
2	PRACTICAL ROOMS	3	15	1	45
3	EQUIPMENT STORE	30	1	1	30
5	STAFF ROOM	3	10	1	30
6	REST ROOMS	50			100
7	LIBRARY			1	190
8	AUDIO-VISUAL ROOM	2.5	30	1	75
	TOTAL				686

URBAN FARM					
S.NO.	DESCRIPTION	AREA/PERSON	NO. OF USERS	NO.S	AREA(SQ.M.)
1	HYDROPONICS FARM	300	1	6	1800
2	AQUAPONICS	300	1	1	300

3	SANITIZING ROOM	2	5	14	140
4	MUSHROOM FARM	100	1	4	400
5	AEROPONICS FARM	200	1	3	600
6	WAREHOUSE	100	1	1	100
7	PROCESSING AND PACKAGING	300	1	3	900
8	STORAGE	100	1	3	300
9	GERMINATION ROOM	66	1	2	132
10	PREPARATION ROOM	60	1	2	120
	TOTAL				4792

INTERACTIVE SPACES					
EXHIBITION					
S.NO.	**DESCRIPTION**	**AREA/PERSON**	**NO. OF USERS**	**NO.S**	**AREA(SQ.M.)**
1	EXHIBITION HALL	2.3	100	1	230
2	GALLERY	2.3	80	1	184
3	STORE	20%			82.8
	TOTAL				496.8
AGRO-MARKET					
S.NO.	**DESCRIPTION**	**AREA/PERSON**	**NO. OF USERS**	**NO.S**	**AREA(SQ.M.)**
1	RETAIL STORE	2.3	80	1	184
2	COUNTER	2.3	50	1	115
3	BAGGAGE LOCKER	20%			59.8
4	SECURITY OFFICE ROOM	10	1	1	10
	TOTAL				368.8
CAFETERIA					
S.NO.	**DESCRIPTION**	**AREA/PERSON**	**NO. OF USERS**	**NO.S**	**AREA(SQ.M.)**
1	DINING(INDOOR+OUTDOOR)	1.3	100	1	130
2	KITCHEN	20%			52
3	STORE ROOM	20%			52
4	DISH WASHING AREA	5%			13
5	COUNTER	5%			13
	TOTAL				260

SERVICES				
S.NO.	**DESCRIPTION**	**UNIT AREA**	**NO.S**	**AREA(SQ.M)**

1	**ELECTRICAL ROOM**	**3**	**3**	**9**
2	**GENERATOR ROOM**	**15**	**1**	**15**
3	**JANITOR'S STORE**	**15**	**2**	**30**
4	**GUARD HOUSE**	**40**	**1**	**40**
5	**MECHANICAL ROOM**	**20**	**2**	**40**
6	**WATER TREATMENT FACILITY**	**100**	**1**	**100**
	TOTAL			**234**

PARKING					
S.NO.	DESCRIPTION	AREA/UNIT	NO.S	AREA(SQ.M.)	
1	4 WHEELERS	18	15	270	
2	2 WHEELERS	2	50	100	
3	BICYCLE	1.4	30	42	
4	TRUCK	30	3	90	
	TOTAL			502	

ACCOMODATION					
S.NO.	DESCRIPTION	AREA/UNIT	NO. OF USERS	NO.S	AREA(SQ.M.)
1	SHARED ROOM WITH A.TOILET	20	2	4	160
2	SINGLE ROOM WITH A. TOILET	18	1	3	54
3	KITCHEN	18		1	18
4	DINING	30	12	1	30
5	STORE			1	10
	TOTAL				262

4.13 AREA ANALYSIS

DESPCRIPTION	**AREA**	**PERCENTAGE**
FARM AREA	4792	53.26865209
RESEARCH&TRAINING	1589.31	33.1659015
INTERACTIVE SPACES	1125.6	70.82318742
ADMINISTRATION	491	43.62117982
OTHERS SERVICES	998	203.2586558
TOTAL BUILT UP AREA	8995.91	

<u>Overall calculation</u>

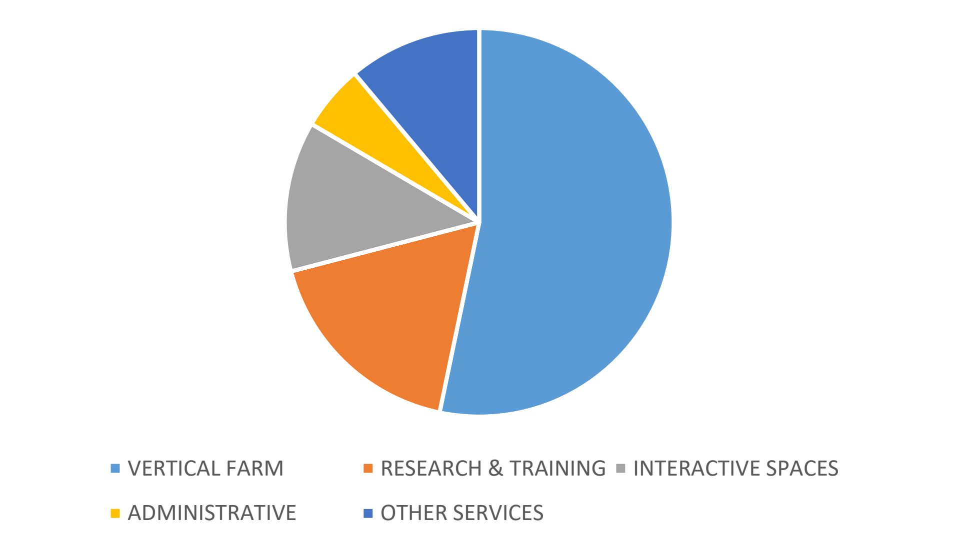
Estimated population: 320 total

Total floor area: 8995.91 sq. M

Wall area= 15% of floor area = 1349.4 sq.m.

Circulation= 20% of floor area = 1799.2 sq.m.

Total built-up area= 12,144 sq.m.



5 PROPOSED SITE

5.12 SITE INTRODUCTION

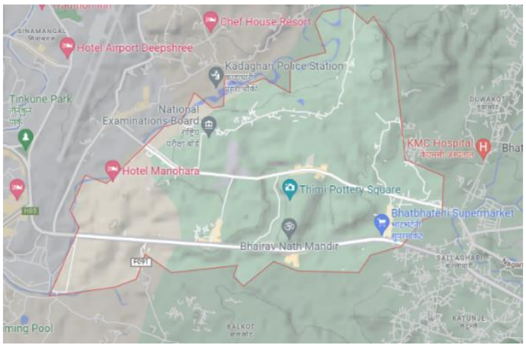
Location: Dibhyaswori, Madhypur Thimi

Site topography: slight contour

Latitude: 27°41'27.30” N, longitude: 85°22'27.28.54” E

Site area: 13,000 sq.m. (25.5 ropanies)

Current use: Agricultural farm



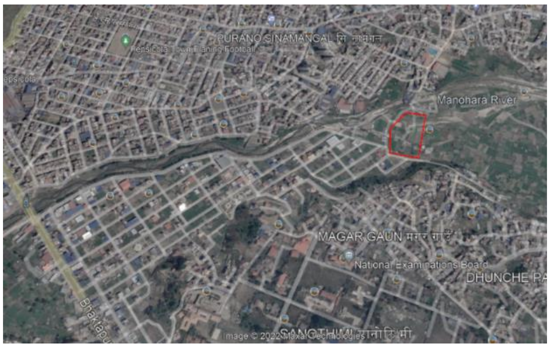


Figure 5. 1- location map of site

WHY THIS SITE??

- ➢ The site has been used as agricultural land since very long ago.
- ➢ Rapid urbanization of the area resulting to loss of agricultural land and increase in demand of vegetables and fruits

- ➢ Residential and commercial neighborhood:
- ➢ Different uses like groceries, restaurants, and residences within half mile walk. Produced agricultural products of farm can be easily sold in nearby restaurants, markets of residential areas or directly to people from nearby residences.
- ➢ In the research area none of the farmers queried had regular interaction with the extension service.
- ➢ Soil of the site represents low to high fertility that has been great for horticulture. Farmers claimed that when chemical fertilizers and other pesticides were used,
  were introduced, production was boosted, and they were eventually phased out experiencing a number of issues related to soil quality loss According to them, the earth became drier and harder, and several of the vegetables that they had traditionally grown were not growing well.

5.13 SITE ANALYSIS

5.13.8 SURROUNDING CONTEXT AND TRAFFIC

West: Dibyaswari planning with vibrant food hubs, commercial plazas, residences and farmlands

North: Pepsicola planning and Purano Sinamangal across Manohara river

South: Magar gaun

East: Agricultural land

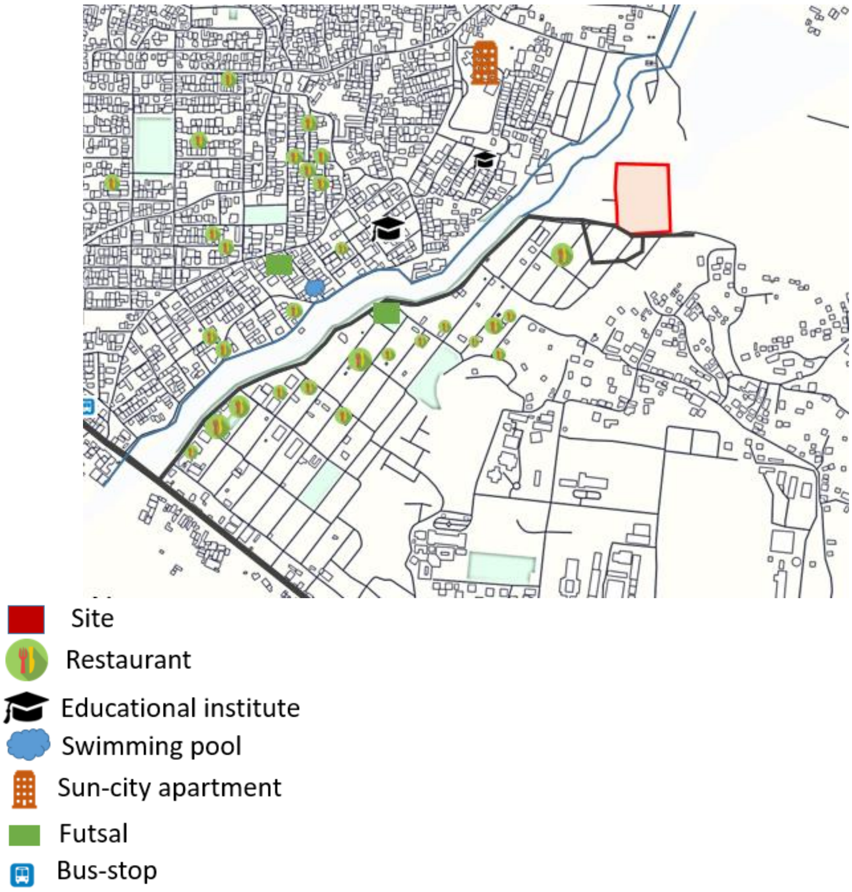
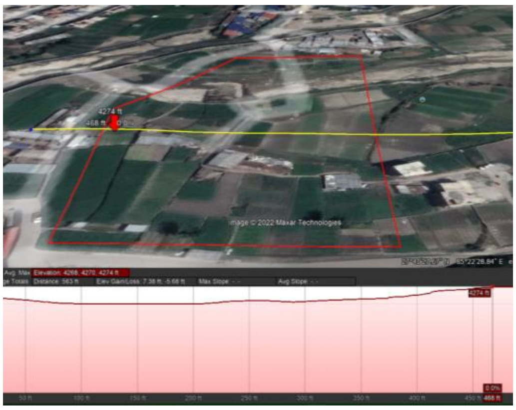


Figure 5. 2- Surrounding views

5.13.9 LAND TOPOGRAPHY

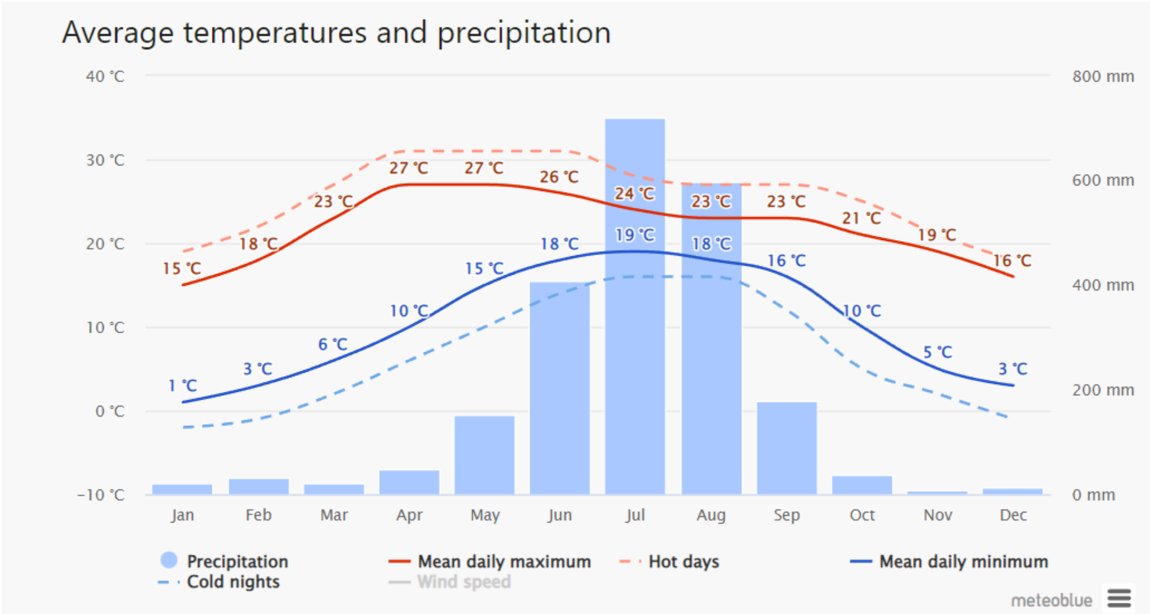
The land has slight contour with gentle slope towards north-west direction.



5.13.10 CLIMATIC ANALYSIS

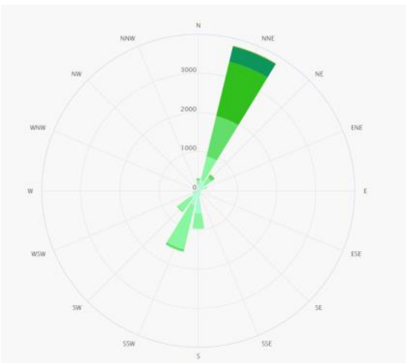
The climatic analysis of that location allows us to design a building that will withstand the climate and provide a comfortable environment for the structure's users.

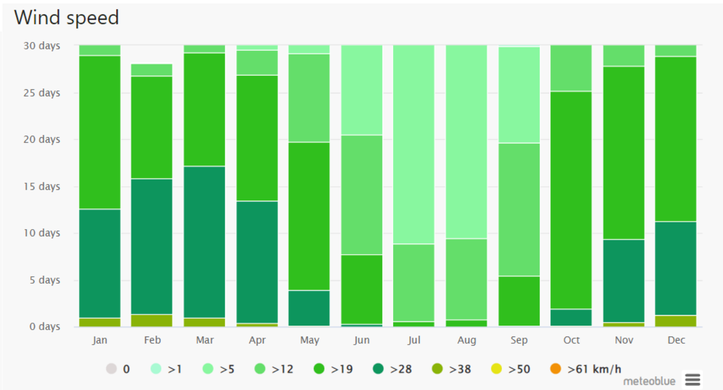
Temperature and precipitation:



Windrose and speed:

Wind is blowing from South-West (SW) to North-East (NE)





5.14 SWOT ANALYSIS

STRENGTH

- Enough Solar Gain
- Good residential area being developed around
- Easy accessibility
- Close proximity to commercial area
- Workable land topography

WEAKNESS

- Site is yet to be popular and well known all over kathmandu valley
- Agricultural lands of northern stretch of the site

OPPRTUNITIES

- Good Infrastructure
- Good visual links
- Fresh Environment
- Existing water drains can be used for water collection and treatment

THREATS

- Flood during monsoon season.
- Tall structure of the farm may affect surrounding agricultural farm.

