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Assessment of the Viability of Vertical Farming Structure in Balibago, Angeles City, Pampanga

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Abstract:

This technique, referred to as Vertical Farming, entails cultivating plants in controlled indoor habitats with exact light, nutrient, and temperature conditions. In vertical farming, plants are piled up in layers that may reach heights of several floors. The Angeles City's landscape is primarily flat terrain with the Abacan River and tributaries at its center. The loss of agricultural land for other purposes is reported to be the main reason causing the decline in the entire area of farms. There are several varieties of vertical farming, but only three are regularly utilized soil-free techniques: hydroponic, aeroponic, and aquaponic. The city's land area is 63.37 square kilometers (24.47 square miles). Due to urbanization, there is an ongoing need for urban land. It also exerted pressure on metropolitan outskirts, necessitating urban land use modification. A survey was conducted to assess the viability of vertical farming structure in Balibago, Angeles City, Pampanga. The study found that most residents are willing to learn about vertical farming and adapt it in the future. Most of the respondents preferred vertical farming to traditional farming. It might not be essential right now, but due to increasing population and demand endangering food security, eventually, this will become a solution to the foreseen food crisis and sustain the daily needs of the Community in terms of agricultural supply.

Keywords **— Vertical Farming, Urbanization, Traditional Farming, Agricultural Supply**

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I. I. INTRODUCTION

The worldwide emerging trends of diminishing water supply, rising population, urbanization, and uncontrolled climate change have contributed to a decline in arable land per person. In the coming decades, it is anticipated that these conditions will threaten the viability of the traditional agricultural model based on large rural farms. Vertical farming, focused on controlled environment agriculture and greenhouse designs suited to urban environments, is one strategy for addressing this formidable challenge (Benke & Tomkins, 2017).

The current world population surpasses 7.85 billion, but this figure is anticipated to rise to 9.8 billion by 2050, with more than 75% of people living in metropolitan areas. This population rise will be followed by increased demand for already-stressed food, water, and energy resources required to maintain this development. Consequently, new

agricultural systems that provide sustainable food production will be required to satisfy these needs (Wallace-Springer, 2022).

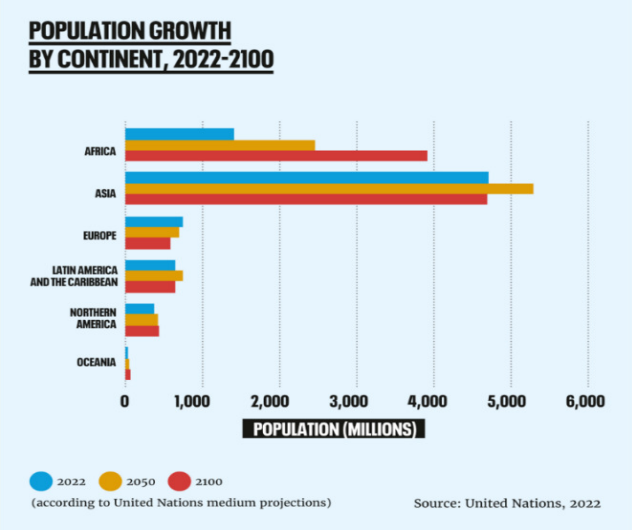


Figure 1. Population Growth by Continent, 2022-2100
(https://populationmatters.org/the-facts-numbers/)

The Philippines' pace of urbanization has stabilized during the last 20 years. However, it has slowed down, suggesting that the rural population is expanding faster than the urban population. Agriculture's falling economic weight in the country and the slight decline in employment in the industry are indicators of urbanization's effects. Farm portions have become smaller and more fragmented due to urbanization, which has also led to the transfer of agricultural areas to urban usage. Significant land was converted due to urbanization, which caused a sharp decline in crop production regions and altered the agricultural landscape of the Metropolitan Manila region. Additionally, it puts pressure on the edges of cities, forcing unavoidable changes in land usage. According to research, there is a need for coordinated policies to protect agricultural land, maintain domestic food production, and support urban agriculture in order to establish and protect green areas in cities. Over the last 12 years, urbanization has reduced the overall area of farm parcels by 414,000 hectares, yet the number of farm parcels has grown by 125,000, indicating decreasing unit sizes. There has been a drop in the area planted with primary crops like rice and maize, while the percentage of housing lots has increased. This is a reason for domestic food production concerns. Due to urbanization, there is an ongoing need for urban land. This is shown by the transfer of agricultural land to urban use, primarily for mixed-use and residential construction (Bravo, 2017).

Elauria (2015) indicated that with a population of 92.3 million people and a total land area of about 30 million hectares, the Philippines is experiencing difficulty distributing a very crucial and limited resource—land—to satisfy the requirements of its citizens. 9.67 million hectares, or over 30% of the country's total land area, are used for agriculture in the Philippines, where about 5 million farmers cultivate such lands. In 1991, there were 9.97 million acres less of this region. Additionally, according to the Philippine Statistics Authority (2013), the average farm size in 2010 was 2.01 ha, which is 0.15 ha less than the average farm size in 1991. The loss of agricultural land for other purposes is likely the cause of the decline in the entire area of farms. Approximately 30% of the total geographical area of the Philippines is farmed by over 5 million farmers, making it a primarily agricultural nation. However, agricultural acreage has been declining owing to land conversion. The fundamental issue is that Filipino farmers are unable to own their land.

Birkby (2016) discovered that one possible answer in the desire for additional space is abandoned warehouses in towns, new structures constructed on ecologically degraded land, or even repurposed cargo containers from ocean voyages. This technique, referred to as Vertical Farming, entails cultivating plants in controlled indoor habitats with exact light, nutrient, and temperature conditions. In vertical farming, plants are piled up in layers that may reach heights of several floors.

Given the immense scale of the world's agriculture, it will be challenging to transform agriculture in a manner that does not harm the natural environment. There is an ever-increasing need for agricultural systems that are both high-yielding and sustainable as food demand continues to rise. The high yields of pesticide-free indoor farms show tremendous potential, in addition to

being an excellent use of places not often employed for agriculture. Although indoor farming is unlikely to replace conventional field farming soon, it has the potential to at least partially address the issue of food security in the coming years (Yap, 2021).

Despommier (2019) expressed that Vertical farming is an effective remedy for the problems associated with conventional outdoor farming. Its primary contribution is to the environment. Vertical Farms also use cutting-edge technology and intense agricultural techniques to enhance yield drastically. Since then, many vertical farms have proliferated around the globe. They doubled in size in a single year and have seen exponential expansion. In five to ten years, the number of vertical farms will increase. This indicates that vertical farming is on track to become a widespread feature of urban landscapes and that cities can produce considerable amounts of food for more than 60 percent of the urban population.

Despite the Philippines' abundance of natural resources, they are underutilized in light of the technologies and techniques available for increasing yields. However, because the nation is not industrialized, it cannot afford modern machinery, infrastructure, and inputs. Vertical farming can utilize a country's relatively limited land area to significantly increase agricultural production and contribute to the nation's gross domestic product and growth (Francisco & Tan, 2013).

According to Organization for Economic Cooperation and Development (2020), the Philippines is a medium-sized nation in terms of land area, but with a population of 107 million, it is the thirteenth most populous country on the planet. Agriculture is an important sector in the Philippines, accounting for 25% of all employment and 9% of the country's gross domestic product. The average farm size is around 1.3 hectares. Due to its small land and large population, the Philippines is an increasing net importer of agro-food goods.

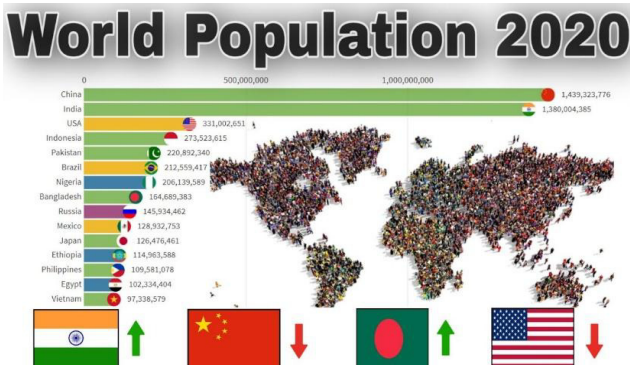


Figure 2. World Population 2020
(https://www.youtube.com/watch?v=QEhxUzeEM5Q)

Atland (2022) pointed that traditional agriculture is planting crops on soil on open fields with natural sunshine and irrigation. On the other hand, Vertical Farming takes place inside, produces crops in stacked layers, and employs artificial growth systems such as hydroponics, aquaponics, and other forms of soilless agriculture. Vertical farming has several advantages over conventional farming. Vertical farming enables producers to cultivate regional or seasonal crops year-round, while traditional agriculture, on the other hand, is restricted by geographic location and seasonal variations. They can grow plants anywhere a greenhouse or controlled environment can be constructed. Consequently, customers (particularly those in metropolitan regions often located distant from traditional farmlands) have better access to a product that is fresher.

Naqvi (2022) indicated that there are several varieties of vertical farming, but only three are regularly utilized soil-free techniques: hydroponic, aeroponic, and aquaponic. Growing plants in water constitute hydroponic farming. Aeroponic farming methods do not even need a water-based medium for plant growth. This technique in the root development chamber employs merely a mist or spray of nutrients. Since aquaponic systems mix hydroponic farming with fish farming, these systems are only used to cultivate rapidly growing crops.

Vertical farming also enables farmers to use their land more efficiently. Multiple layers of growing systems may be planted on top of one another in vertical gardening, resulting in yields

that are often significantly greater than in traditional farming. Given the rapid growth of worldwide population, it will be crucial to use one's land as effectively as possible to secure the global food supply (Andreas, 2020).