5.15 BYE-LAWS

Set-back = 3m

ROW of road at south = 6m from CL of road

ROW of river at north = 20m

Ground coverage = 40%

6 DESIGN DEVELOPMENT

6.12 CONCEPT

- **SYMBIOSIS >> MUTUALISM**

Symbiosis is a broader term that encompasses a variety of relationships, including mutualism. Mutualism refers specifically to a type of symbiotic relationship in which both organisms involved benefit from the interaction. In contrast, symbiosis can refer to relationships that are mutually beneficial, neutral, or even harmful to one or more of the organisms involved. Thus, the concept of mutual symbiosis is taken for the design development of the project with an aim to solve prevailing food insecurity in the valley and growing impact of building construction to nature through architectural interventions.

Process:

Symbiosis is a concept that has gained popularity in recent years as a way to design structures that are sustainable and harmonious with nature. By incorporating the principles of symbiosis in our designs, we can create structures that are not only aesthetically pleasing but also provide a host of benefits to the environment and its inhabitants.

One of the main advantages of designing mass structures based on symbiosis is that it allows us to create self-sustaining ecosystems that can thrive without any external input. This can be achieved by incorporating green roofs and walls, which provide a habitat for plants and animals, and help to purify the air and water. Additionally, renewable energy sources such as solar panels and ecofriendly and energy efficient materials can be integrated into the structure to provide a sustainable source of energy.

Application of symbiotic concept:

The idea is to portray symbiosis between followings: -

1. Human and nature

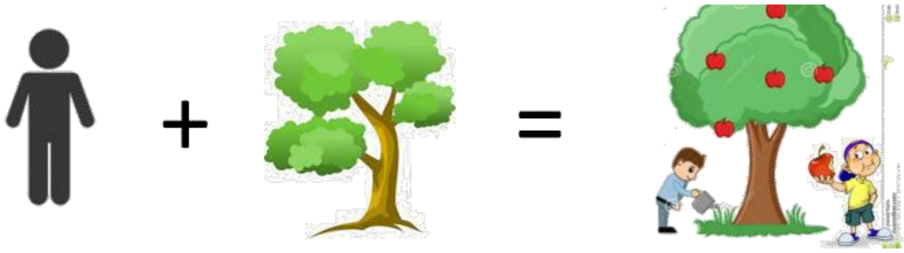
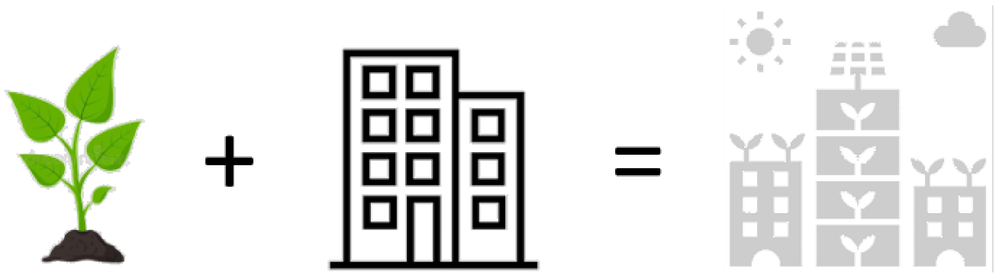


Figure 6.1-Relation between human and nature

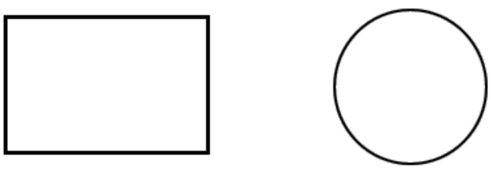
Nature supports human wellbeing & people must be responsible for conservation of nature. Looking at the current scenario, the growing distance of cities from agricultural land has broken the connection of people and nature. So, the project aims to build high tech urban farm within an urban territory in order to bring food near to its consumption.

2. Agriculture and architecture



In recent years, there has been growing concern of decrease in agricultural lands with increase in no. of buildings. This has resulted in food insecurity in the city. So, symbiosis of agriculture and architecture through hi tech urban farm will create vertical space for plants to grow and create energy efficient green buildings.

3. Old and new architectural forms and materials



Agricultural farms of the valley are found to have rectangular form and plan. The rectangular plan creates functionally flexible space. Whereas, the literature review and research shows that circular shape is the shape that allows maximum intake of sunlight. The major vertical farm is made circular while other supporting facilities are given rectangular form.

Similarly, existing building materials like brick, bamboo, steel and concrete are used along with new building material, CLT panels. The main benefit of CLT over other traditional construction materials is that it has huge savings in carbon.

Design Philosophy:

As Norman Foster once said, "As an architect, you design for the present, with an awareness of the past, for a future which is essentially unknown." Designing mass structures based on symbiosis is one way we can ensure a sustainable future for generations to come.

Hierarchy principle of design

In order to create visual emphasis on farming block of the vertical farm, principle of hierarchy by shape is used in the design development.

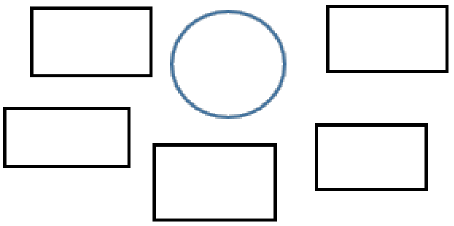


Figure 6. 2- Hierarchy by shape

6.13 DESIGN APPROACH

- **Design around center plaza**

Central plaza is created to act as major interactive and circulation space. The plaza is surrounded by supporting facilities with direct access of each facility from the plaza. Then, programs are arranged based on the flow of people and degree of privacy required in each program.

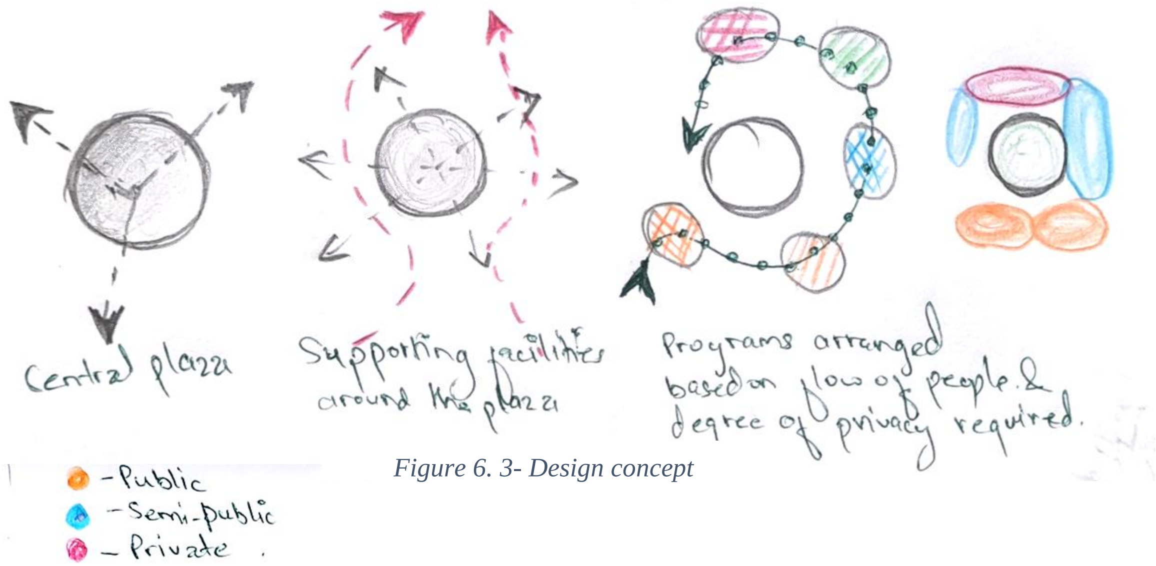
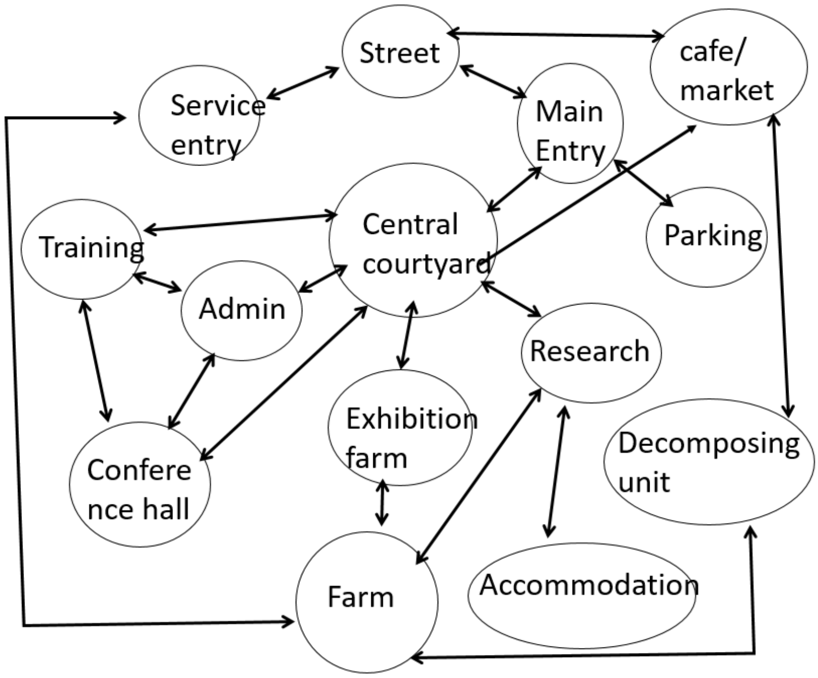


Figure 6. 3- Design concept

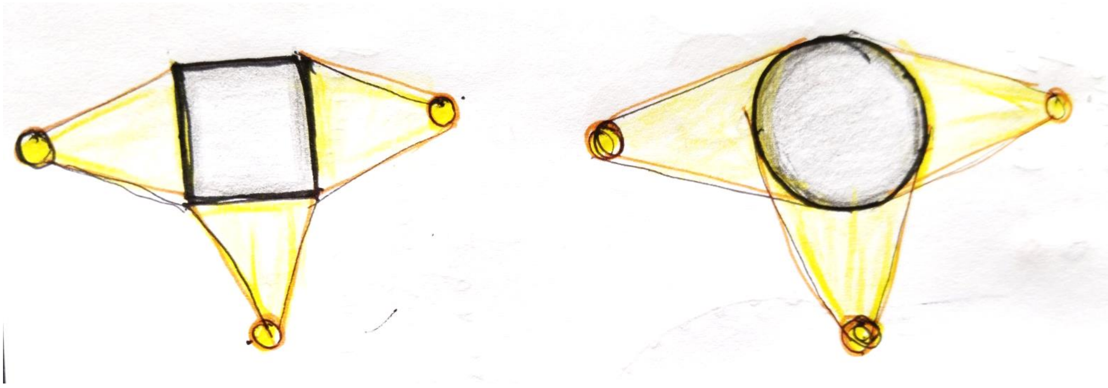
- **Space allocations and connections**



Various functional spaces required for the project are listed and required connections between those spaces are then visualized through bubble diagrams.

- **Form and solar impact**

The shape was designed or oriented to get the most natural sunlight, which was essential for the agricultural plants. From the figures below, it is clear that sunlight incidents on larger surface area in circular shape that in square or rectangular shape. So, circular shape and form is taken for designing vertical farm to have more light penetration into the building.



- **Zoning and planning**

The horizontal zoning was then carried out with respect to the diagonal axis. The building's position is then determined in response to the site. The positioning and orientation are done to make the most of the wind and natural light. The farm land is oriented so that the majority of it faces the south. The building can achieve cross ventilations with the use of the wind direction. This effectively mitigates the stack effect that takes place inside the atrium.

Also as major access to the site is from the south-west road, south west side of the site is considered as major visual point. So, visual axis is made from this point to far end of the site forming a diagonal axis as shown in the figure below.

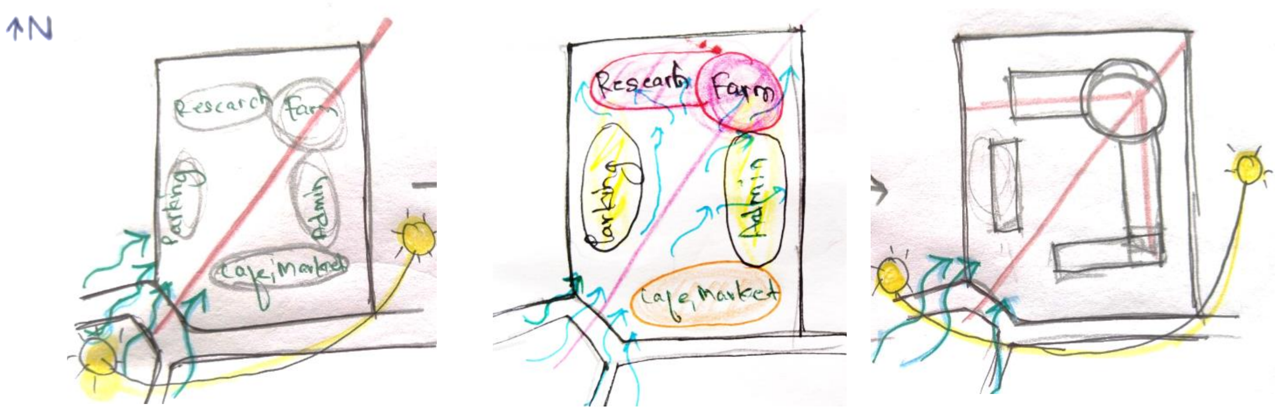


Figure 6. 4- zoning along diagonal axis

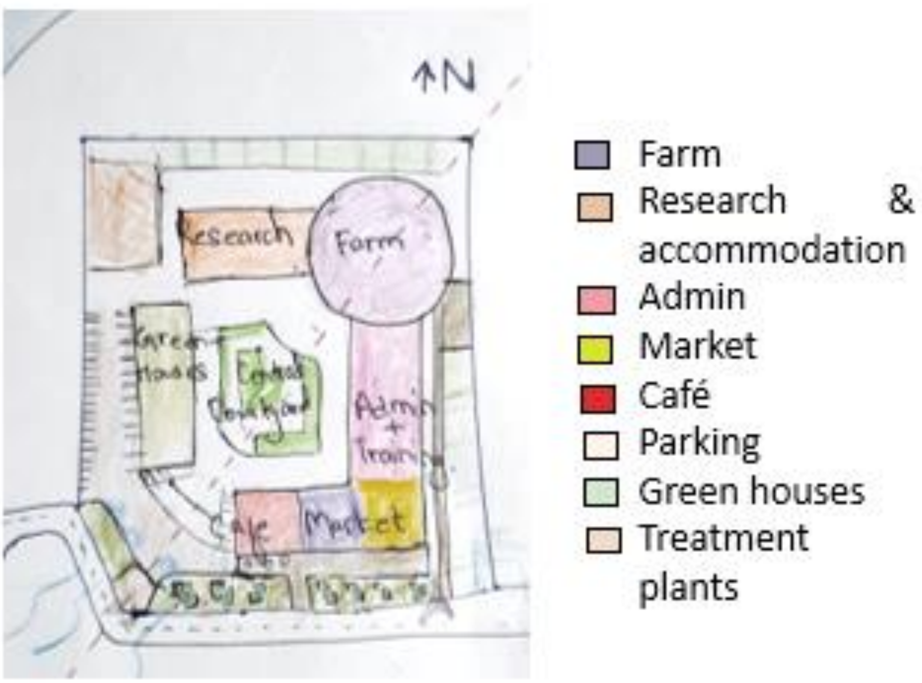


Figure 6. 5-Conceptual Plan

Vertical zoning:

The building is then divided vertically according to their uses. A fish tank or fish farm in the basement or ground level of the structure is a basic necessity for a vertical farm. The placement of the fish tank on the ground level was the initial step in the development. Above floors consists of hydroponic farms for growing green vegetables, cauliflower, cabbage, strawberries, mushroom, etc. while aeroponic farm is placed at top floor.

Further the building is divided into Public, Semi Public and Private Zones. Public zones consist of agro-market, café and outdoor plaza. Semi-public zones consist of admin, training units, public oriented farms and exhibition spaces. Public zones consist of research labs, core farming units and accommodations.

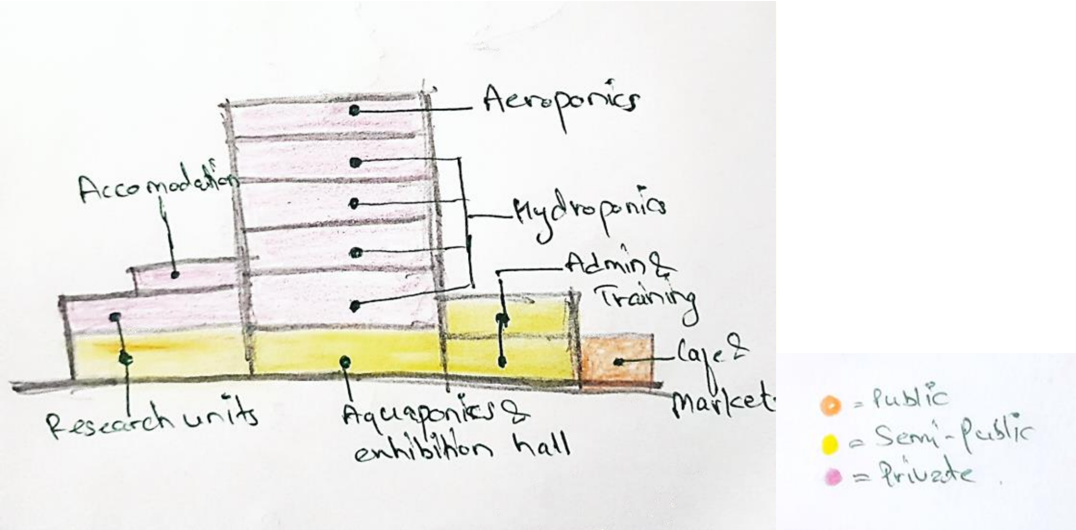


Figure 6. 6- vertical planning concept

➢ **Form development**

A diagonal axis of the site taken as main visual axis. Then, building blocks arranged on both sides of the axis. Height differences of the blocks are made considering solar path, wind direction and proximity with the road so that each blocks get proper sunlight and air circulation.

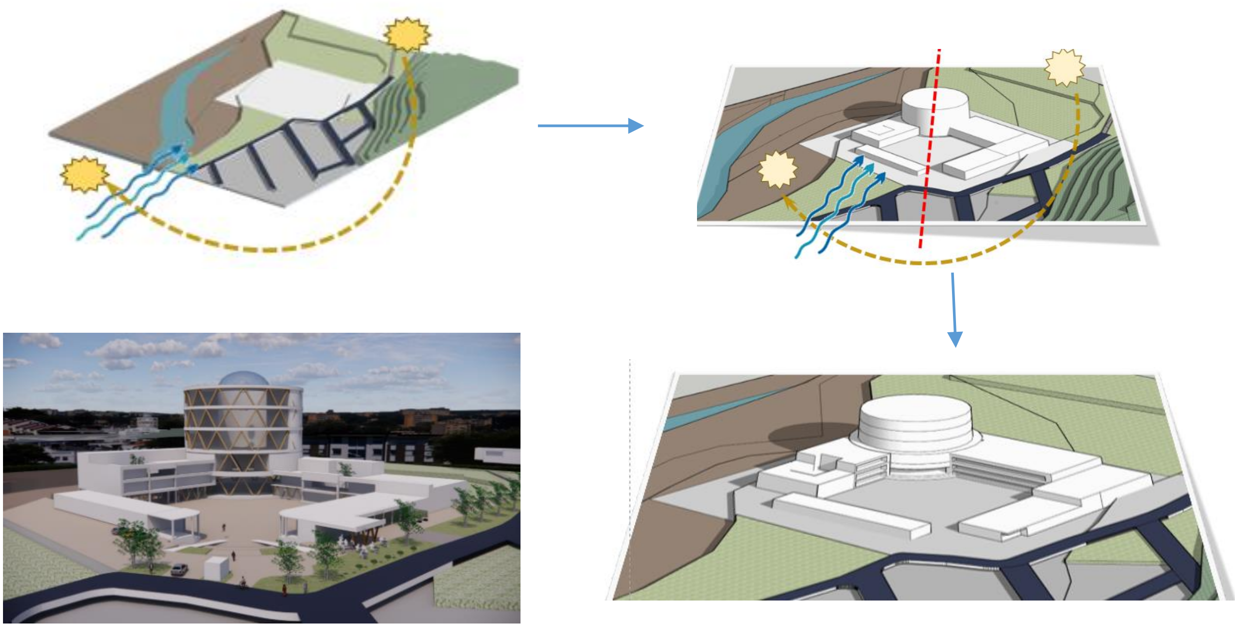
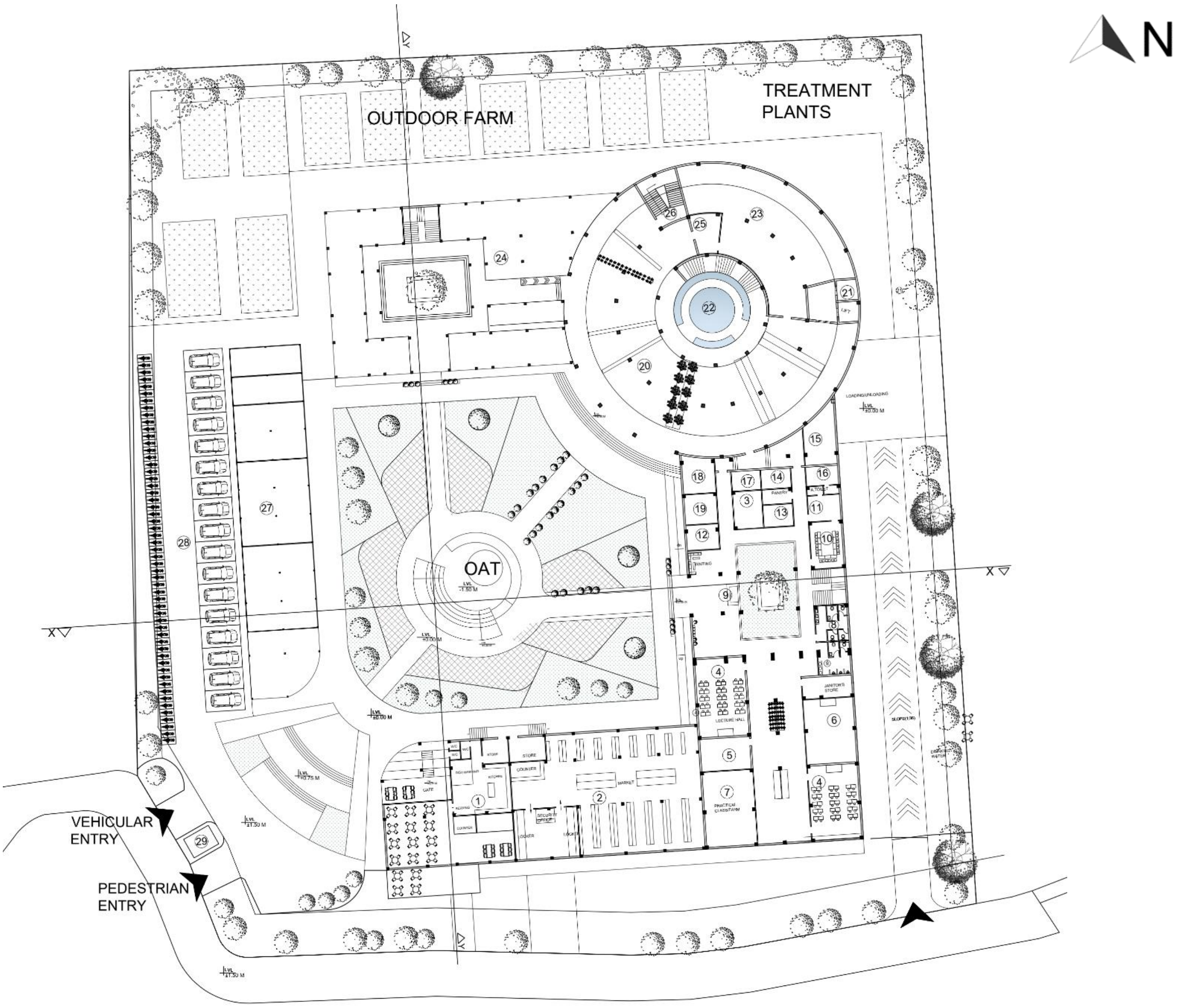


Figure 6. 7-3D visualization

7 PLANNING

7.1 MASTER PLAN

As seen in the final master plan, the pedestrian entrance and vehicular entrance is provided from the diagonal corner (south-west) of the site along the main visual axis. Service entry is provided from the same primary road at south-east corner of the site which leads directly to backside of farming block. The street side plaza area consists of guard house at the entrance which serves for both pedestrian and vehicles. The outdoor plaza alongside the road consists of outdoor seating spaces for general public, physically and visually connected with café and market. The central plaza with amphitheater acts as heart of the agriculture center that connects admin area, research units and farming units. Ground floor of farming block and green house are dedicated to visitors.



LEGENDS

1. CAFETERIA
2. MARKET
3. STAFF ROOM
4. LECTURE ROOM
5. EQUIPMENT STORE
6. DEMONSTRATION ROOM
7. PRACTICAL ROOM
8. WASH ROOMS
9. RECEPTION
10. MEETING ROOM
11. EXECUTIVE HEAD'S OFFICE
12. LOGISTIC DEPARTMENT
13. MANAGER'S ROOM
14. CHANGING ROOM
15. ELECTRICAL AND MECHANICAL ROOM
16. DIRECTOR'S OFFICE
17. CONTROL ROOM
18. ACCOUNT SECTION
19. MAINTENANCE DEPARTMENT
20. EXHIBITION HALL
21. SERVICE LIFTS
22. AQUAPONICS
23. PUBLIC ORIENTED INDOOR FARM
24. PUBLIC ORIENTED FARM
25. SANITIZING ROOM
26. FIRE EXIT
27. GREEN HOUSE
28. PARKING
29. GUARD HOUSE

MASTER PLAN (SCALE= 1:500)
SITE AREA: 14286.6325 SQ.M
PLINTH AREA: 4429.46 SQ. M
GROUND COVERAGE: 31.01%

7.2 FLOOR PLANS

7.2.1 FIRST FLOOR PLAN

The first consists of semi-public spaces which are accessible to dedicated publics only. Library, practical and theoretical training rooms of admin block is accessible to staffs and public enrolled in the training programs provided by the agriculture center.

The 1st floor of research is more private in nature. Researchers, staffs and people related with the research works are allowed in this area. Central courtyard with open lounge at south side acts as break out space that connects offices of scientists at west side and research labs at east and north side.

Central circular block consists of mycology lab, mushroom farm and storage. The planning is done based on the flow of material and degree of sanitation required in each area.

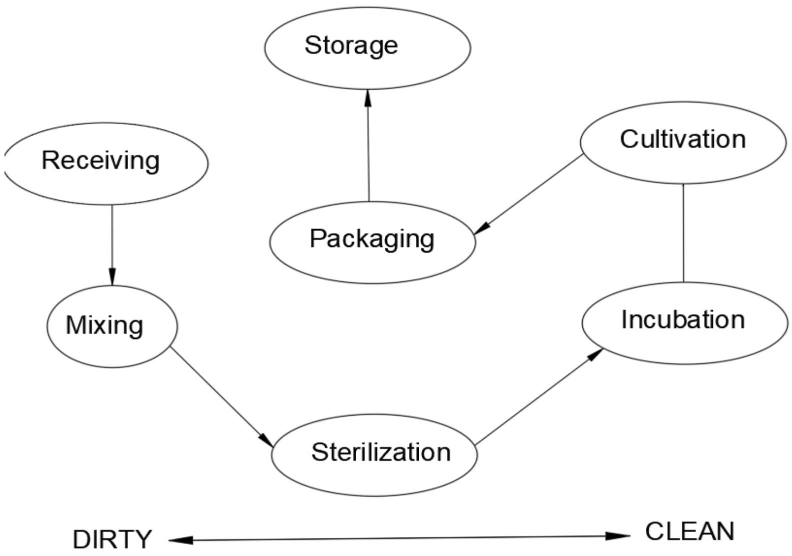


Figure 6. 8 - Operational process of farm

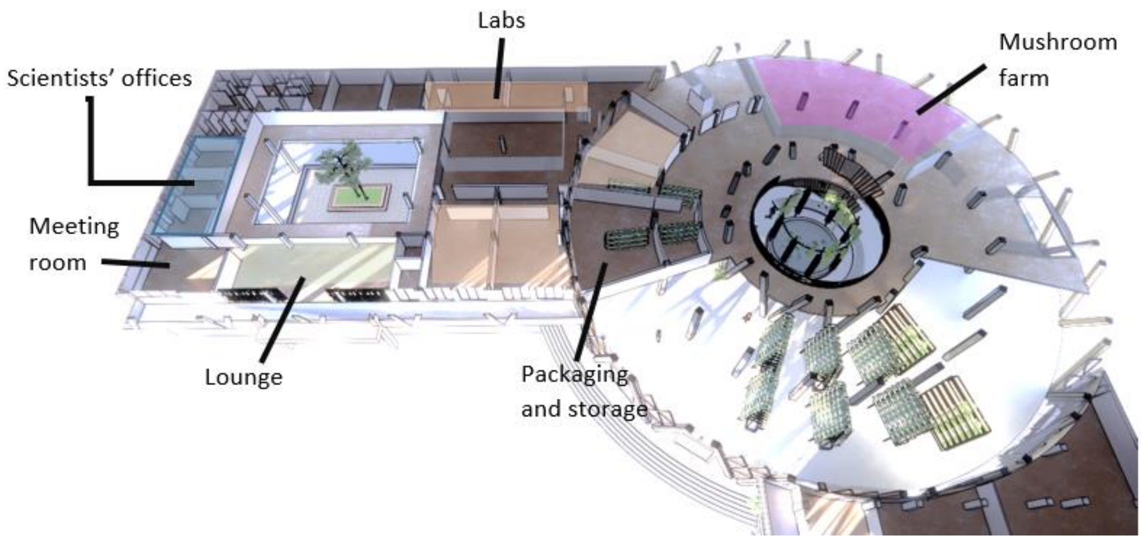
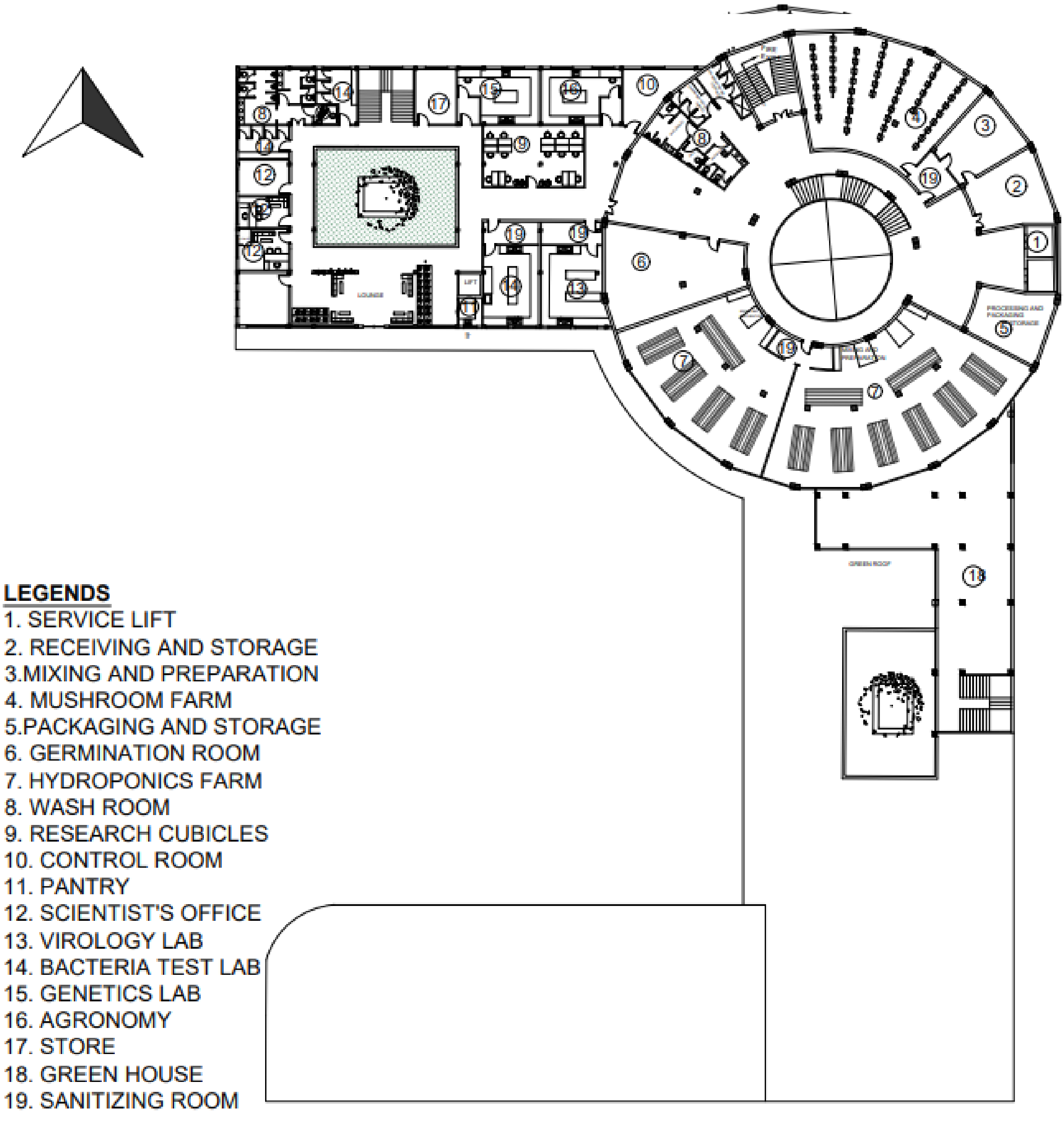


Figure 6. 9 - Research and farm spaces of 1st floor



7.2.2 SECOND FLOOR PLAN

Second floor of admin unit consists of green house for vertical farming and roof garden. The circular unit consists of mushroom farm and supporting facilities of mushroom farm as in first floor. The 2nd floor plan of research unit is similar to that of 1st floor.