In 2020, the Philippine agriculture industry contributed 10.2% to the nation's GDP and employed 9.75 million people, according to data from the Philippine Statistics Authority (PSA). Agriculture occupies more than 7.9 million hectares of Philippine land, according to official figures. According to the Global Hunger Index, the country ranks 68th out of 116 nations in terms of hunger, which may be exacerbated by climate change and the spread of the pandemic (Project to Address Food Security Issues in PH via Improvement of Vegetable Value Chain Begins | Philippines | Countries & Regions | JICA, 2022).

The Philippines had a total of 75 disasters from 2006 to 2013, which resulted in losses and damages to the agriculture sector of $3.8 billion. The Philippines has one of the most susceptible agricultural systems in the world, according to FAO. It has few resources to provide a secure food system for its citizens since it is a disaster-prone nation. Despite effectively producing and exporting rice, wheat, and maize, which together occupy more than 67% of the nation's arable land, the country may soon see decreased yields due to heat and water stresses that are made worse by climate change. The Philippine government has been actively working to utilize urban agriculture methods to their advantage due to growing worries about food insecurity. The Urban Agriculture and Vertical Farming Act of 2019, which also seeks to address urban environment management, was submitted by Philippine Senator Francis Pangilinan. The Department of Agriculture has identified 18 crucial tactics to combat food insecurity in the nation. This includes "the development of appropriate crop production techniques, including vertical agriculture, hydroponics, bio-intensive gardening, and greenhouse farming suitable for urban settings. The following are 5 existing Vertical Farms to look out in the Philippines (5 Vertical Farms to Look out for in the Philippines, 2021):

1. NXTLVL Farms, is the pioneer and leading indoor urban farm in the Philippines. With farms in Metro Manila, this company is able to grow nutritious leafy greens as close to their consumers as possible "with the guarantee of no bad leaves or waste on delivery";

2. Urban Roots has established an indoor, hydroponic farm and a greenhouse growing microgreens, lettuce, strawberries, and other unique leafy vegetables in the heart of Metro Manila. This 280 sqm farm is built inside a retrofitted garage, delivering primarily to diet-food delivery companies, a juicing company, culinary schools, and consumers who order weekly";

3. Good Greens and Co. is a vertical farming solutions provider that aims to bring fresh, high-quality produce to urban homes by building farms in the heart of these communities. Founded in 2018, the company houses their first aeroponic farm in Taguig, Metro Manila;

4. Alongside Good Greens & Co., the National Capital Region's Navotas City Council unveiled the tallest aeroponic vertical farm in the country. The four-tower farm stands on a 300sqm area in the Tanza resettlement community; and

5. Urban Greens is currently transforming a 700sqm warehouse in Manila into the countries first mid-size indoor vertical farm with further larger production sites in Manila and beyond in the pipeline – all at a fraction of the electricity usage compared to other vertical farms.

Austria (2021) specified that Christopher De Venecia, the representative for Pangasinan's fourth congressional district, and other members of Congress sponsored a measure supporting urban agriculture that Congress approved on the third reading. In a statement, de Venecia said that the purpose of House Bill No. 8385, an act supporting integrated urban agriculture in metropolitan areas countrywide to address food security, is to instill the minds of Filipinos the notion that food production is not limited to rural regions. "Under the proposed act, local government units shall identify and develop idle government lands and private lands and buildings, without prejudice to the owners of the private lands, buildings, and open

spaces within their jurisdiction, for partial or complete conversion to a community garden, food forest garden, urban farm, or vertical farm to support community and food nutrition," he said.

Sarao (2022) indicated that the law incorporates the Instructional Gardening program within the academic curriculum of primary and secondary students in both public and private institutions. "Now that pupils are back in school, teachers must also consider teaching them other life skills. "The instructional gardens program will provide them with the skills necessary to raise food in a space-constrained environment," Lee added. Under the terms of the proposed legislation, private individuals and enterprises who provide grants, endowments, gifts, or donations, as well as technical help for the promotion and incorporation of Institutional Gardens into the school curriculum, will also be eligible for tax benefits.

According to DA Communications Group (2022), more private sector partners are collaborating with the Department of Agriculture (DA) to execute the National Urban and Peri-Urban Agriculture Initiative under the agency's Plant, Plant, Plant umbrella program. Agriculture Secretary William D. Dar, Planters Products Inc. President and CEO Ranilo Maderazo, Urban Greens Founder and CEO Ralph Becker, and Philippine Agriculture and Resources Research Foundation Inc. President Candida Adalla launched an indoor vertical farming project in Esteban, Makati City. The "Enhancement of the Indoor Hydroponics System for Lettuce, Kale, Basil, and Tomato Production" project received initial financing of P3 million from the DA-Bureau of Agricultural Research (BAR). He also pushed local government units (LGUs) to provide a larger budget for food security projects and to draft an ordinance mandating buildings and public open spaces to offer room for urban agriculture or edible landscaping. "As much as possible, people must engage in intensive local production. "Citizens must prepare to withstand the (looming food) catastrophe," warned Secretary Dar. Maderazo, on the other hand, said that the initiative would be repeated in other locations and expressed his hope that the LGU officials who attended the event would encourage their new mayors to execute the urban agro program for the benefit of their residents.

The highly urbanized City of Angeles, situated in the province of Pampanga, is positioned to serve as the main urban center of Central Luzon. Since 2012, the number of business enterprises serving the city and neighboring cities and towns has increased steadily. As of 2018, it has a total land area of around 6,337 hectares and is home to 470,282 people. The population is predicted to reach 641,706 by 2025 (ANGELES AQUIPARK Building Climate Resiliency through Urban Plans and Designs, 2019).

According to Sison (2020), Rea Dizon, an agricultural specialist with the agriculture office of Angeles City, asserts that urban gardening is prospering in this city despite the epidemic. Dizon credited Mayor Carmelo "Pogi" Lazatin's "Gulayan sa barangay at sa paaralan" food security program, which was extensively implemented in target areas before to the COVID-19 outbreak. Under the urban agricultural and greening initiative for the city's 33 barangays, this is natural organic farming. It was started in agricultural barangays, notably Cuayan, Sapangbato, and Pulung Maragul. Officials and inhabitants of the community are now equipped with the technical knowledge and capacity to conduct seminars and trainings. Training programs for women, out-of-school adolescents, and expanding farmers were organized to supplement the local instructors in several communities. In addition, Executive Assistant IV Reina Manuel highlighted that Lazatin's sustainability program tackles the effect of the pandemic since urban farming optimizes food production and encourages every home to cultivate its vegetable garden and safe, nutritious, and delicious produce. It is also a source of revenue for farmers and makes Angeles City an intelligent and green metropolis. Manuel noted that the "Lingap Lugud" relief efforts of Lazatin involve the distribution of vegetable seeds for the cultivation of organic food in the city.

To boost the urban greening effort of this highly urbanized city, the local government via the Barangay Affairs and Public Assistance Center

(BAPAC), inaugurated "Tanim Gulay sa Bawat Barangay" at the city hall. The initiative seeks to provide a sustainable urban gardening and vegetation program for the city via backyard gardening, which is concurrent to the existing "Gulayan sa Barangay" program of the City Agriculture Office (CAO) with the city's 33 villages in charge. This aims to boost the city's capacity to generate its own food by transforming unused space into parks and gardens, which will also economically benefit Angelenos in the future. Vertical Agriculture is the current agricultural trend, particularly in metropolitan areas such as Angeles. For example, Singapore has successfully incorporated this tendency into its environmental, social, and economic advantages. Mayor Edgardo Pamintuan said that the city aims to emulate the program. Pamintuan stated, "They have tasked the village chiefs via BAPAC with guiding their citizens toward achieving their aim of making Angeles more environmentally friendly." Only 7.78% of Angeles City's total land area is now suitable for agriculture. The City Government believes that the initiative can fulfill the demand for urban greening via the engagement of barangay-based groups, academies, and people, as well as the use of current gardening trends and techniques. The City Government believes that the initiative can fulfill the demand for urban greening via the engagement of barangay-based groups, academies, and people, as well as the use of current gardening trends and techniques (Angeles City Launches Barangay Urban Greening Project, 2017).

As part of the festivities commemorating the 44th Nutrition Month, a three-day food market was inaugurated. Calaguas said that during the month of July, the City Agriculture Office would provide seedlings to schools around the city. "To encourage Angelenos to establish their own vegetable gardens, the City Agriculture Office has opened its doors to walk-in citizens who wish to receive free vegetable and fruit seeds," he stated. Mayor Edgardo Pamintuan underlined the importance of healthy living through choice. "Residents should be prudent, leverage our current strengths, and invest in them so that it can continue to work and serve effectively," he added. The mayor also emphasized the significance of backyard/urban gardening in Angelenos' quest for healthy nutrition (PTV NEWS - CD, 2018).

The northern portion of Angeles City is now occupied with residential subdivisions and business areas, including malls, hotels, fast food franchises, and restaurants. Correspondingly, commercial land usage intensified in the region, and the majority of the barangays (villages) in the area are now the most populous in the city (ANGELES CITY CASE STUDY on the PATH to CLIMATE RESILIENCY, 2022).