7.2.3 THIRD FLOOR PLAN

The third floor consists of accommodation for staffs and researchers and mushroom farm. Planning of functional, circulation and service spaces is same as in 1st and 2nd floor.

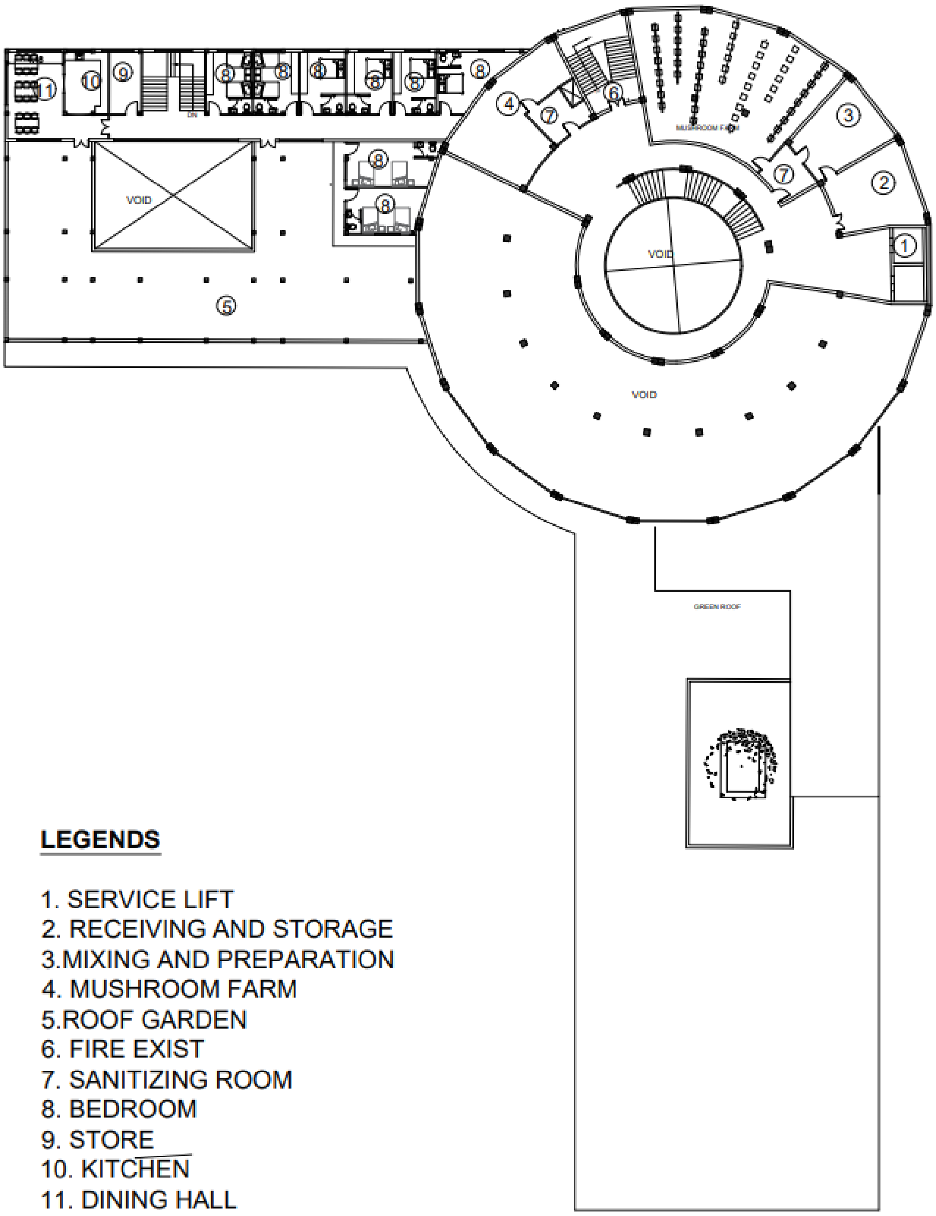


Figure 6. 11- 2nd Floor Plan

7.2.4 UPPER FLOOR PLANS

The fourth, fifth and sixth floor comprise of similar plans consisting of core farming systems like hydroponics and aeroponics with their supporting facilities like germination room, storage and control room.

8 DESIGN DETAILS

8.1 USE OF BIOPHILIC DESIGN PRINCIPLES

➢ Visual and physical connection with nature

Connection of functional spaces with nature visually is made through orientation of openings of indoor spaces towards green outdoor spaces. Courtyard with trees and balconies with farming modules helps to create physical and visual link of indoor spaces with nature and greenery.

Figure 8. 3- Central circulation space with view of atrium

Figure 8. 2- Street view

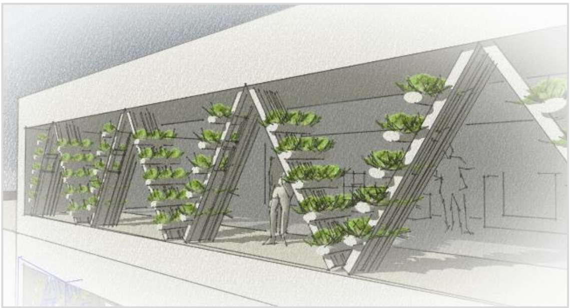


Figure 8. 1– View of balcony

➢ Light and shadow play

Use of louvers as shading device and farming modules helps to create light and shadow play. It not only creates visually beautiful patterns but also gives sensation of natural time to inhabitants.

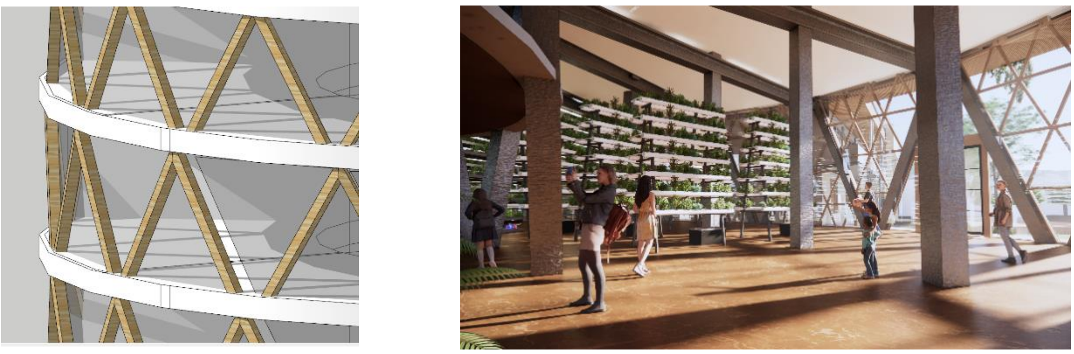


Figure 8. 4- Triangular frames creating shadow patterns

➢ Use of eco-friendly building materials

Along with concrete and steel, cross-laminated timber panels are employed as structural and architectural elements. CLT systems are structurally equivalent to steel and concrete, yet they are lighter. The CLT technology is appropriate for projects with weak soil because it allows for smaller, less expensive foundations. According to studies on life cycle assessments, CLT has a lesser overall environmental impact than other construction materials. Moreover, CLT preserves carbon and emits fewer greenhouse gases when it is manufactured.

Figure 8. 5- Glulam and CLT structure

➢ Use of water element

Aquaponics for commercial farming as well as exhibition show case is installed in the center exhibition hall of ground floor.

Figure 8. 6- Exhibition hall with aquaponics showcase

8.2 PRODUCTION PROCESS

A number of steps are included in the farm's plant producing process. The seed after laboratory testing is prepared in a stray with the appropriate amount of water added. The seed is then moved to a floating tray housed in the seed storage chamber. After germination, the seeds are kept in growing systems like NFT system, vertical aeroponics system and aquaponics system, where the roots can absorb the proper nutrients to aid in growth. A control panel regulates the temperature and degree of fertilizer supply required for the growth of the plants. The farm has a nutrient tank where extra nutrients from outside sources, such coco peats, are mixed with nutrient-rich water from a fish tank on the bottom floor.

These systems can be used to grow a variety of fruits and vegetables. The harvested goods are then stored in a storage area until being supplied to retailers and other groups. The diagram below also explains the procedure.

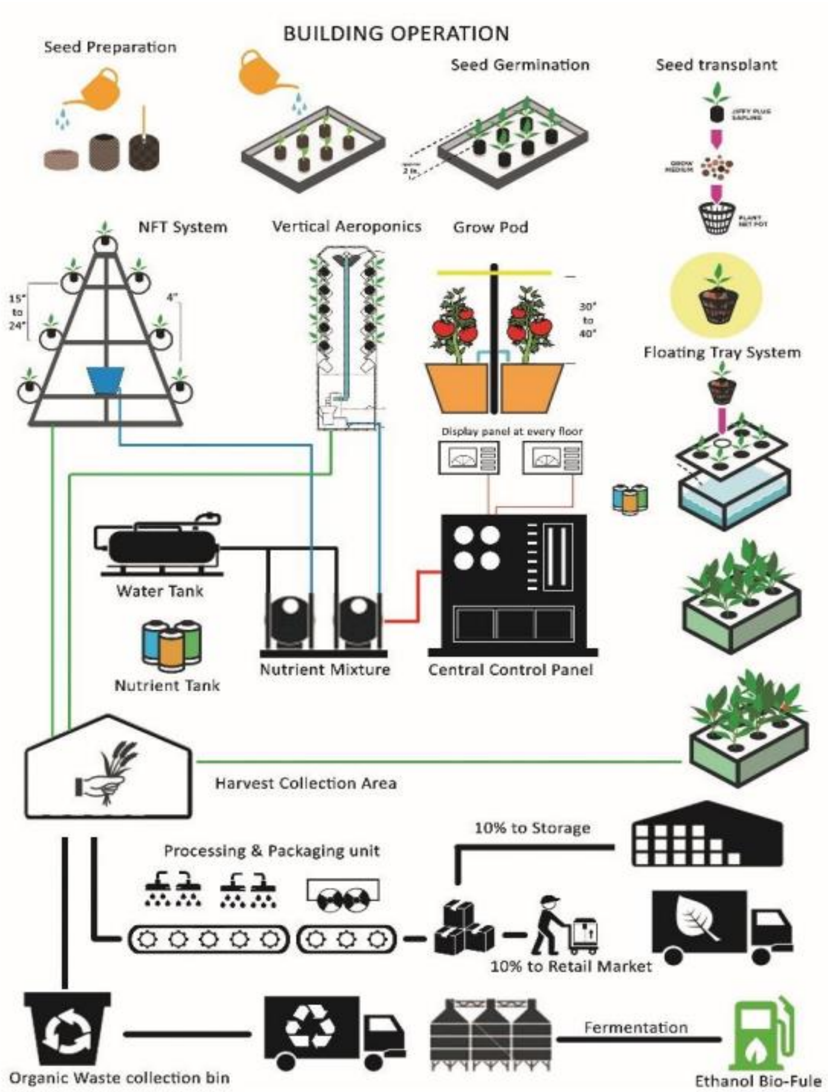


Figure 8. 7- Production process, (Adhikari, 2019)

8.3 PRODUCTION RATE

Regardless of the season, vertical farming enables more efficient, controlled production. In comparison to conventional farming, one acre of vertical farming can produce the same amount of food as 10 to 20 conventional acres.

Calculation of mushroom production:

5 bags in one stand can produce 30 kg of mushroom in 3 months

An area of 145 m^2 can accommodate 52 bags

Therefore, 4 no's of 145m^2 mushroom farm produce = 52 X 30 X 4 = 6240 kg/ 3months

Calculation of other fruits and vegetables with reference of tomato production:

1 sq. m can host 3-4 plants of tomatoes.

1 plant can bear 10-20kgs of tomatoes.

So, 1 sq.m can produce 30-60kgs.

With the year round production, the 3020 sq.m of farm can produce around 147 tons of vegetables.

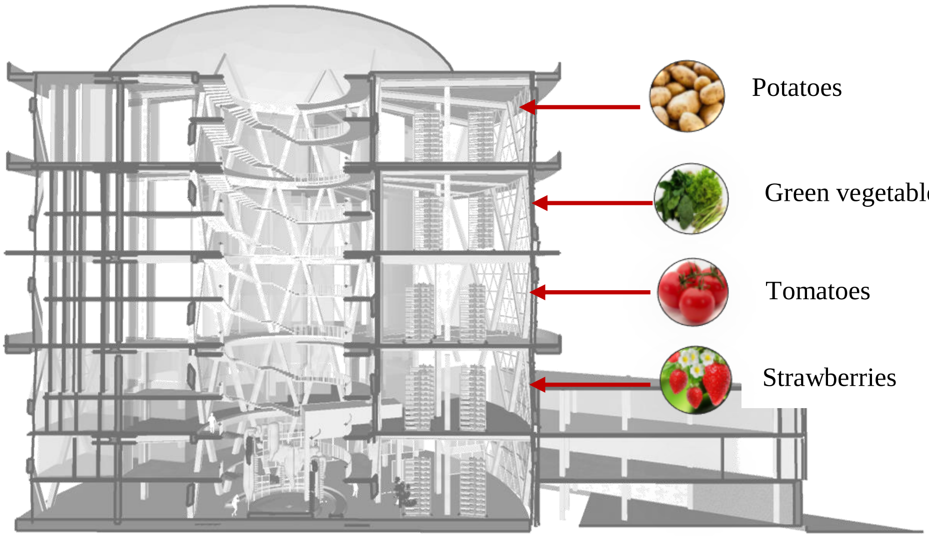


Figure 8. 8- Building section showing vertical farm for various fruits and vegetables

8.4 GROWING SYSTEMS

The farming systems include the Nutrient Water Tank, LED lighting, and several growing techniques like the NFT System, Vertical Aeroponics, and Grow Pods System. The NFT System consists of metal tubes or perforated pipes arranged in such a way that water is conserved by flowing with gravity. According to the gravity flow, the water flows from the top tube to the bottom.

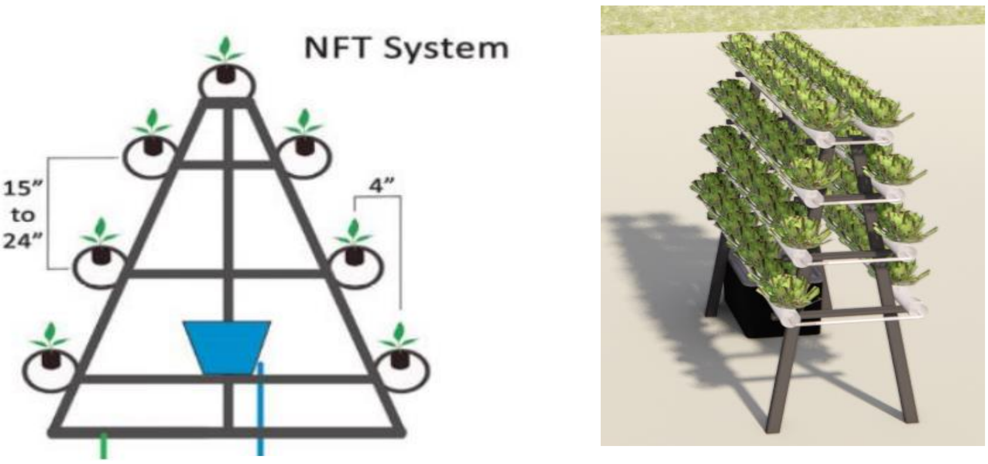


Figure 8. 9- Nutrient Film Technique, (Szen, 2017)

In vertical aeroponics, the roots use the moisture in the water to absorb the nutrients the crop needs to flourish. Moreover, it uses less water than traditional farming methods.

Figure 8. 10- Vertical Aeroponics, (Tim Heath, 2014)

The Grow Pods systems utilize a simple hydroponics mechanism in which the operation is carried out by dipping the roots in nutrient-rich water. The grow pods help to reduce the amount of space needed for farming while increasing output.

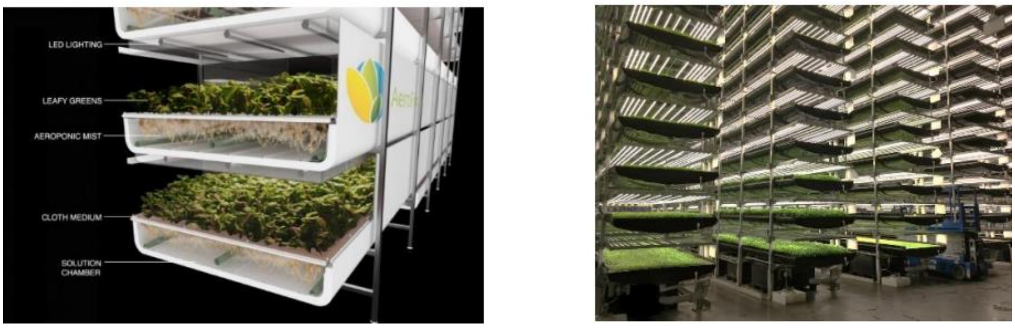


Figure 8. 11- Grow pods system in trays, (ToyokiKozai, 2016)

The required amount of nutrients and artificial light used for farming purpose is set by the control panel. The most effective LEDs for crop production are blue and red ones since they emit an adequate amount of PAR waves, which are needed for photosynthesis. The intensity of the light ranges from 4100 to 16000 Lux. Solar energy can also be used as a source of lighting, which helps the entire structure use less electricity.

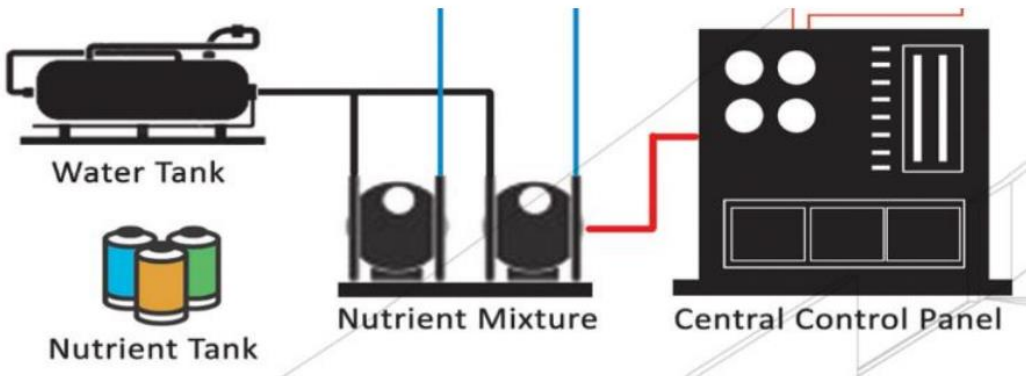


Figure 8. 12- Control panel

Figure 8. 13-LED grow lights, (ToyokiKozai, 2016)

PHYSICAL MODEL

Front View

Main Entry

Aerial View

9. STRUCTURE

The structure of the building is designed as combination of moment frame system and dia grid system. The 36m tall circular section of the building is designed as dia-grid structure of steel. The rectangular wings of smaller height are designed as moment frame structure of glulam timber. The infill wall for both systems is of CLT Panels.

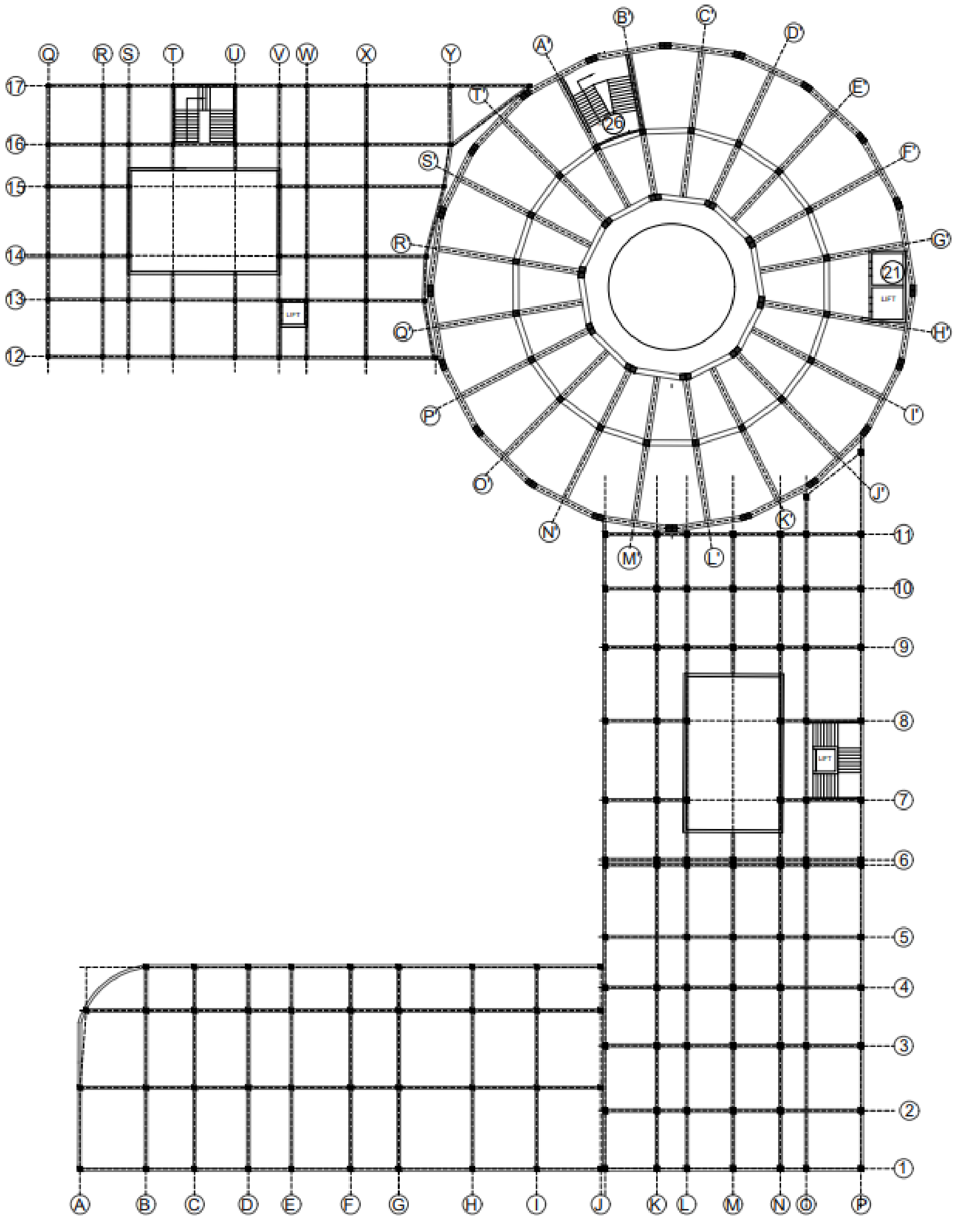


Figure 9. 1- Beam and column layouts

9.1 DIA GRID STRUCTURE

A diagrid structure is a type of space truss that effectively reduces shear deformation by carrying the lateral load via the axial action of diagonal members. Tall building structural designers are interested in the structurally efficient behavior produced by the employment of bracing in perimeter structures. When resisting lateral and gravitational loads, the bracing angle is crucial. Much less structural steel is required when using this kind of structural form. (Kamath, 2016) A diagrid structural system for tall buildings produces axial force along the column direction under horizontal load as a result of the inclined columns. This has the benefit of resisting horizontal wind load and seismic load and provides more design freedom, making a diagrid structural system for tall buildings an efficient new structure style for tall and super-tall buildings. (Chengqing Liu, 2017)

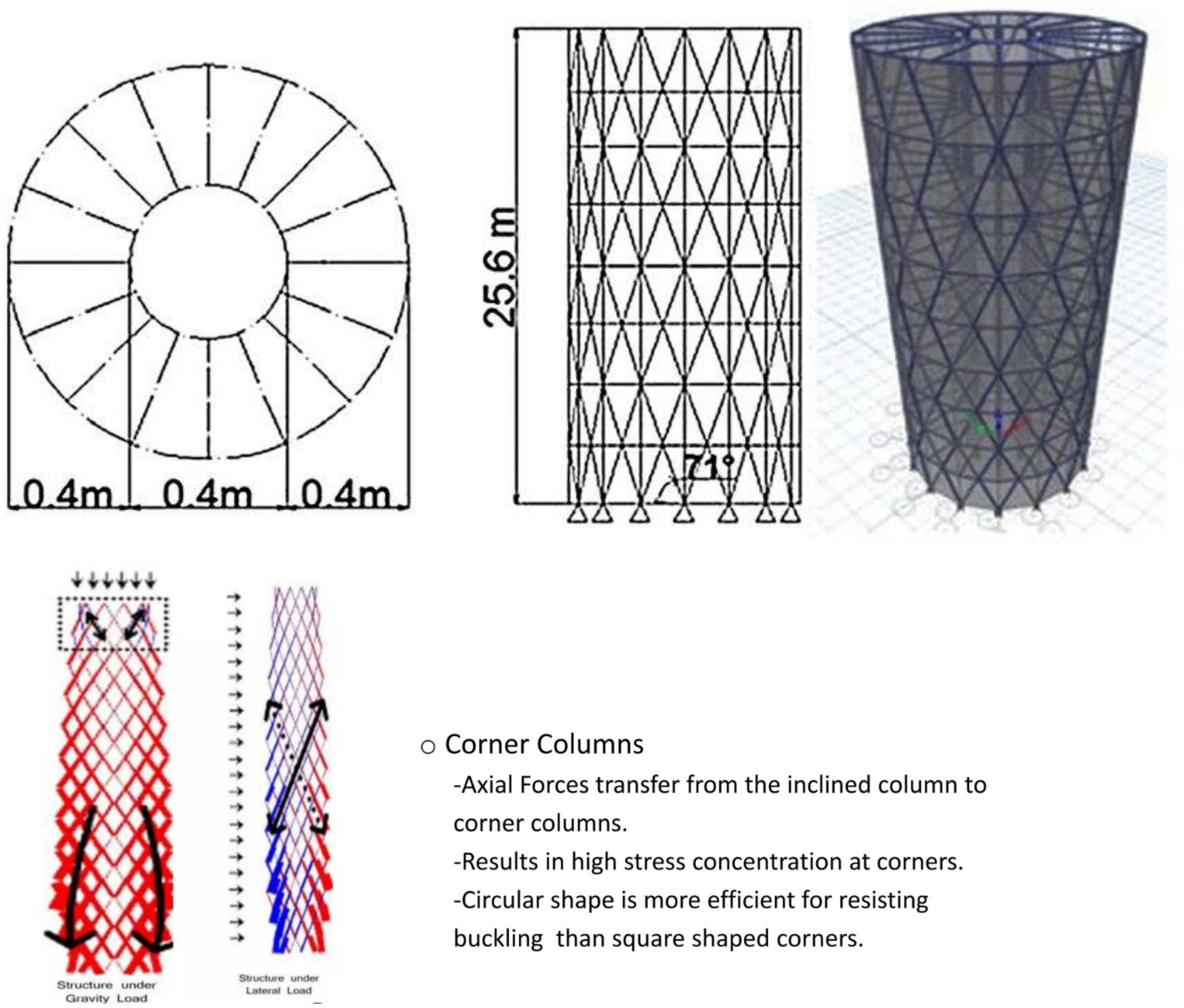
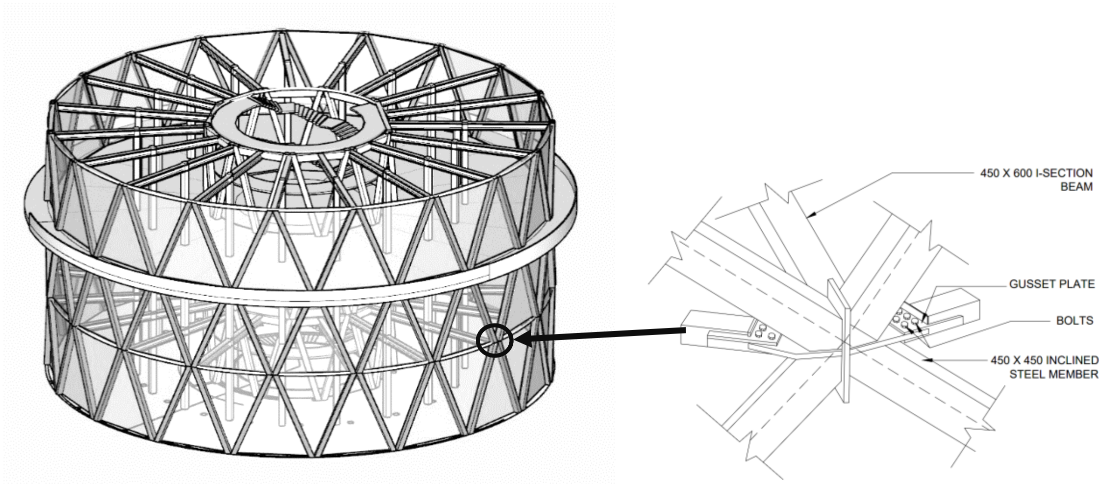


Figure 9. 2 - Arrangement of Structural elements and load transfer in circular dia grid system

Source: (Chengqing Liu, 2017)

Diagrid structure is used for the tallest block i.e. vertical farming block in order to minimize structural materials and create visually aesthetic structure. Arrangement of diagonal elements, columns and beams are done according to the above model, retrieved from literature study of research journals. The elements of exterior and interior circumference of the circular block is connected with vertical box columns and radial I-section beams as shown in the figure below. A short stub beam is used to connect I-beams to box-columns by bolted end plate connection.



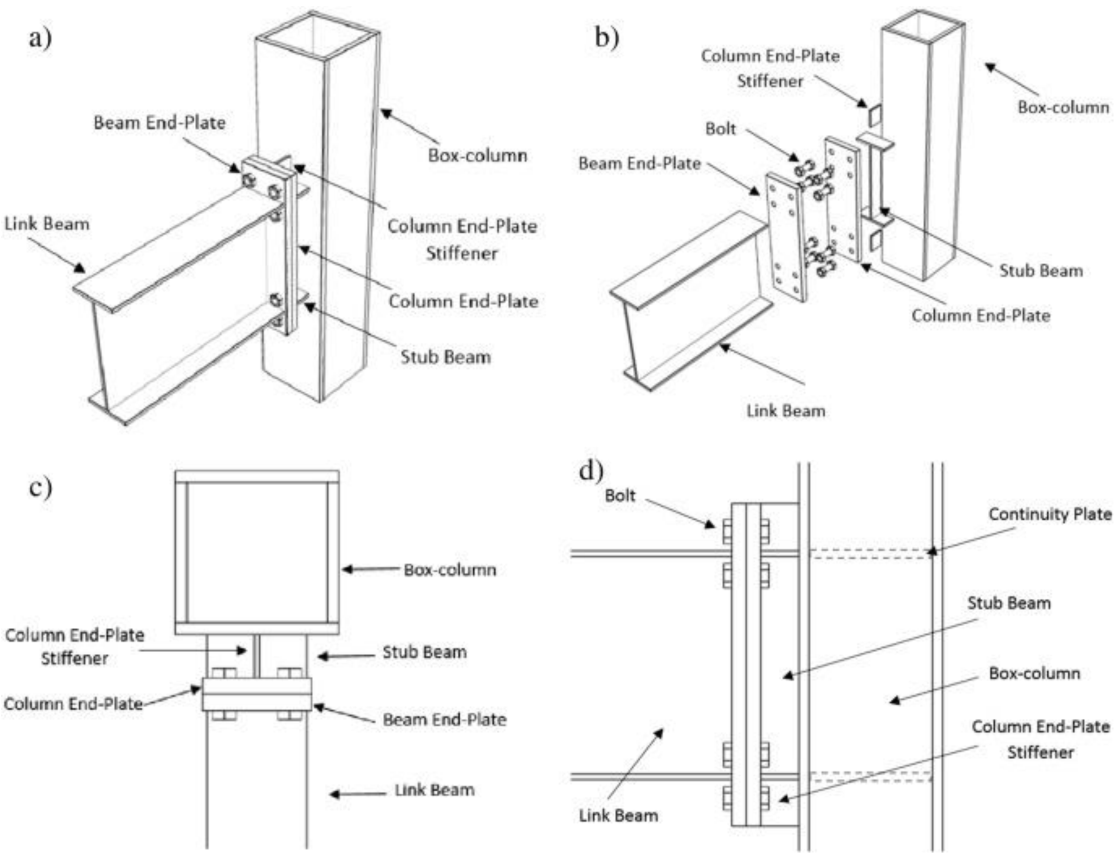


Figure 9. 3- Beam and column connection details

Source: *(Saeed Erfani, 2016)*

9.2 MOMENT FRAME STRUCTURE

The rectangular parts of the building are designed as moment frame structure. The structure comprises of glulam (Glue Laminated Timber) beams and columns with CLT (Cross Laminated Timber) panels as wall infill material.