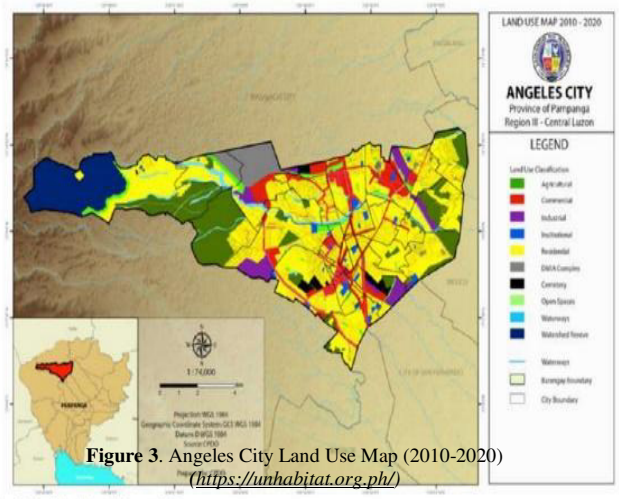


Figure 3. Angeles City Land Use Map (2010-2020) *(https://unhabitat.org.ph/)*

According to the Bureau of Agricultural Statistics (2016), there has been a significant decrease in the amount of agricultural land in Angeles City, Pampanga from 11,000 hectares in 2000 to 8,200 hectares in 2016. This can be attributed to rapid urbanization and conversion of agricultural land to residential and commercial use. The report also notes that the decrease in agricultural land has had a negative impact on the local economy as agricultural production has decreased significantly. The report recommends that the local government of Angeles City take steps to protect and preserve the remaining agricultural land. This includes providing incentives to farmers to keep their land in agricultural production and increasing access to credit and other financial services to help farmers remain in business. In addition, the local government should

promote sustainable farming practices to ensure that the land remains productive and can continue to support the local economy.

National Food Authority (2017) indicated that the city's food supply is heavily dependent on imported commodities, with only 18% of households able to access locally produced food.

Angeles City has the lowest percentage of agricultural fields among the provinces in Central Luzon, which is around 20%, making it highly reliant on imported food. (Quiñones et. al., (2017)

Barangay Balibago, Angeles City is a populous residential and commercial area located in the province of Pampanga. It is composed of 2.45 square kilometers of land area and has a population of over 42,000 people. The barangay has a bustling business district, well-maintained infrastructure, and vibrant culture. It is well-connected to the rest of Angeles City and the province of Pampanga with its access to major roads and highways.

1.2 Study Area

Angeles City is a highly urbanized city and one of the country's most economically developed metropolitan areas. Within the province of Pampanga, the city is surrounded by Clark Freeport Zone and Mabalacat to the north, Mexico to the east, San Fernando to the southeast, Bacolor to the south, and Porac to the southwest. This landlocked city's landscape is primarily flat terrain with the Abacan River and tributaries at its center.

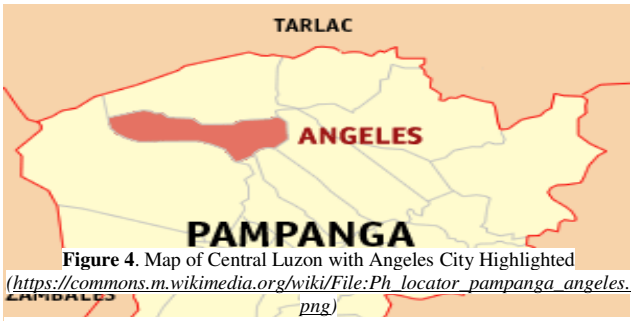


Figure 4. Map of Central Luzon with Angeles City Highlighted *(https://commons.m.wikimedia.org/wiki/File:Ph_locator_pampanga_angeles.png)*

The latitude of Angeles, Philippines, is 15.156311, and the longitude is 120.591774. Angeles, Philippines, is situated in the Philippines nation in the Cities location category with the GPS coordinates of 15° 9' 22.7196" N and 120° 35' 30.3864" E.

The city's land area is 63.37 square kilometers (24.47 square miles). According to the results of the 2020 Census, its population was 462 928. This constituted 3.73 percent of Central Luzon's total population. Based on these numbers, the population density is estimated to be 7,305 people per square kilometer or 18,918 people per square mile.

1.2.1 Accessibility

Figure 5. Gulayan sa Barangay *(https://www.google.com/maps/place/Hadrian+St,+Balibago,+Angeles,+Pampanga/@15.1717123,120.5941854,17z/data=!3m1!4b1!4m6!3m5!1s0x3396ed8b52f8ec85:0x3b8cac1f13d0ac8e!8m2!3d15.1717123!4d120.5967603!16s%2Fg%2F1tdhjby_)*

The location is Hadrian St., Balibago, Angeles City, Pampanga, which is the farm of the Barangay called "Gulayan sa Barangay". The researchers collaborated with the Barangay Captain to use its farm as the location of the Vertical Farming Structure. The total land area of the project is approximately 450 square meters, which will be used for the establishment of Vertical Farm.

1.3 Review of Related Literature

Angeles City in supporting Urban Agriculture

Angeles is a heavily urbanized city in the province of Pampanga in Central Luzon, with a projected 2020 population of over 500,000. This number increases or even triples throughout the day, when residents of neighboring towns and cities commute to the city for employment, school, recreation, and commerce. In addition to being one of the most economically developed cities outside of the National Capital Region, Angeles is also

renowned for its rich culture and history (ANGELES CITY CASE STUDY on the PATH to CLIMATE RESILIENCY, 2022)This figure below shows the projected population of Angeles City, Pampanga from 2016 to 2025.

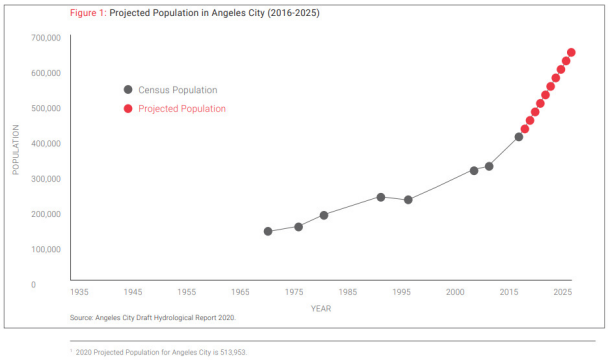


Figure 6. Projected Population in Angeles City (2016-2025)
(https://www.international-climate-initiative.com/en/iki-media/publication/case-study-on-the-path-to-climate-resiliency-angeles-city/)

Approximately 415 hectares of land have been subdivided and transformed into mixed-use residential-commercial complexes since 2010. This land area represents about 0.7% of the city's total land area, translating to a 0.7% rate of land conversion for the specified time frame (ANGELES CITY CASE STUDY on the PATH to CLIMATE RESILIENCY, 2022).

In a city where only 20 % of the area is dedicated to agriculture out of 6,337.39 hectares, there is an initiative similar to urban gardening to aid Angelenos during the Covid-19 epidemic, in which every livelihood is at risk. Since a community quarantine was established on the whole island of Luzon, commercial enterprises were closed, halting economic activity. Urban Gardening: Residents residing in Angeles are encouraged to engage in the "Luntian sa Barangay Lingap Project," a sustainable urban gardening initiative for food security. The "Luntian sa Barangay Lingap Project" is a sustainable initiative for food security that is one of Mayor Carmelo "Pogi" Lazatin, Jr.'s new concepts for protecting Angeleos during the health crisis caused by the Covid-19 outbreak. This is intended to inspire Angelenos to use their empty lot and practice gardening at home (Urban Gardening in Angeles during the Time of Covid-19, 2020).

Philippine Government in promoting Urban and Vertical Farming

The Department of Agrarian Reform (DAR) has launched its urban farming initiative, Buhay sa Gulay, in Barangay Kawayan, Tacloban City, with the intention of transforming 20 hectares of unused land into a profitable vegetable garden. Castriciones and other agency officials presented P48.23 million worth of support services projects and 137.12 hectares of agricultural land to agrarian reform beneficiaries in the Eastern Visayas province. Castriciones also donated 137.12 hectares of land to 88 landless farmers from the municipalities of Alangalang, Babatngon, Dagami, Dulag, Jaro, La Paz, Pastrana, and Tacloban City during his visit. Under the DAR-to-Door program, the DAR chief also delivered a certificate of land ownership award to farmer-beneficiary Rogelio Pobadora at his home in Barangay Cabalawan, Tacloban City. Pobadora was awarded 5,744 square meters of land (Mayuga, 2021).

According to the DA Communications Group (2022), state universities and colleges (SUCs) can step in and upscale their research on a massive level for six urgent areas of concern: balanced fertilization, urban and peri-urban agriculture, local feeds formulation and production, aquaculture and mariculture, food mobilization, and climate resiliency. In response to the high cost of fertilizers and to prevent a decline in crop yields, the Department of Agriculture (DA) is implementing a variety of measures, including the distribution of fertilizer subsidies, communication with fertilizer-producing nations, and the adoption of a balanced fertilization strategy, among others. Secretary Dar also urged SUCs to be innovative and include aquaponics in vertical farming systems, emphasizing that shrinking agricultural areas should not impede food production. Regarding food mobilization, the agri-chief advised developing legislative and logistical solutions to minimize dependency on fuel and long-distance travel to

deliver more farmers' output to the tables of customers.