CLT is comprised of layers that alternate at 90 degrees to one another, so it has the same two-way spanning properties as a concrete slab and is strong in both directions. The strong axis is the direction with the greatest number of layers orientated in it, while the weak axis is the way with the fewest.

Glulam is constructed using layers that are all oriented in the same direction, so it is frequently utilized for members that require strength in one direction such as columns and beams.

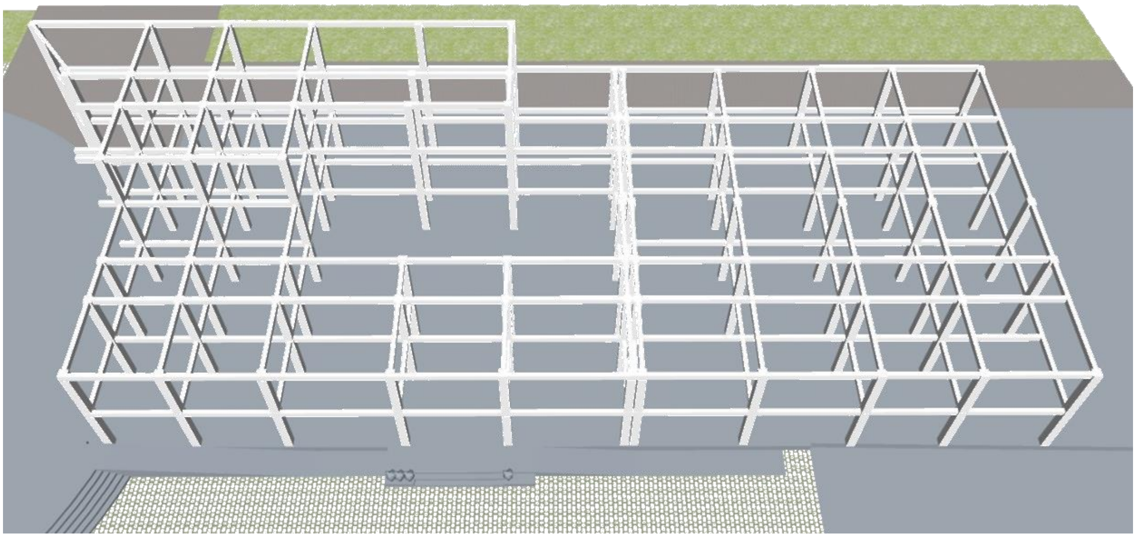


Figure 9. 4- 3d skeleton of admin and training unit

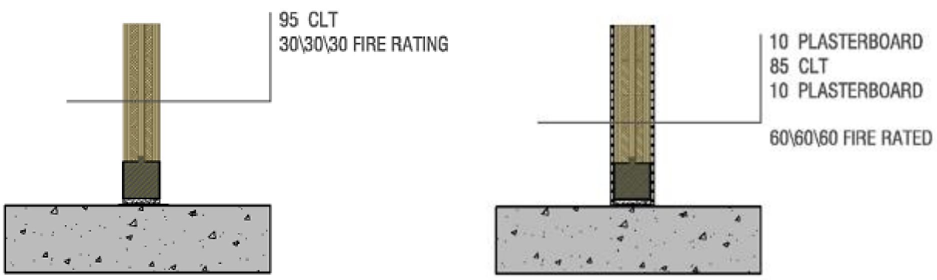
Benefits of Glulam and CLT structure:

1. Fast and light

CLT is lighter than conventional structural materials like concrete and steel, according to its proponents, making it safer and easier to construct with. Also, since waste can be collected and recycled more easily in a manufacturing setting, construction is typically neater.

2. Fire resistance

The CLT panel's outside layer chars during a fire, and for a while, this char's exterior creates a shield while preserving strength. Lining CLT panel with plaster board to add resistance.



3. Low carbon

CLT is considered to be a more environmentally friendly material than steel or concrete. The carbon footprint of mass timber constructions is, on average, 35% less than that of equivalent concrete buildings and approximately 50% less than that of steel structures, according to a recent study that modeled hundreds of various multi-storey building types.

Connection details

Any timber-framed structure's structural performance and serviceability depend on proper connecting details. It is crucial to take moisture-related wood expansion and contraction properties into careful consideration in order to avoid creating tension perpendicular-to-grain strains.

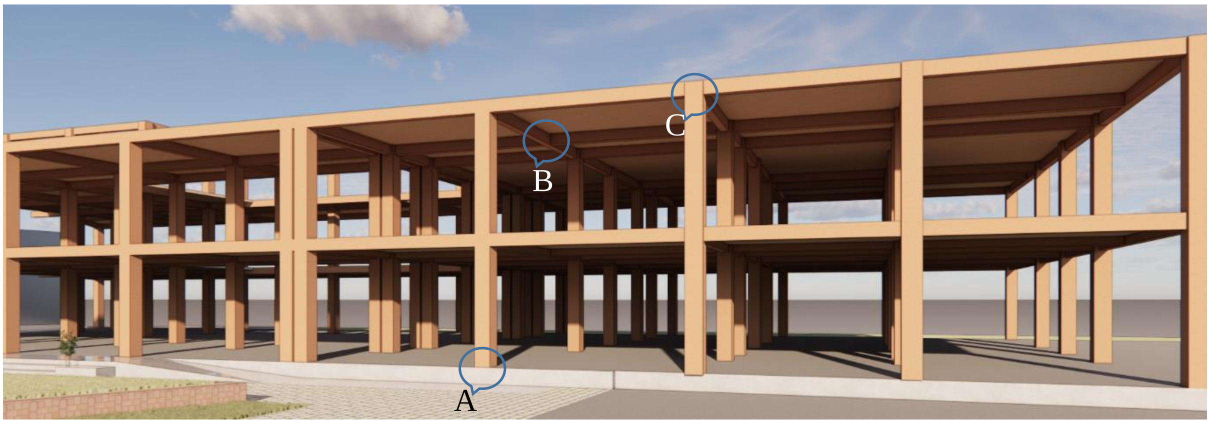


Figure 9. 9- Glulam beams and columns structure

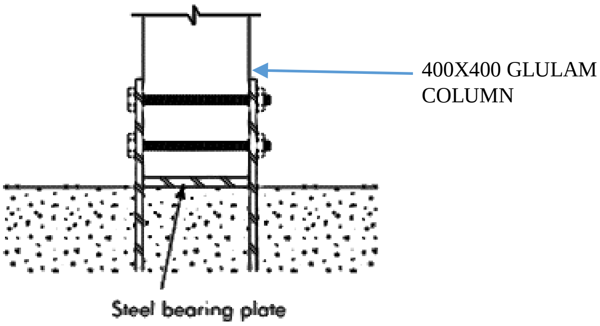


Figure 9. 8- Detail at A (Timber column to concrete base)

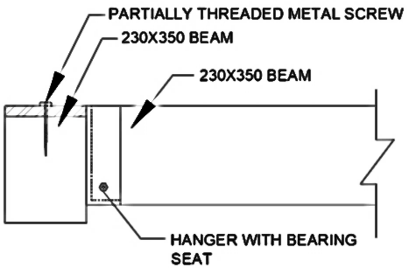


Figure 9. 8- Detail at B (Beam to beam connection)

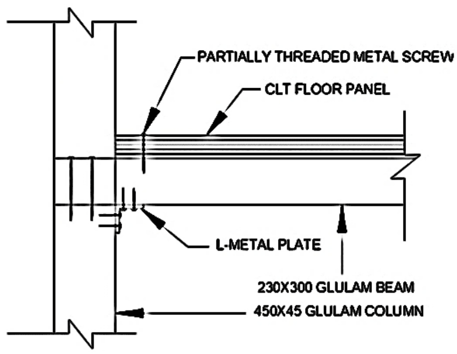


Figure 9. 8- Detail at C (Beam and column connection)

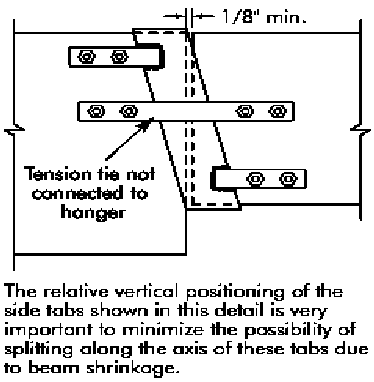


Figure 9. 8- Cantilevered beam connection

Source: 2005 Engineered Wood Systems, www.apawood.org

9.2 FOUNDATION

Since the site is located nearby manohara river and soil type is soft soil, combination of raft and isolated foundations is used. A raft foundation, often known as a mat foundation, is simply an uninterrupted slab resting on the ground that covers the whole footprint of the building, sustaining it and dispersing its weight to the ground. Isolated footings, also referred to as Pad or Spread footings, are frequently employed for shallow foundations in order to carry and disperse concentrated loads, such as those brought on, for instance, by columns or pillars.

The 36m tall circular structure will have raft foundation to effectively distribute its large load to larger area of the ground. While other rectangular structures of maximum 15m height will have isolated footings.

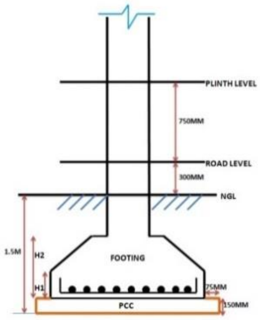


Figure 9. 11- Isolated footing

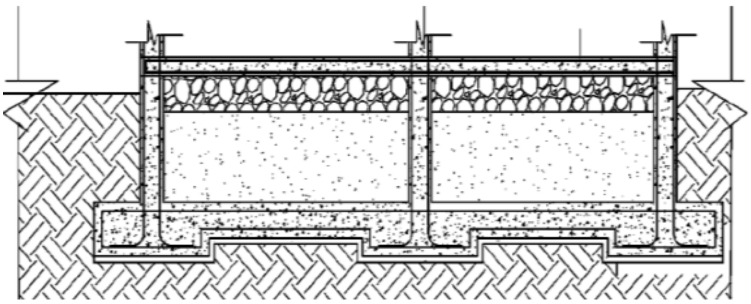


Figure 9. 11- Raft footing

10. BUILDING SERVICES

Building services play a significant role in the design process as well. It consists of both regularly utilized services and emergency services.

10.1 WATER SUPPLY

A calculation is first performed to determine the building's water requirement. The water demands calculation is shown below.

According to NBC 208:2003,

Water requirement for offices in urban area = 45 LPCD

Population in the building = 320

So, total water demand = 320 X 45 = 14,400 Liters/day

For farming,

Water requirement for plants per sq.m = 7 liters/day

Total farming area = 3770 sq.m

So, water required for farming = 3770 X 7 = 26,290 Liters/day

For fire hazards,

The required water storage = 50,000 liters according to NBC

Total water requirements = 14,400 + 26,290 + 50,000 = 90,690 liters

= 90.69 m^3

The total demand of water in the building is around 91,000 liters. This water can be achieved by making a boring plant near the building and collecting rain water. The boring water is then sent to the underground water tank, fish tank of aquaponics present in the ground floor and overhead water tanks present in the terraces of farming block, admin block and research block. Water demand for each block are separately calculated in order to find the appropriate sizes of each water tanks.

For circular farming block,

Water demand for farming = 7 X 3200 = 22,400 Liters = 22.4 m^3

Underground tank size = 3m X 4m X 2m = 24m^3

Water demand for users of the block = 70 X 45 = 3150 Liters= 3.15m^3

Overhead tank size = 1m X 2m X 2m = 4m^3

Total water demand = 25,550 liters

For research and accommodation,

Water demand = 85 X 45 = 3,825 liters = 3.825 m^3

Overhead water tank size = 1m X 2m X 2m = 4m^3

For green house,

Water demand = 400 x 7 = 2800 liters

Outdoor Water tank size = 1m X 1.5m X 2m = 3m^3

For admin, training, café and market units,

Water demand = 160 X 45 = 7425 liters = 7.425 m^3

Overhead water tank = 2m X 2m X 2m =8m^3

Combined capacity of all the tanks including 40m^3 fish tank present in ground floor = 24+4+4+3+8+50=94m^3

Water sources

1. Rain water harvesting

The process of collecting and storing rainwater with the aim of using it again during the dry season or during a drought is referred to as rainwater harvesting.

Below a calculation is shown for rainwater harvesting.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Average precipitation mm (inches)	44 (1.7)	53 (2.1)	68 (2.7)	128 (5.0)	236 (9.3)	454 (17.9)	952 (37.5)	715 (28.1)	384 (15.1)	90 (3.5)	15 (0.6)	29 (1.2)
Average precipitation days (≥ 1 mm)	5	9	12	19	25	29	31	30	29	15	4	4

Monthly average precipitation and precipitation days in Madhyapur Thimi, Bagmati Province, Nepal. Generated using Copernicus Climate Change Service information. Data for period from January 2017 to January 2022.

Figure 3- monthly average precipitation data of Madhyapur Thimi

Source: https://nomadseason.com/

Here,

The average annual rainfall = 3168mm

Total rainwater catchment area = 4420 m^2

Total rain water harvesting potential
= catchment area x run off coefficient x annual rainfall of area exposed
= 4420 x 0.7 x 1.4
= 4331.6 cu. m.
= 4331600 liters per annum
= 11,867.4 liters per day

Therefore, around 11000 liters' water required for the building is obtained from rain water.

2. Boring plant

Remaining required water is obtained from boring plant built near the building.

10.2 SANITATION

The disposal the waste is carried out in a network of manholes which reaches the septic tank then to the communal drain line.

The size of Septic Tank according to Indian Standard I.S. 2070 for the population of 300 people is Length (L) = 10m, Width (W) = 3.3m, and Depth (D) = 2m.

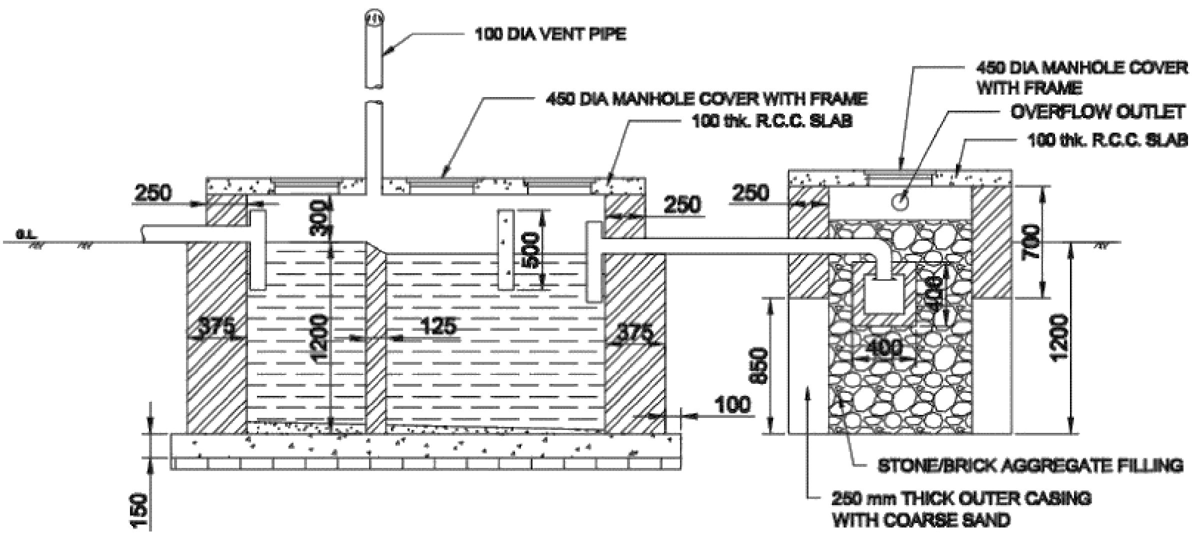


Figure 10. 1- Septic tank section details

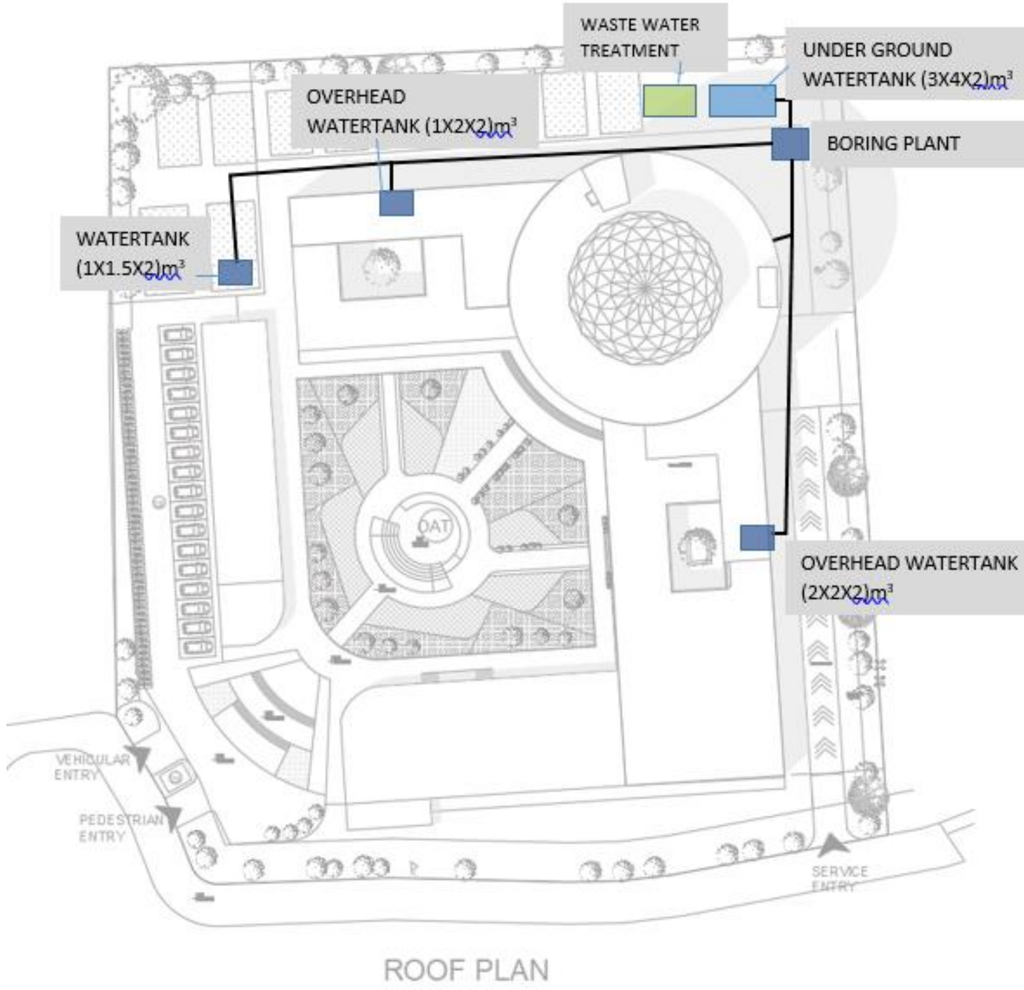


Figure 10. 2- Plan of water supply

Ground Water Recharge Pit

The extra runoff water or surface water are sent to ground water recharge pits present in the four corners of the plan. The pit overall depth is 1.5m in which the last 0.5m is filled with coarse aggregates.

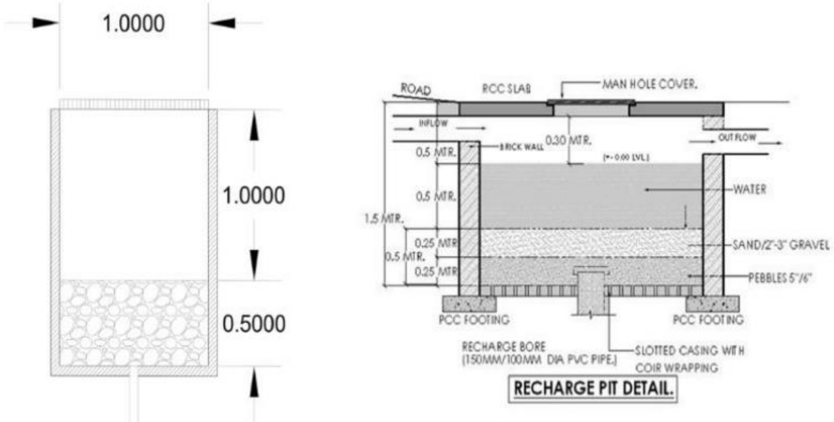


Figure 10. 3- Ground water recharge pit

11. SUSTAINABLE APPROACH

11.1 BUILT FORM

The structure of the building is also planned to maximize ventilation and sunlight. When all the air is drawn upwards toward the farm where the plants can absorb the necessary CO2 present in the air, the atrium that is present inside the building supports in creating the stack effect. The central opening at the top of the building is used to extract the remaining air.

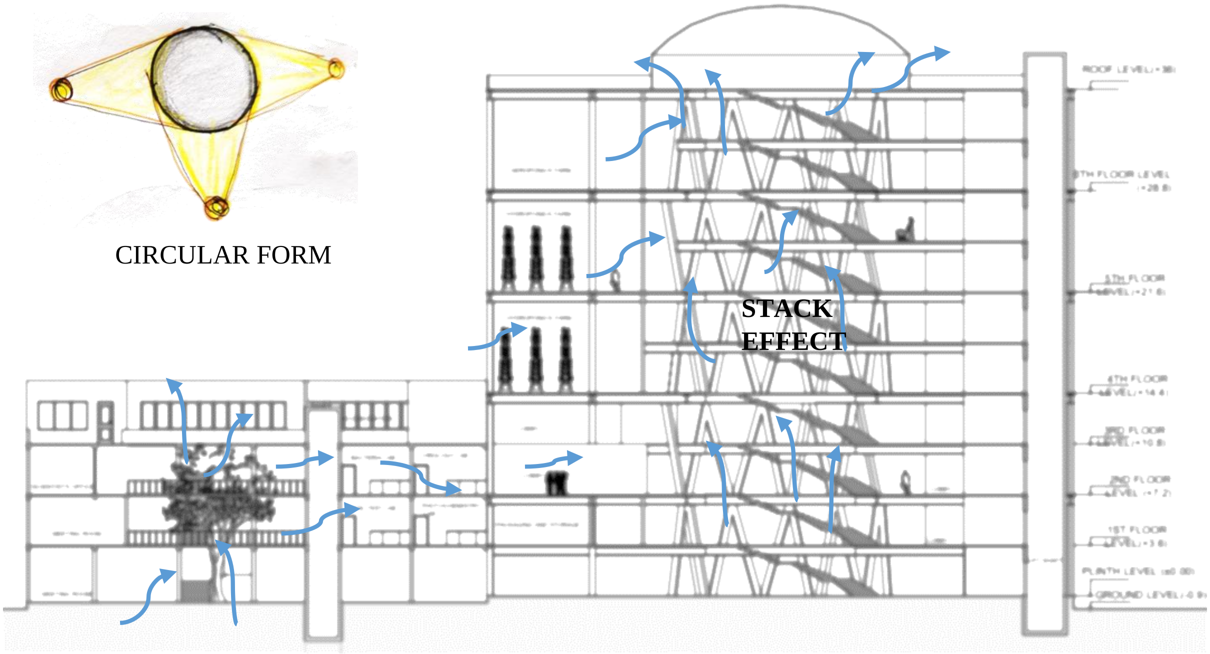


Figure 11. 1 - Building section showing stack effect

11.2 ROOF GARDEN

Any kind of vegetation planted on a building's roof is known to as a roof garden. In addition to serving as a beautiful feature, roof gardens also serve to improve the architecture, regulate temperature, offer leisure activities, and provide food and habitats for wildlife.

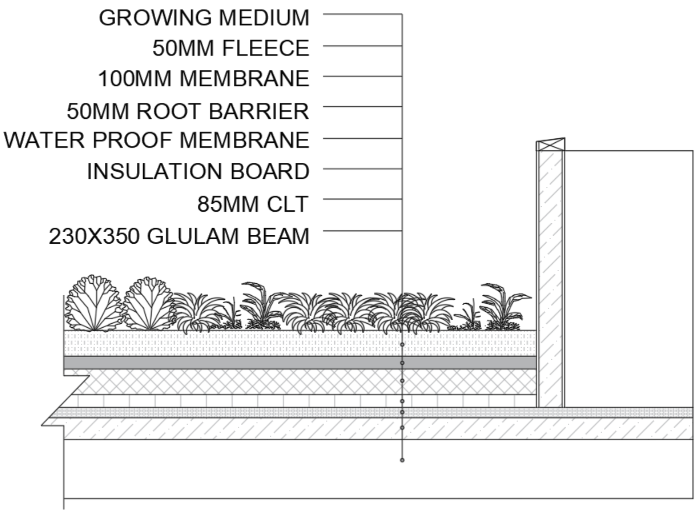


Figure 11. 2 - Green roof section

11.3 GREEN FAÇADE

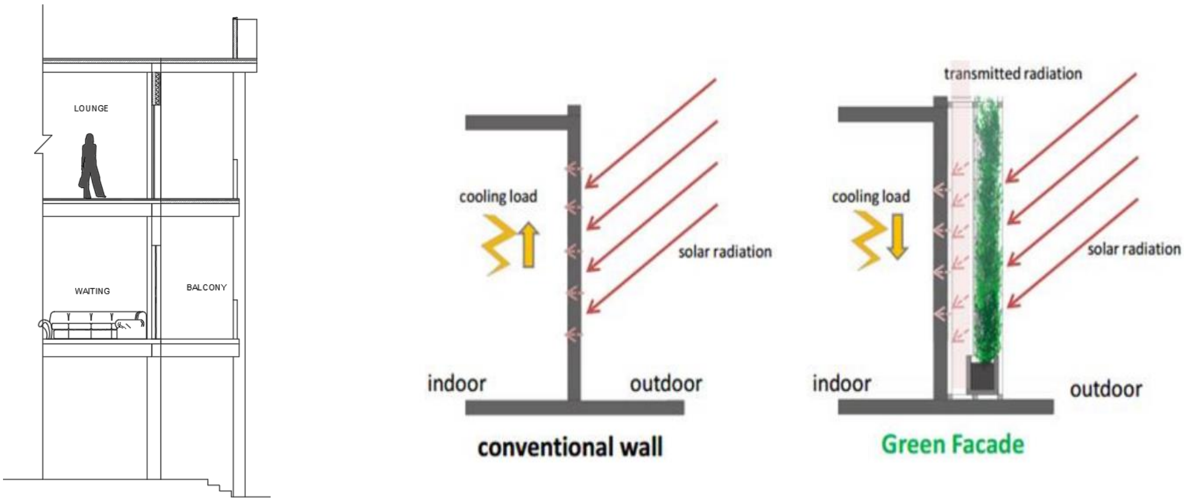


Figure 11. 3- Section showing green facade

The main advantage of green façade is improvement in energy efficiency of building. Creating green façade in balcony spaces outside of labs and offices helps to block direct sunlight, purify air and hence create fresh and healthy environment to users of the building.

11.4 PERMEABLE SURFACES

Permeable materials have been utilized to cover exposed surfaces outside the structure. These surfaces help to collect and reuse the water by absorbing it. Several materials, such as lush lawns, porous asphalt, grass Crete, and permeable concrete surfaces, are used to create the surfaces.

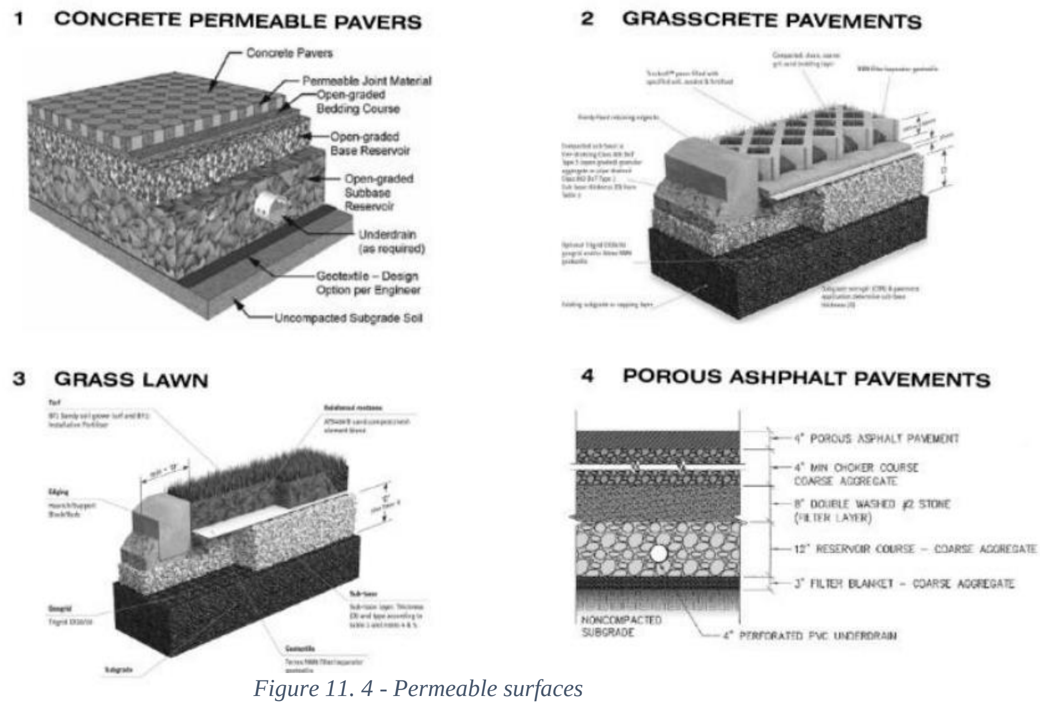
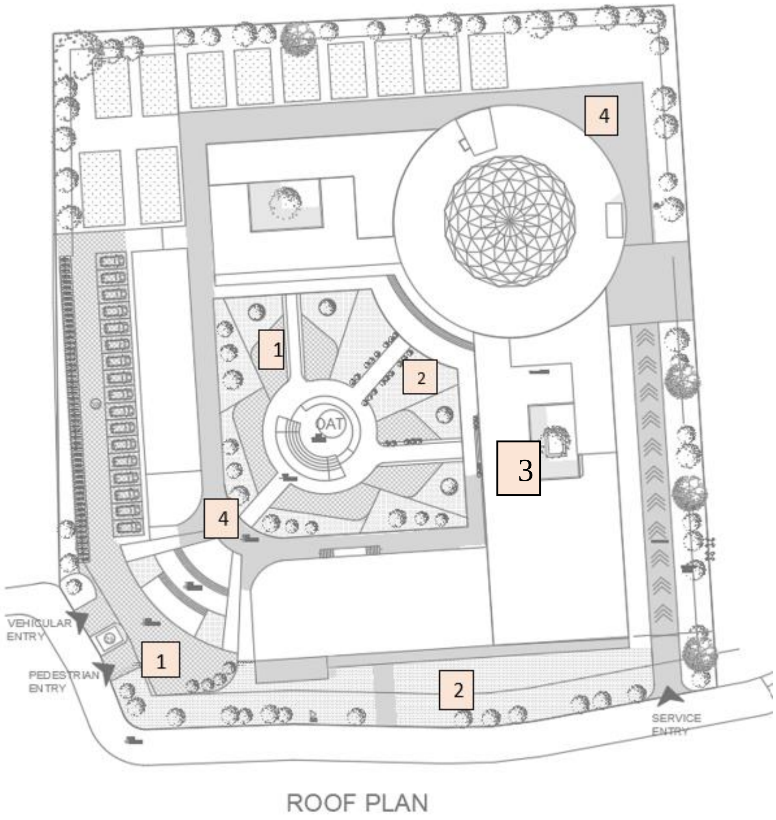


Figure 11. 4 - Permeable surfaces



11.5 SOLAR ENERGY

Solar energy is a renewable energy source that more sustainable than energy sources based on fossil fuels. Solar panels use the sun's light, which is the planet's greatest renewable resource, to transform solar energy into electrical energy.