According to House of Representatives Press Releases (2017, elaborated that he House special committee on food security has adopted a replacement measure that aims to foster agricultural development in Metro Manila and other metropolitan areas around the country to assist the nation in achieving self-sufficiency and sustainability in food production and food security. The unnumbered substitute bill, to be known as the "Integrated Urban Agriculture Act," seeks to cover all urban spaces, such as vacant, government or private lots or buildings, and available land resources in state or private universities and colleges that are suitable for cultivating crops and raising poultry, livestock, and aquaculture. Reps. Estrellita Suansing (1st District, Nueva Ecija), Michael Romero (1-PACMAN), Harlin Neil Abayon III (AANGAT TAYO), Orestes Salon (AGRI), Gary Alejano (MAGDALO), and Emmeline Aglipay-Villar authored it, and it superseded House Bills 2818, 4354. (Party-list, DIWA). The law establishes self-sufficiency and sustainability in food production and security as fundamental State objectives. In addition, it stipulates that the state must aim towards self-sufficiency in food production and climate-resilient urban communities through the promotion of modern, appropriate, cost-effective, and environmentally safe agriculture technologies in order to ensure food security, promote a healthy citizenry, and advance and improve the quality of life for urban dwellers in order to ensure a healthy and sustainable environment and food security in the country. The law stipulates that the owner of a building or land should get a P10 real property tax incentive and tax credit for every square meter designated for urban agriculture. The legislation requires establishing the Office of Urban Agriculture under the Department of Agriculture to ensure that urban agriculture-related activities are carefully regulated and coordinated (DA).

Through the flagship "Plant, Plant, Plant" initiative, the Department of Agriculture (DA) introduced urban agriculture to address food supply and accessibility. Incorporating new farming technology may also aid in developing resilient food systems that can contribute to the modernization and expansion of the country's agricultural industry. "For many decades, urban gardening was mostly seen as a pastime rather than a solution to the issue of food poverty. "However, with diminishing land and water resources and climate change hurting smallholder farmers and fisherfolk, urban agriculture is becoming a feasible alternative for securing food supplies, particularly in metropolitan areas," said agricultural secretary William Dar. "There is a need to support the appropriate implementation of urban agriculture in the metropolitan region so that when food supplies from the provinces tighten, there will still be sufficient food in urban areas. The main objective is to provide food security, but in time this might also give a means of subsistence," he noted. Utilization of contemporary technologies and agripreneurship are the pillars of Secretary Dar's "Agriculture 2.0" transformation guiding philosophy. These include the promotion of vertical farming and the use of agricultural technologies such as hydroponics, aquaponics, and aeroponics — all of which are designed to optimize the use of the remaining restricted area for food production, so attaining increased productivity and efficiency.

Many farms lost due to land conversion

Sicogon, an island in the province of Iloilo, was no longer the popular tourist destination it had been in the 1970s and 1980s. Two property developers, Ayala Land, Inc. and Sicogon Development intended to transform the island into a premier tourism destination. There were still 334.6 hectares classified as agricultural land in Sicogon, and 216 agrarian reform beneficiaries resided there (Cabildo, SubingSubing, Revsio-Cruz, et al., 2017).

The Department of Agrarian Reform (DAR) ratified the transfer of the land from agricultural to non-agricultural use on May 29, 2016, as a result of a settlement with the farmers reached in 2014. Consequently, the island is being developed into a commercial and tourist hub with hotels, shopping malls, apartments, and a 1,200-meter runway (Cabildo, SubingSubing, Revsio-Cruz, et al., 2017).

Sicogon is only one example of converted agricultural fields that have transformed into thriving residential, commercial, industrial, or institutional centers of activity. According to the Department of Agrarian Reform (DAR), In 1988, when the Comprehensive Agrarian Reform Law (CARL) went into force, a total of 97,592,5 hectares of agricultural land, about the size of Metro Manila and Cebu City, were approved for conversion to non-agricultural uses. Conflicting land uses have resulted from the widespread conversion of prime agricultural land, fueled partly by fast urbanization, population growth, and speculation (Cabildo, SubingSubing, Revsio-Cruz, et al., 2017).

Urbanization and Population growth

The Philippine archipelago has a total 0f 7,017 islands. It has roughly 30 million hectares of land area which 9.7 million hectares of this is considered agricultural land.

Agrarian Undersecretary Luis Pangulayan (2017) stated that one of the significant drivers of land conversion is rapid urbanization and population growth. The state has permitted widespread conversion of agricultural lands into other uses outside of Metro Manila due to the demand for housing, employment and the necessity to promote economic growth and investments.

According to the study conducted by Philippine Statistics Authority (PSA), between 1990 and 2015, Bulacan, Rizal, Batangas, Laguna, and Cavite provinces posted significantly greater population growth rates than Metro Manila and the whole country.

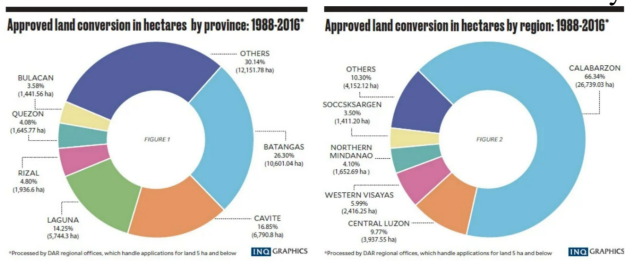


Figure 7. Approve land conversions in hectares by province/regions 1988-2016

(https://newsinfo.inquirer.net/876377/many-farms-lost-to-land-conversion)

These two figures exhibit the percentage of land conversion in hectares by province and Region from 1988 to 2016. Interestingly, since 1988, the provinces closest to or surrounding the capital have had the highest rates of land conversion.

Such was the situation in Batangas province, where the Department of Agrarian Reform (DAR) authorized, on February 1, 2016, the conversion of 27 hectares into additional solar farm land in the municipality of Calatagan. Solar Philippines Commercial Rooftop Projects feature the country's biggest solar farm with 160 hectares, where rice, maize, and other commodities are formerly grown (Cabildo et al., 2017).

This poor agricultural output may be ascribed to some of the difficulties the agriculture business faces today. Rapid urbanization and population increase are contributing factors to the extensive conversion of valuable agricultural land. For example, the rising demand for housing complexes, residential villas, and commercial properties has resulted in the massive conversion of agricultural lands not just in Metro Manila but also in major cities around the nation (Cabildo et al., 2017).

Atilano (2017) said that the Philippines are an agricultural nation with 30 million hectares of land, of which 47% is agricultural land. Philippines has plenty of land, natural resources, diligent farmers, and agricultural research organizations. However, although agriculture is the foundation of Philippines economy, people need to prioritize it more. People must allow constraints, such as a lack of infrastructure for irrigation, a road from the farm to the market, farmers' access to money, technology, the market, mechanization, and comprehensive capacity building, to impede the development of the agricultural sector.

Urbanization results in the ongoing loss of agricultural land, directly in the form of land appropriation and indirectly in using agricultural land for non-productive rural activities such as hunting and fishing, horse breeding, and hobby farming. These urbanization processes pressure farmers by diminishing agricultural land, generating negative externalities, and increasing land competition (Ustaoglu et al., 2017).

Save farming and farmers, stop converting land

Since agrarian reform was adopted in 1988 until 2016, about 100,000 hectares of agricultural land (97,592,5 hectares) — or the combined area of Metro Manila and Cebu City have not produced food, according to Sen. Kiko Pangilinan's Senate Bill 256, the Agricultural Land Conversion Ban Act. Population increase and fast urbanization have both contributed to the issue of declining agricultural areas. According to data, Luzon, which accounts for 80.6% of all permitted land conversions nationwide, Visayas, 7.8%, and Mindanao, 11.6%, are the three regions most affected by the widespread land conversion.

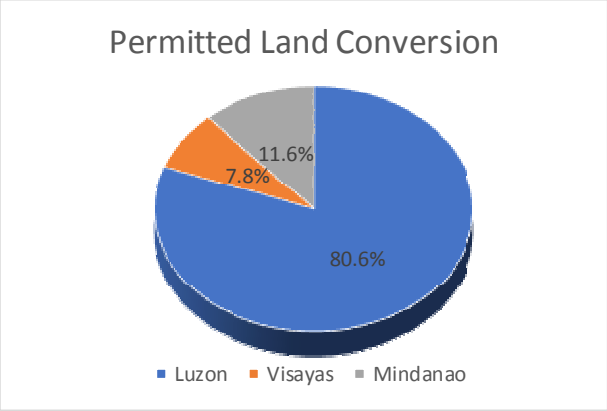


Figure 8. Permitted Land Conversion

According to the Philippine Statistics Authority's (PSA) Agricultural Indicators System (AIS) report on production and productivity, the country's harvested agricultural crop area decreased by 1.3 percentage points to 13.32 million hectares in 2019.

Philippine Statistics Authority (PSA) stated that the nation's agricultural employment rate decreased steadily from 2013 to 2015, falling by an average of .53 to 1.39 percent. At least 31 million Filipinos, both men, and women, worked in agriculture in 2013, but that number fell to 29.1 million in 2015. Furthermore, Sarmiento et al. (2019) highlighted the shrinking numbers of farmers due to the diminishing agricultural areas caused by the nation's slow industrialization.

Due to the drop in agricultural farm labor caused by the COVID-19 pandemic, which affected roughly 100.77 million individuals, the output produced by agricultural sector was lowered by 3.11 % or 17.03 million tons. This might result in a 3.76 billion USD (1.4 %) drop in Southeast Asia's gross domestic product. On a local level, the epidemic has changed the way people think about food and how farmers grow it. The pandemic has highlighted the link between consumption patterns and supply networks as well as the urgent need to reframe agricultural systems. Urban agriculture is a deliberate answer to growing issues about food security, climate resilience, and people's general well-being amid urbanization and the rising urban population (Director Gregorio, 2022).

The Department of Agrarian Reform (DAR) has launched its urban farming initiative, Buhay sa Gulay, in Barangay Kawayan, Tacloban City, with the intention of transforming 20 hectares of unused land into a profitable vegetable garden. Castriciones and other agency officials presented P48.23 million worth of support services projects and 137.12 hectares of agricultural land to agrarian reform beneficiaries in the Eastern Visayas province. Under the DAR-to-Door program, the DAR chief also delivered a certificate of land ownership award to farmer-beneficiary Rogelio Pobadora at his home in Barangay Cabalawan, Tacloban City. Pobadora was awarded 5,744 square meters of land (Mayuga, 2021).

According to House of Representatives Press Releases (2017, elaborated that he House special committee on food security has adopted a replacement measure that aims to foster agricultural development in Metro Manila and other metropolitan areas around the country to assist the nation in achieving self-sufficiency and sustainability in food production and food security. The unnumbered substitute bill, to be known as the "Integrated Urban Agriculture Act," seeks to cover all urban spaces, such as vacant, government or private lots or buildings, and available land resources in state or private universities and colleges that are suitable for cultivating crops and raising poultry, livestock, and aquaculture. The law

establishes self-sufficiency and sustainability in food production and security as fundamental State objectives. In addition, it stipulates that the state must aim towards self-sufficiency in food production and climate-resilient urban communities through the promotion of modern, appropriate, cost-effective, and environmentally safe agriculture technologies in order to ensure food security, promote a healthy citizenry, and advance and improve the quality of life for urban dwellers in order to ensure a healthy and sustainable environment and food security in the country.

According to Benke & Tomkins (2017), The unstoppable trends of expanding population, urbanization, dwindling water supplies, and ongoing climate change have contributed to reducing arable land stocks per person. As agricultural land supplies dwindle, policymakers face the task of ensuring sustainability and feeding the world's fast-rising population, which is anticipated to reach 9.7 billion by 2050. Urban vertical farming, which extensively uses technology and automation to optimize land utilization, is an example of a solution for boosting future food supply. The vertical farm strategy attempts to considerably boost productivity while reducing the environmental impact within a context of urban, indoor, climate-controlled high-rise structures.

According to Januszkiewicz and Armusz (2017), Envisioning urban farming for food security during the climate change era. Vertical farm within highly urbanized areas. In IOP Conference Series: Materials Science and Engineering (Vol. 245, No. 5, p. 052094). IOP Publishing. Food production will be imperiled by global climate change in the coming decades. This essay is concerned with a novel prospect and the wisdom of developing a systematic solution to the issue of food security in densely populated areas. It suggests that vertical farms will play a role in future horticultural production. This study emphasizes the integration of extensive horticulture production into urban areas, where most food consumption occurs. A new holistic approach incorporating the knowledge and developments of numerous scientific fields must emerge to successfully transition food production from vast rural areas to dense urban environments.

According to Al-Kodmany, K. (2018), urban planners and agricultural professionals have claimed that cities need to generate food to meet a growing population's demands. This article examines concerns linked to food security, urban population development, agricultural scarcity, "food miles," and associated greenhouse gas (GHG) emissions. The study investigates urban agriculture as a solution to these issues. Recent developments in greenhouse technologies such as hydroponics, aeroponics, and aquaponics have provided the vertical farm concept with a promising future.

Vertical farming involves growing plants in a controlled environment. In vertical farming, plant layers may reach a height of several storeys in height. Urban vertical farming is a relatively recent concept, but interest in this strategy is growing. The future of cities is uncertain, but the creative vertical farms are emerging (Birkby, 2016).

According to Sarkar & Majumder (2015), The vertical eco-farm is a strategy to create large amounts of food all year long and provide a variety of high-quality, fresh, wholesome advantages. Population growth is accelerating worldwide, and the need for food is a severe issue. The review of eco-farming will aid eco-farming farmers and researchers in developing effective designs and monitoring the vertical Eco-Farms' characteristics. The current situation of the chances for art and issues with vertical sustainability in the arts.

Kalantari et al. (2018) specified that in the next 50 years, 80% of the world's population is projected to reside in urban regions as the world's population continues to increase rapidly, accompanied by a significant increase in food consumption. Producing sustainable urban food necessitates considering all aspects of sustainability, including environmental, social, and economic development. Designing and executing vertical farms is a novel way to solve the sustainability problem and fulfill the rising need for food. Vertical farming raises plants and animals on vertically

inclined surfaces, such as skyscrapers in metropolitan settings with limited land and space.

Vertical farming can increase food output, preserve food quality and safety, and contribute to urban agriculture that is more sustainable. Environmentally, socially, and commercially, it might be advantageous to cultivate food inside metropolitan areas due to its well-known benefits. Vertical farms may give options for enhancing global food security. Designing and implementing vertical farms is a revolutionary strategy proposed to address the sustainability problem and meet the increasing food demand. Vertical farming is cultivating plants and animals on steeply inclined surfaces, such as those found atop skyscrapers, in areas with limited land and space. Vertical farming may be helpful by boosting food production, protecting food quality and safety, and fostering sustainable urban agriculture. Growing food in urban environments offers several social, economic, and environmental advantages. Increasing global food security may also be accomplished by using vertical farms (Kalantari et al., 2018).

According to Sanchez (2015), As an agricultural country, the Philippines must support equitable development and create more resilient agriculture and food systems that can withstand natural catastrophes and address the consequences of climate change. Constant difficulties in the agricultural sector have resulted in low farm incomes, low rural employment, a lack of food security, and poor agricultural competitiveness. Others included a need for significant measures to assure food security and eliminate rural poverty, a lack of programs to integrate agriculture with industry, and a lack of programs to link agriculture with programs in the private sector.

As stated by Melling (2022), Land conversion is altering the categorization of a piece of land. This is a regular occurrence when raw land is converted to unoccupied land or when vacant land is affected by development. The property's product determines the total land conversion. Land conversions are common in the United States and may be accomplished in various methods, depending on the property owner's ultimate objectives. It is due to the land is often adaptable and may be reused when required.

The Only Way is Up in Vertical Farming

According to Siddique (2022), vertical farming refers to a system in which indoor crops are grown vertically/stacked in towers. The primary objective of this agricultural technique is to enable farmers to cultivate more crops in a restricted area. Vertical farming employs towers filled with crops, refined using natural and artificial light to maintain the optimal light level for plant growth. Vertical agriculture uses up to 95% less water than conventional agriculture. Vertical farming enables producers to raise more food in less area, improving fresh produce supply to meet the rising demand. Vertical farms enable more people to obtain locally farmed vegetables as urbanization expands. Vertical farming permits the production of products with consistent quality and yield. In addition, food cultivated in vertical farms tends to be more nutritious because of the regulated application of plant nutrients. No nutrients are gone to the environment, less equipment serves than in conventional farming, waste is well controlled, and there is no loss of productivity due to weather.

There are several definitions of vertical farming based on size, density, level of control, layout, building type, location, and purpose. Consequently, depending on the stakeholder, vertical farming is considered anything from a marginal crop-producing activity to a critical system for future food security. The interchangeable usage of "vertical farming" as an activity and "vertical farm" as a noun adds to the misunderstanding. Vertical farming may be characterized in its simplest form as the multilayered production of plants to enhance yield per unit space (Gerreway, 2022).

Jacob (2017) mentioned that the cultivation of leafy greens and herbs on stacked trays, in a highly regulated environment such as abandoned buildings or old warehouses, with no sunshine and soil - just LED lights, a tiny quantity of water, and some science. From a modest concept in Dr. Dickson Despommier's 1999 medical ecology class, this crop production technique is gradually

revolutionizing production of food and is becoming one of the solutions to global food shortages. Vertical farming is unlike conventional cultivating crops in vast fields or greenhouses. It is all about maximizing vertical space and maximizing manufacturing efficiency.

Vertical agriculture is a solution altering the food production. It is a controlled-environment agriculture (CEA) in which crops are cultivated inside in vertically stacked rows using LED lighting technology in place of natural sunshine. The three strategies for vertical farming are mentioned here. Vertical farms use up to 99 percent less water than conventional farms, and the minimal amount of water required is recycled and reused inside the indoor system. This is in sharp contrast to conventional agriculture, which currently accounts for 70 percent of global freshwater withdrawals. In dense metropolitan locations, Vertical farming's capacity to produce more food in up to 99 percent less space is incredibly alluring. For example, one business produces 120 pounds of mushrooms each week in a space the size of a bookshelf. Vertical farms may be erected practically everywhere, allowing for local food production in areas where open-field agriculture is not feasible. Vertical farms may provide fresher, safer, and more nutritious produce to surrounding populations in less time by shortening the food supply chain in open land-constrained regions (Fuller, 2021).

Al-Kodmany (2018) observed that Vertical farming allows efficient and sustainable food production, save water and energy, boost the economy, decrease pollution, provide new job possibilities, restore ecosystems, and increase access to healthful food. In a regulated environment, crops will be less vulnerable to climate, pests, the nitrogen cycle, crop rotation, contaminated water runoff, pesticides, and dust. Therefore, indoor agriculture may provide a better environment for growing food. As a result of indoor farming's year-round operation and independence from weather conditions, it might also result in higher yields and permanent revenue. In addition, indoor farming offers a low-impact approach that may save travel expenses and greenhouse gas emissions by shortening the distance between remote farms and local markets. Significantly, vertical farms might aid in resolving the issue of limited cropland. As stated by the Organization for Food and Agriculture of the United Nations, there were 0.42 hectares (1 acre) of arable land per person on the planet in 1961. Due to population increase and urbanization, this number decreased by almost half to 0.23 hectares by 2002. In 2011, the United Nations concluded a worldwide assessment of the world's land resources, concluding that one-fourth of all arable land is severely degraded.

Systems of Vertical Farming

There are different kinds of Vertical Farming Methods, these are the Hydroponics, Aeroponics, and Aquaponics.