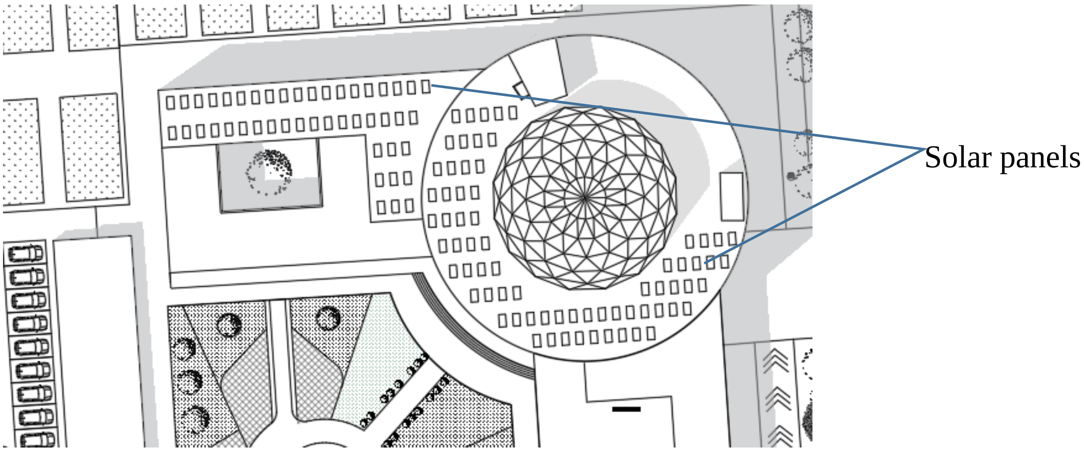


Figure 11. 5- Roof with solar panels

Since the building requires good amount of energy and light for production, solar cells can help us generate the required amount of electricity. The calculation for solar is given below:

The size off 250 WP of solar cell is approx. 2 SQ.M (Lejtman, 2022)

The average area for solar panels in the building = 300 + 1000 = 1300 SQ.M

The total no. of solar cells = 1300/2 = 650

Solar power generated = 650 X 250 W

= 162,500W = 162.5 KW POWER

12. 3D VISUALIZATION OF SPACES

Figure 12. 1- View from entry plaza

Figure 12. 2- Public oriented green house

Figure 12. 4- Lobby to training units

Figure 12. 3- Theory classroom

Figure 12. 5- Lobby with farming modules

Figure 12. 6- Exhibition hall of vertical farming modules

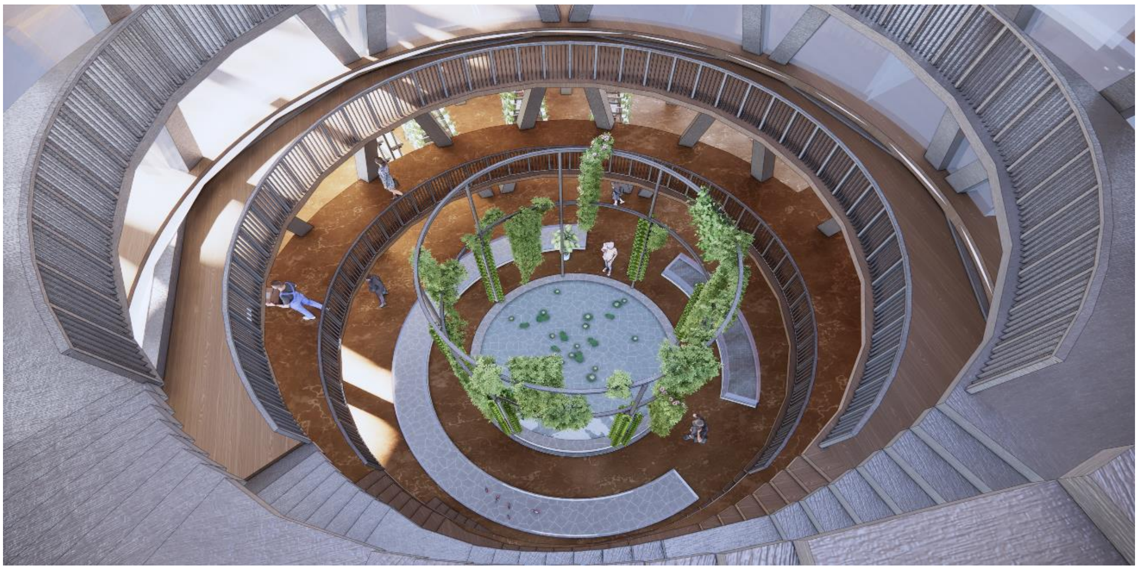


Figure 12. 7- Central atrium

Figure 12. 8- OAT

13. CONCLUSIONS

This project aims to design an urban farm with necessary support facilities like research labs to create a sustainable and practical solution for growing organic and healthy crops. The design aims to preserve nature and minimize environmental impact by looking at previous studies and analyzing different sites.

The vertical farm and research unit is visually appealing and useful for the local community. It provides a new way of farming that can help us face challenges like population growth, climate change, and the increasing cost of food. Bringing the farm closer to the people offers a more efficient and cost-effective way to address food security.

In summary, this project shows how smart design and a focus on sustainability can create a space that benefits both the environment and the community. Projects like this will become more important for ensuring a secure food supply and promoting eco-friendly practices as we continue to face global challenges.

14. REFERENCES

(n.d.).*2023 Forest and Wood Products Australia Ltd*. (n.d.). Retrieved from Wood solutions: https://www.woodsolutions.com

ADAM GHANDAR, A. A. (n.d.). A Decision Support System for Urban Agriculture using Digital Twin: A Case Study with Aquaponics. *IEEE Access*.

Adhikari, S. (2019). *VERTICAL FARM AND RESEARCH UNIT.*

al., S. e. (2020). Urban Farming - A Sustainable. *Research Today*, 2(5) Spl.:323-324.

Association, 2. E. (2005). *Apanews*. Retrieved from Glulam Connection Details

Boni, N. R. (2017). Thermal Behavior of Double Skin Facade in Terms of Energy Consumption in the Climate of North of Iran-Rasht. *Research Gate*.

Bulb laboratories. (n.d.). Retrieved from https://www.bulblaboratories.com/

Chengqing Liu, Q. L. (2017). A review of the diagrid structural system for tall buildings. *Wiley online library*.

Dhungana, N. (2020, May 14). *Online khabar*. Retrieved from Online Khabar website: https://english.onlinekhabar.com

HannahSnyder. (2019). Literature review as a research methodology: An overview and guidelines. *Elsevier journals*.

HANSEN, B. (2010). 2010 Laboratory of the Year. *R&D Magazine*.

Heather. (2018, May 18). *Origin hydroponics*. Retrieved from Origin hydroponics website: https://originhydroponics.com/

Hydroponincs Nepal. (n.d.). Retrieved from hydroponicsnepal.com

Kamath, K. (2016). An Analytical Study on Performance of a Diagrid Structure Using Nonlinear static Pushover Analysis. *ResearchGate*.

Kitsiou, G. P. (2017). Methods for Literature Reviews. In G. P. Kitsiou, *Handbook of eHealth Evaluation: An Evidence-based Approach.* Victoria: University of Victoria.

Lejtman, A. (2022, august 4). *Climate biz*. Retrieved from https://climatebiz.com/

Maharjan, A. (2022). *urban farming research centre.* Kathmandu.

National Botanical Garden . (n.d.). Retrieved from Government of Nepal : https://nbg.gov.np/about-us/

Nepal - Agricultural Land (% Of Land Area). (n.d.). *Trading Economics*.

Neufert, E. a. (2002). *Architect's data.* BLackwell science.

Nirmala Basnet, C. L. (2019). Impact of Pesticide and Fertilizer on Human Health: A Case Study in Godawari Area, Kathmandu, Nepa. *research gate*.

Nnaemeka, C. N. (2015). Case Study As a Tool for Architectural Research.

NNAEMEKA, C. N. (2015, december). *CASE STUDY AS A TOOL FOR ARCHITECTURAL RESEARCH*. Retrieved from academia: https://www.academia.edu/

Nyaupane, S. (2021). Use of Insecticides in Nepal, Its Impact and Alternatives of Insecticides for Nepalese Farmers. In S. Nyaupane, *insesticides.* london: Intechopen.

Poudel, M. N. (2016). Prospects and limitations of agriculture industrialization in Nepal . *Agronomy Journal of Nepal (Agron JN).*

Ramjee Ghimire, N. J. (2021). Agricultural Extension Services in Nepal. In N. J. Ramjee Ghimire, *INNOVATIONS IN AGRICULTURAL EXTENSION* . East Lansing: MICHIGAN STATE UNIVERSITY.

Rashmi Maria Royston, P. (2018). VERTICAL FARMING: A CONCEPT. *Research gate*.

Raut, U. B. (2008). *Urban Agriculture for Sustainable Urban Development.*

Saeed Erfani, A. A. (2016). Connection of I-beam to box-column by a short stub beam. *elsevier*, 136-150.

Sagar GC, J. N. (2019). Pesticides Use in Nepal and its Effects on Human Health – A Review. *ACTA SCIENTIFIC AGRICULTURE*.

Sapkota, K. (2018). Indigenous and Scientific Knowledge in the Farming System: A Case of Urban Agriculture in Kageshwori-Manohara Municipality. *Tribhuvan University Journal*.

Stein, E. W. (2021). The Transformative Environmental Effects Large-Scale Indoor Farming May Have On Air, Water, and Soil. *SAGE Journals*.

Su, P.-H. (2021). *URBAN FARMING DESIGN IN LOS ANGELES:*. ROCHESTER, NY.

Sunar, B. (2022). hydronics farming. (S. Awal, Interviewer)

Suparwoko, B. T. (2017). Urban Farming Construction Model on the Vertical Building Envelope to Support the Green Buildings Development in Sleman, Indonesia. *Elsevier*, 258-264.

Szen, N. W. (2017). *Re-imaging future of vertical farming: Using modular design as the sustainable solution solution.* University Sains Malysia .

Tim Heath, Y. S. (2014). Vertical farms offer a bright future for hungry cities. *The Conversation*.

ToyokiKozai, G. (2016). An Indoor Vertical Farming System for Efficient Quality Food Production. In *Plant Factory* (pp. 7-33). Academic Press.

Wallace-Springer, N. (2022, 2 14). *PRO-MIX*. Retrieved from Premier Tech : www.pthorticulture.com

Walsh, N. P. (2017, April 2). *archdaily* . Retrieved from https://www.archdaily.com/868129/sasaki-unveils-design-for-sunqiao-a-100-hectare-urban-farming-district-in-shanghai

ANNEX A

Questionnaire on physical, technical and business aspects of Hydroponics Nepal

About site selection and planning

1. How was the site selected for farm in Tokha and corporate office in Dhumbarahi?

- Following things should be considered for site selection
  a. Site area: around 14 ropani
  b. Climate: Better select Sub Tropical for year round leafy vegetables production But Tropical and Temperate regions can also be utilized for production with provision of greenhouses
  c. Land Orientation: Must receive proper sunlight and air movements.
  d. Water resources: Must have proper year round available water source like boring and shallow well
  e. Area for expansion

2. Have you considered the social and economic background of the surrounding people or targeted people?

- Yes, most of the community people are Newar with Agriculture as their secondary profession.

3. What are the physical infrastructures required for the operation of the company?

- Physical Infrastructures
  a. Land
  b. Buildings
  c. Vehicles
  d. Warehouses
  e. Road and electricity
  f. Water supply
  g. Greenhouse structure
  h. Hydroponic set ups
  i. Soil less set ups and drip irrigation
  j. Invertors/power back Ups

4. What impacts do you plan to have through your services in the surrounding community and is it having the kind of impact as planned?

- No, as we are planning to expand and most of the works are under construction so after the project set up completion, Hydroponics Nepal is planning to provide training, employment to community people and youths

About farm and company

1. How can you choose the right hydroponics system for particular purpose?

- Size: 5000 planting holes
  Area: 1 ropani

Requirements: Hi-tech greenhouse, Hydroponics Module and Proper Technical information

2. How durable are the modules of the farming systems?

- Durability: 15 years if materials hydroponics set up made from food grade UPVC
  Durability: 5 years if Hydroponics set up PVC pipes only

3. What is the tentative capital of the farm?

- Farm capital: 2 Crore

4. How much quantities of products are planned to be produced per area of land? And how much have been produced in recent years?

- Actually produced: 45kgSalads/ week and 30Kg cherry Tomatoes/week
  Planning after further expansion: 300Kg salads/week and 250Kg cherry tomatoes/week

5. What is the gross sales of the Tokha farm?

- Total sales: 40000/week
  Planning: 500000/week

6. Is there the provision of storage of produced food products? What is the capacity of the storage, amount of energy consumed and how long can the food products be stored?

- Yes, 100L capacity with 15 days of storage provision

7. Does the produced food ever left unsold and went waste?

- 5% of the times

8. Even though the hydroponic system has higher production rate with less input of seedlings or required nutrients, the price of produced product becomes higher due to expensive set-ups and more energy consumption. So, what is the chances gaining profit or losses at starting and later stages?

- 90% with proper planning, technical guidance and marketing

9. Besides rooms for farming units, what are the other administrative and technical rooms that you have in your farm and corporate office? Eg; nutrients and pathogen testing labs, store room for seedlings, store room or cool bots for produced foods, demonstration or training rooms, meeting room, offices for manager, staffs, food technologists, etc.

   - Storage room, Office and meeting hall, Nutrient Mix hall, Kitchen Warehouse

10. What are the building materials used for the construction of the farm?

    - Greenhouse materials: GI pipes, plastics and accessories
    - Hydroponics NFT set Ups Construction Materials: Sand, Cement, Gravel, Bricks etc Prefabricated house

11. What are the common type of wastes and garbage produced in the farm and how are those wastes managed or disposed?

- Nutrient leachates: Utilized for garden plants Plant and
  other degradable wastes: Used for composting and recycle

12. What is the lighting requirements inside the farm?

- LED lights and Florescent Lamps

13. Knowing that hydroponics is a way to grow plants in a more controlled manor that can be year round using less pesticides (more than often no pesticides) and can use only 1/10th the water per plant of traditional crops- Do you feel like hydroponics is a viable option to produce healthy food with more affordability? More efficiently? For more people and in more places?

- Yes, in near future, there will be no options other than growing soil less Vegetables, Rooftop farming so we need to search for more sustainable and futuristic farming technology as soil status is degrading day by day.

14. What degree of ventilation is required inside farming rooms and other technical rooms? How is the provision made in your farm?

- Ventilations must be maintained in such a way that there should have proper airflow, low humidity and Temperature moderation.
  Use of exhaust Fans and Large no of wall fans
  Use of Top Vent Greenhouse
  Use of Green shade nets and cover

15. Does the company have separate physical market store for selling of products of farm and other things required for the farming or are those products sold online and directly from farm?

- No, Products sold online and directly from farm

16. What kinds of people and what no. of people visit the office and the farm? Eg. Farmers, researchers, students for educational purpose, Argo entrepreneurs, etc.

- Average 5 per day including Agro entrepreneurs, Researchers and Students

17. What were the challenges the company or farm had faced and is facing?

- Challenges that had faced:
  a. Weak market linkage
  b. Nutrients constituents and raw material availability
  c. Small Technical errors and Huge losses

Challenges has been facing

a. Digital market creation

b. Awareness and educating people

c. Lack of trained human resources

Questionnaires for local farmers

1. Where do you sell your agricultural products?

2. Is income from crops sufficient for your family?

3.Do you employ workers in your farm?

4.How familiar are you with vertical farming systems like hydroponics?

5. Will you want to learn and switch to this new technology like hydroponics if you know the health, environmental and long-term economic benefits of vertical farming?

6. As initial cost of vertical farming systems is high, what is the maximum amount you can invest on it?

ANNEX B