Hydroponics is "one of the oldest and most used vertical agricultural techniques." Hydroponic gardeners enable their plants' roots to develop in water solutions rather than soil. The National Park Service (NPS) reports that plants absorb oxygen and nutrients such as phosphorus, nitrogen, and calcium via their roots when exposed to air and a water-based solution. The NPS reported that most hydroponic growers utilize a "growing medium" in place of soil to aid in nutrient absorption by the roots. One of the most significant incentives for greenhouse producers to migrate to hydroponics systems is the system's total cost reductions compared to traditional growing techniques. Typically, a hydroponic system would need less space than a soil-based system, allowing for more room to be used for plant production. Hydroponic growing remains a popular alternative to conventional techniques due to its effective use of limited space due to new modifications to vertical growth and its overall cost savings.

Aeroponics exposes plant root systems to air without using a growth medium. Roots are occasionally misted in lieu of streams or pools of water and dissolved nutrients. Due to the decreased medium usage, the system is more flexible and can be readily flushed or investigated for rooted issues if required. Although initial expenditures may be on the pricier side, the cost to operate the system over time is less than that of traditional methods.

Aeroponics, often seen as a subset of hydroponics, may need more sophisticated equipment and care than some of the more straightforward hydroponic methods. Aeroponic vertical farms provide faster plant development and more agricultural yields per unit area than previous technologies.

Aquaponics is a distinct kind of hydroponics that blends plant growing with fish breeding. According to a publication from the University of Arkansas in Pine Bluff, plants and fish give mutual advantages in an aquaponics system. As vegetation grows, it filters water for fish. In turn, fish excrement that microorganisms have decomposed may serve as plant fertilizer, reducing the requirement for an external source of nutrients.
This implies that aquaponics operations are not suitable for plant-focused producers. Aquaponics is more complex than other kinds of hydroponics due to the intricacy of maintaining perfect settings for plants and fish and feeding and caring for fish (Guida, 2020).

Exploring the Advantages and Disadvantages of Vertical Farming

Advantages Of Vertical Farming

Due to the limited access to land for farming, there is a need for sustainable farming tasks to pave the way for adding to food needs. Numerous factors pressure the food industry and processing, including population growth. The answer to these issues is Vertical Farming (VF). VF has grown as a project combining the design of buildings and farms in a high-rise building. VF is a system of growing crops in skyscrapers to maximize land use by having a vertical design and cultivating plants, animals, fungi, and other living forms for food and fiber by artificially stacking them vertically above each other. Vertical farms are now used in many countries. These farms are primarily grown and produce different types of crops inside cities (Kalantri, 2021).

Gupta and Ganapuram (2022) named that in conventional farming, crops are susceptible to global warming, natural disasters, and weather fluctuations. There is also a tremendous strain on natural resources to feed the ever-increasing population, given the diminishing cultivable area, freshwater, and declining yields. Although vertical farming systems do not enable the production of all types of crops in terms of return on investment, it is one of the most favored options for sustainable crop production. Information and communication technology advancements may make vertical farming a reality. To allow plants to flourish in a simulated indoor environment, combining technologies from diverse fields is necessary. By combining big data analytics, robots, the internet of things, and agro domain simulation/modeling technologies, IT and other technology businesses may create vertical farms cost-effective.

Currently, more than fifty percent of the world's population resides in metropolitan regions. Urbanization will reach 68% of the world's total population by 2050, comparable to an increase of over one million people every ten days (Forman & Wu, 2016).

There is little question that the demand for food and other essential resources (e.g., water and energy) will continue to climb as the global population increases (Seto et al., 2017; Acuto et al., 2018).

Long-term land degradation is another issue that impacts the sustainability of food production. Converting forest or wetland areas is undesirable since it will result in deforestation, soil erosion, increased greenhouse gas (GHG) emissions, and, eventually, the loss of other critical ecosystem services (Qiu & Turner, 2013; Qiu et al., 2018). To satisfy the world's future food security and resource needs, there is a pressing need to investigate creative agricultural technologies that permit the production of more food per unit of land or water while reducing their environmental impacts.

Qiu (2020) quoted that numerous economic, environmental, social, and political benefits of indoor vertical farming are attractive to policymakers and cultivators. If hydroponics or aeroponics are employed as the cultivation technique, there are minimal input needs, such as herbicides and insecticides, and no need for soil. In addition, indoor farming does not need substantial agricultural equipment such as tractors, trucks, and

harvesters. Due to the carefully regulated environment, the output will not be subject to weather-related solid pressures, which may result in yearly yield variation and many quality and yield losses. The potential for year-round production and the absence of seasonality constraints may increase overall yields and biomass per unit of land area, resulting in greater earnings. Due to its reduced land requirements, an indoor farm may be situated close to customers (e.g., in and around cities) to decrease the expenses associated with long-distance transportation. In addition, indoor vertical farming may be combined with other technologies, such as renewable energies (such as solar panels on the top of the growing facility), to minimize energy expenditures. Additionally, recycling gray water may increase water-related advantages (e.g., from stormwater harvesting). Greater fertilizer-use efficiency in a regulated and circular system minimizes nutrient losses and lessens the pollution of freshwater resources (e.g., eutrophication). Other environmental advantages include a decrease in energy use and greenhouse gas emissions from long-distance transportation of food and agricultural supplies (e.g., fertilizer and pesticides). Vertical farming helps prevent carbon and nutrient losses and preserve the long-term health of soils since there is no disturbance to the earth (e.g., traditional tilling). Because it is produced indoors, there is less air pollution-related to its manufacturing (e.g., emissions from large machinery)

There are also significant environmental advantages. Notable instances include the availability of adequate and healthful organic food not tainted with chemicals (i.e., food security). However, the United States Department of Agriculture's organic certification only applies to soil-based goods. The increased water-use efficiency of indoor farms minimizes the demand for freshwater extraction for irrigation. Specifically, it is claimed that indoor vertical farming has up to 350SO more water efficiency and utilizes as little as 1% as much water as typical open-field production methods (Nex, 2018).

Disadvantages Of Vertical Farming

The major disadvantage of vertical farming is the high initial cost of building indoor grow rooms. Large-scale production may benefit from vertical farming more than small-scale farming. It can be less economical than outdoor growing in locations where the environment does not permit year-round cultivation. Additionally, restricting what may be produced, most vertical farms primarily concentrate on high-return and short-rotation crops like salad greens. Growing plants inside increase their vulnerability to illnesses like verticillium wilt, which may kill them and render them unfit for human consumption. There is an excessive dependence on technology, and ideal lighting, temperature, maintenance, and humidity are required (Jenna, 2022).

Operational and capital costs for vertical farming enterprises may be high. Venture capitalists or investment companies often need to invest in more giant vertical farms. Finding an appropriate site may take time, especially in metropolitan regions with high land and construction costs. The cost of growing, harvesting, and perhaps storing the product is included in operating expenditures, as are the labour, energy, and materials required. Energy is often the second-highest operating cost after labour, although additional inputs (such as water, fertilizers, carbon dioxide, transportation materials, and product labelling) are also required. Production costs are anticipated to decrease as the vertical farming sector grows, and production techniques and systems gain popularity (Lubna et al., 2022).

The practice of vertical farming has significant drawbacks. Compared to conventional farming, it is more costly since investing in specific tools and knowledge is needed. The lights are left on throughout the day and use power. Because they need more sunlight throughout their life cycle, vertical farms are less effective than typical farms at producing crops like vegetables or fruits. As a result, it is mainly used to grow leafy greens like lettuce and herbs (Sela, 2022).

Overall

Sustainable food production is required due to the global population's continued fast expansion and the significant increase in food consumption

over the next 50 years. Vertical farming has several benefits over more conventional techniques as an innovative way of growing food. When investigating this technology, several disadvantages must be taken into account. Since vertical farming is a novel idea, it is challenging to assess its long-term sustainability. However, research indicates that a successful business strategy merits funding (Jenna, 2022).

1.4 Statement of the Problem

This study aims to assess and provide a possible design for the construction of vertical farming significant to the increasing demand in agricultural resources and declining of farmlands in our country. Specifically, this sought to answer the following question:

1. Is the Vertical farming structure viable in Brgy. Balibago, Angeles, City, Pampanga?
2. What are the benefits that can be gained by the farmers and urban community in constructing this kind of modernized agricultural buildings?
3. How can it resolve the issue in land conversion and how can it be an alternative way compared to the traditional agricultural methods?

1.5 Objectives of the Study

1.5.1 General Objective

The main objective of this study is to assess the viability of Vertical Farming in Angeles City, Pampanga while addressing the land conversion issues and modernizing the agricultural standpoint.

1.5.2 Specific Objectives

This study aims to achieve the following:

- To assess the advantages acquired by the farmers and urban population in vertical farming.
- To propose a possible design of vertical farm structure in the current land conversion issues and modernized the agricultural system of the local farmers.

1.6 Significance of the Study

The proposed study will be a great help by having a deeper understanding and background in making the design of the vertical farm structures. Thus, it will benefit the following:

Farmers. Vertical farming will be a modernize way of farming and can be an innovative way when it comes to planting seasonal crops, avoiding flood and extreme drought, can control the amount of water and other benefits.

Agricultural Sector. The propose study can be a great help in funding or budgeting the agricultural budget and paving the way to the modernization of farming with respect to the infrastructure use since farmlands are now gradually converted into subdivisions and residential areas.

Construction Industry. The innovative introduction of vertical farm especially here in our country can contribute to the increase of project of the construction industry in terms of helping the production of raw materials and also create a valuable connection to the agriculture by means of providing efficient and effective vertical farmland.

Urban Areas. Urban farming is now introduced to cities but lacks wide area of arable land on the other hand, vertical farm can be beneficial especially to cities having available vacant areas for the construction of the structure, maximizing the given space but producing more crops and also lessen the transportation fee and somehow help in the shortage of foods in the vicinity.

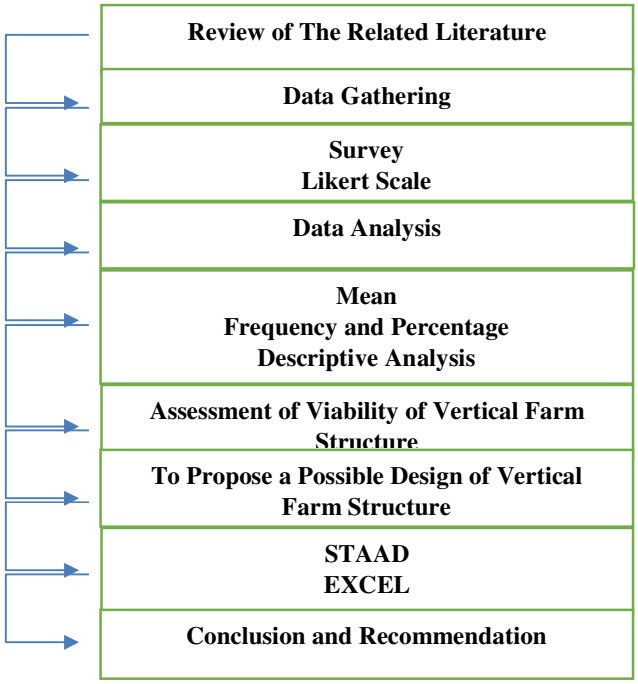
Future Researchers. The study will help the future researchers as basis or guide and can also be a subjected to improvement and alteration that may help our community.

1.7 Scope and Limitations

This research focuses on assessing, designing a possible structure, and promoting vertical farming as a potential alternative to traditional farming and its growing problem of land conversions. The design of the proposed vertical farm will be based on the National Structural Code of the Philippines 2015 (NSCP 2015). The researchers will consider the load required in Pampanga and apply it to the structure's design to withstand loads and ensure its integrity. Furthermore, the researchers conducted their study in Brgy. Balibago, Angeles City, Pampanga.

This research is be limited to assessment, designing a possible structure for vertical farming, and promoting it to the people, specifically the urban community and farmers. Farming methods used in vertical farming, such as hydroponics, aeroponics, and aquaponics, were not utilized in this study. Soil bearing testing is not considered. Additionally, cost benefit ratio is also not included. Furthermore, machine, equipment, and detailed specifications will not be considered because it is outside of the expertise of researchers.

1.8 Conceptual Framework



1.9 Definition of Terms

Aeroponics — the growing of plants by suspending their roots in the air and spraying them with nutrient solutions

Agricultural acreage — the land area that is either arable, under permanent crops, or under permanent pastures

Agro-food goods — centered on **making, processing, preparing and packaging food products for human consumption**.

Agronomists — a branch of agriculture dealing with field-crop production and soil management.

Aquaponics — a system of growing plants in the water that has been used to cultivate aquatic organisms

Automation — the technique of making an apparatus, a process, or a system operate automatically.

Coir — fiber from the outer husk of the coconut, used for making ropes and matting.

Comprehensive Agrarian Reform Law of 1988 (Republic Act No. 6657) — Enacting a comprehensive Agrarian Reform Program to advance social justice and industrialization, establishing the system for its execution, and providing for other reasons.

Cultivating – To prepare land for agricultural production.

Department of Agrarian Reform — Directs the execution of the Comprehensive Agrarian Reform Program (CARP) via land tenure improvement, agrarian justice, and the coordinated delivery of vital client-beneficiary support services.

Dwindle — to become steadily less or to shrink.

Exorbitant — the amount of price charge is unreasonable.

Food and Agriculture Organization — United Nations specialized agency directing worldwide efforts to eradicate hunger. FAO's mission is to ensure that all people have regular access to sufficient quantities of high-quality food and enjoy active, healthy lifestyles.

Fragmented — having related or associated pieces of stored data disorganized in a way that makes them more difficult to access

GHG — Greenhouse Gas

Holistic — relating to or concerned with wholes or with complete systems rather than with the analysis of, treatment of, or dissection into parts.

Horticulture — the science and art of growing fruits, vegetables, flowers, or ornamental plants.

Hydroponic — the process of growing plants in sand, gravel, or liquid. Also known as aquaculture or tank farming, began as a way of studying scientifically the mechanisms of plant nutrition.

Imperil — to bring into peril.

Industrialization — the act or process of industrializing **:** the widespread development of industries in a region, country, culture, etc.

Irrigation — the watering of land by artificial means to foster plant growth

NFT — Nutrient Film Technique

Nutrient Film Technique — a hydroponic growing method that uses a continuous stream of nutrient solution to nourish plants

Philippine Statistics Authority (PSA) — Be in charge of all national censuses and surveys, sectoral statistics, community-based statistics, consolidation of chosen administrative recording systems, and preparation of national accounts.

Scarcity — the quality or state of being scarce. especially: want of provisions for the support of life.

Unequivocal — leaving no doubt: Clear, Unambiguous.

Unequivocally — in an unequivocal manner

Urbanization — the process through which cities grow, and higher and higher percentages of the population who comes to live in the city

Wholesome — promoting health or well-being of mind or spirit/promoting health of body/ sound in body, mind, or morals.

II. METHODOLOGY

2.1 Phase 1 – Methodological Framework

2.1.1 Research Design

This study employs a mixed methodology, including both quantitative and qualitative research, to reach a result. The advantage of mixed methods research is that it capitalizes on the strengths of each data source while compensating for its shortcomings. Researchers integrate qualitative and quantitative methodologies to broaden their evidence, enhance the credibility of their conclusions, and show the results of one method with the results of the other.

2.1.2 Respondent

Vertical farming company and urban people of Angeles, Pampanga with an age of 18 and above, were chosen to be respondents and can participate in the research. The researchers picked the participants to get their views vertical farming and inform them of its future benefits.

2.1.3 Research Instrument

The researchers utilized two instruments which are surveys and interviews to effectively gather relevant data. The question constructed by the researchers is based on objectives and the statement of the problem. Interview is a face-to-face dialogue between a researcher and a participant in which information is transferred to the interviewer.

Surveying is the process by which the researcher collects data through a questionnaire. 4-point Likert scale was utilized in survey questions. A Likert scale is a rating system used to quantify attitudes, actions, and views. Following a statement or a question, there are a set of five or seven answer statements. 1.0-1.75 (Strongly Disagree), 1.76-2.50 (Disagree), 2.51-3.25 (Agree), and 3.26-4.0 (Strongly Agree) were used for the Scale. Respondents select the choice that most accurately reflects their feelings toward the statement or topic.

2.1.4 Sampling Size

The researchers utilized Raosoft for the computation of sampling size. It is a sophisticated web survey and form application developer. This program evaluates the information generated from a sample to determine the smallest sample size possible for the analysis. The software calculated a total minimum of 381 respondents out of 42,274 total population of Brgy. Balibago, Angeles City, Pampanga.

2.1.5 Sampling Technique

Convenience sampling was chosen by researchers as a sampling technique for the collection of data. It is a technique for collecting data that is conveniently positioned around an area. Convenience sampling entails selecting respondents based on their proximity to the researcher. There is no pattern in obtaining these respondents; they can be collected simply by asking individuals on the street or in public.

2.2 Phase 2 – Data Collection

For the effective collection of data, researchers considered different types of systematic methods. The researchers carefully measured, observed, and analyzed accurate information to support the projected data. Data collection took place outside the university premises. Letters are

prepared and constructed by the researchers to inform the school to facilitate surveys and interviews. Questionnaires are prepared, given to the chosen respondents and discussed so they can answer with full knowledge and awareness and interviews will be conducted. The question constructed by the researchers is based on objectives and the statement of the problem. The researchers gathered and tallied the data for analysis after the respondents completed the questionnaire.

2.3 Phase 3 – Data Analysis

The researchers considered frequency and percentage and mean for the interpretation of the data gathered by the researchers as a research instrument for survey results. Wherein mean one of the most significant and often employed metrics of central tendency is the mean. To calculate the mean for a specific collection of observations, the sum of all the values in the data is divided by the total number of values in the data. While frequency distributions can display the proportion of observations or the actual number of observations that fall inside each range. The distribution is known as a relative frequency distribution in the latter case. Both category and numerical variables can be employed using frequency distribution tables.

2.4 Phase 4 – Design Procedures

The researchers utilized AutoCAD to create a floor plan for the Vertical farm structure layout design. Using the NSCP 2015 approved formulae, the total factored loads were determined and applied. The structural design of the vertical farm is investigated using Excel and STAAD structural software. STAAD is a computer software for structural analysis and design created in 1997 by Research Engineers International in Yorba Linda, California. Using STAAD Pro, you can build any structure and confidently communicate synchronized model data with your design team. Ensure that your steel, concrete, wood, aluminum, and cold-formed steel projects are completed on schedule and under budget, regardless of their complexity. Using over 80 international codes, you may safely design buildings anywhere, avoiding the need for employees to master numerous software package (Dibyandu Pal, 2019).

Codes and Specifications

The researchers will consider the following provision and codes for the design of the proposed structure. Following the requirements will ensure the safety and strength of the structure, where it can withstand all the applied loads. Incorrectly designed elements of a building may collapse, resulting in catastrophic effects such as high costs or, in the worst-case situation, the loss of life, which cannot be compared to any expense. All section under every provision will be utilize.

1. National Structural Code of the Philippines 2015 or (NSCP2015) Volume 1: Buildings, towers and other Vertical Structures.

2.4.1 Chapter 2: Minimum Design Loads

Minimum Design Loads lays out the requirements for general structural design and the methods for determining dead, living, soil, flood, wind, snow, rain, and atmospheric ice loads, as well as their combination loads appropriate for inclusion in building designs.

2.4.2. Loads

Loads are the forces that result in stresses, deformations, or accelerations. When applied to a structure or its components, these loads cause strain or displacement as a result of the building's self-weight, including permanent loads known as Dead Loads, occupancy or non-permanent loads known as Live Loads, and earthquake loads known as Seismic Loads.

2.4.3. Dead loads (Section 204 of the NSCP 2015)

Dead loads, also known as persistent or static loads, consist of those loads that generally stay constant across time. Dead loads are the weight of a structure's parts, such as beams, walls, roofs, and structural flooring components. Furthermore, transaction load may also include permanent non-structural walls, immovable fixtures, and even built-in cabinets.

2.4.4. Live Loads (Section 205 of NSCP 2015)

Live loads are the forces generated by occupancy and planned usage. They indicate the forces actively moving through the structure or acting on a specific structural element. These loads are also measured in PSF and include the projected

weight of people, furniture, appliances, autos, and other items. Live loads shall always exceed the loads specified in Section 205 of the NSCP 2015 and must correspond to the expected maximum loads for the intended use or occupancy.

2.4.5 Wind Loads (Section 207 of NSCP 2015)

As the wind blows against a structure, the resultant force exerted on the heights is known as the wind load. To prevent structural collapse, the building's structural design must absorb wind forces safely and effectively and transmit them to the foundations. As stipulated in sections 207A through 207F of the NSCP 2015, buildings and vertical structures must be designed and built to withstand wind loads.

In solving for wind loads, the researchers will determine the occupancy category of the building, basic wind speed in the area, and wind load, including wind directionality factors, exposure effect, and topographic factors. Lastly, the velocity exposure coefficient, which are parameters based on the code and requirement of section 207 of the NSCP 2015.

2.4.6 Earthquake Loads (Section 208 of NSCP 2015)

Earthquake load occurs owing to the inertia force generated by seismic excitations in the structure—the force of inertia changes with mass. The greater building mass implies that the seismic loading will likewise be substantial. When the earthquake load exceeds the element's moment of resistance, the structure will shatter or be damaged. In the Philippines, due to the country's specific location in a high seismic-risk zone, it is crucial to consider seismic influence while constructing structures. The goal of the earthquake provision is to design a structure resistant to earthquakes to prevent property and life losses. The code will be based on the section 208 of NSCP 2015.

III. RESULTS AND DISCUSSIONS

This chapter contains the analysis, presentation and interpretation of the findings resulting from this study. Each table aims to answer each objective listed in the previous chapter of this study.

3.1 Results of Survey

Table 1. Knowledge Assessment about Vertical Farming on Residents of Angeles City

	Yes		No	
	n	%	n	%
Do you have an idea about vertical farming?	127	32.6	262	67.4
Do you know the difference about traditional farming and vertical farming?	126	32.4	263	67.6
Are you willing to learn about vertical farming?	363	93.3	26	6.7
Are you willing to adapt vertical farming in the future?	368	94.6	21	5.4
Do you prefer vertical farming than traditional farming?	352	90.5	37	9.5

Results show that majority of the residents have no idea about vertical farming (67.4%) as well as not aware of its difference to traditional farming (67.6%). On the other hand, majority of the residents are willing to learn about it (93.3%), willing to adapt it in the future (94.6%) and prefer vertical farming than traditional (90.5%).

Table 2. *Vertical Farming Cost Evaluation*

	Mean	Interpretation
Vertical farming is an affordable way to reduce the environmental impact of food production	3.18	Agree
I am aware that it may have a possibility that cost more but will produce a quality structure for farming	3.27	Strongly agree
Vertical farming helps my community reduce its reliance on imported food products	3.36	Strongly agree
The cost of operating a vertical farming system is worth the benefits it provides	3.42	Strongly agree
Vertical farming has a relatively low cost of production compared to traditional farming	3.24	Agree
Vertical farming is an economical way to provide fresh, healthy food to my local community	3.35	Strongly agree
I think that vertical farming is a good way to reduce the cost of food production	3.26	Strongly agree
Overall mean	3.30	Strongly agree (Very Positive Perception)

Overall mean of 3.30 suggest that they strongly agree on the positive attributes about vertical farming cost, implying that their perception is at very positive level. Among the seven attributes, five are rated as strongly agree while remaining two are agree. Highest mean is 3.42 which denotes a strong agreement that the cost of operating a vertical farming system is worth the benefits it

provides. On the other hand, lowest mean is 3.18 which suggest that they agree that vertical farming as affordable way to reduce the environmental impact of food production. These results show that respondents believe that the believe that the benefits of the vertical farming outweigh the cost associated with it.

Table 3. *Perceptions of Residents on Traditional and Vertical Farming*

	Mean	Interpretation
Vertical farming is more cost-effective than traditional farming	2.53	Agree
Vertical farming minimizes land usage compared to traditional farming	3.47	Strongly agree
Vertical farming eliminates the need for transportation costs associated with traditional farming	3.35	Strongly agree
Vertical farming is an efficient way to maximize crop yields compared to traditional farming	3.35	Strongly agree
Vertical farming is less labor-intensive than traditional farming.	3.38	Strongly agree
Vertical farming uses less water than traditional farming	3.39	Strongly agree
Vertical Farming Overall mean	3.81	Strongly agree (Very Positive Perception)

They only agree to the statement that Traditional farming is more cost-effective than vertical farming (2.53) while overall mean on perception about vertical farming obtained a mean of 3.59. This denotes that their perception on traditional farming is still positive while very positive for vertical farming. All five positive attributes related to vertical farming all obtained a strong agreement rating. Highest mean is 3.47 which is about vertical farming minimizing land usage compared to traditional farming. Lowest mean is 3.35 about how it eliminates the need for transportation cost, as well as it is efficient to maximize crop yields. Furthermore, these results show that the Residents would prefer vertical farming over traditional farming methods.

Table 4. *Perceptions of Residents about Urbanization*

	Mean	Interpretation
Urbanization can lead to overcrowding in cities	3.42	Strongly agree
Urbanization leads to increased pressure on resources	3.46	Strongly agree
Urbanization increases the cost of living	3.41	Strongly agree
Urban development has reduced the availability of farmland for local farmers	3.43	Strongly agree
The Urbanization resulted in substantial land conversion, which in turn, led to a drastic decrease in crop production	3.35	Strongly agree
Urbanization brings with it improved technology which can be used to increase crop yields and improve the quality of food crops	3.42	Strongly agree
Urbanization can lead to reduced access to markets for agricultural products, which can reduce farmers' incomes	3.31	Strongly agree
Urbanization has resulted in a decrease in the number of agricultural workers, leading to a decrease in agricultural productivity	3.39	Strongly agree
Overall mean	3.40	Strongly Agree (Very Negative Perception)

Overall mean of 3.40 suggest that they have very negative perception about urbanization. The statement "Urbanization brings with its improved technology which can be utilized to increase crop yields and improve the quality of food crops" was reversed before computing overall mean as agreeing to this statement implies a positive perception, which is not parallel to the rest of the statements. They strongly agree on all the attributes, where highest mean is 3.46 which is about how it leads to increased pressure on resources Lowest mean is at 3.31, which is about their strong agreement that urbanization can lead to reduced access to markets for agricultural products, reducing farmer's income. Additionally, the results shows that respondents are aware that urbanization puts pressure on the resources and agricultural sector due to continuous increase in population.

Table 5. *Perception of Residents About Land Conversion*

	Mean	Interpretation
The loss of farmland in my town is a concern to me	3.55	Strongly agree

A combination of market-driven and regulatory measures should be the primary strategy	3.53	Strongly agree
Conversion of land for non-agricultural use reduces the amount of land available for agricultural production	3.37	Strongly agree
Land conversion has a negative impact on the viability of agricultural operations	3.42	Strongly agree
Land conversion can lead to a decrease in food production	3.46	Strongly agree
Overall mean	3.47	Strongly Agree (Very Negative Perception)

Resulting overall mean is 3.47 implying a very negative perception of residents about land conversion. Highest mean is 3.55 which suggest a strong agreement that the loss of farmland in their town is a concern to them. The lowest mean is 3.37, implying that they strongly agree that conversion of land for non-agricultural use reduces the amount of land available for agricultural production. Moreover, the results shows that respondents are aware of the negative effects of land conversion to arable or existing farm lands.

***3.2** Interview Interpretation*

According to the company representative, the maintenance requirements for a vertical farm vary depending on the area, number of crop-supporting towers, and boards. Electricity is included if the vertical farm is located within a facility or building. Furthermore, the exact amount of maintenance expenses incurred on a monthly basis is not disclosed. However, these expenses can be offset by sales.

The company representative stated that they did not have precise data or figures regarding the daily water usage of crops. They use a technique which can recycle surplus water through reverse pumps for absorption. It is estimated that the quantity of water transpired daily by aeroponics is 1 1/3 cups. However, the majority of crops grown indoors require an amount ranging from 1/4 to 1/3 cups of water per square foot each day. It is noteworthy that the amount of water consumed may vary in accordance to the type of crops, their needs and specifications. For a pod to be deemed as a good-quality crop, each plant must weigh a minimum of 30 grams. Devices and electronics are employed to monitor crops, and they are harvested every 45 days to ensure their quality. Furthermore, 500 sq meters of land will allow a farmer to construct 12 towers which have a height of a 4-storey building. These 12 towers can produce 108,000 holes for the cultivation of crops. It is equivalent to 5 hectares using traditional or horizontal farming.

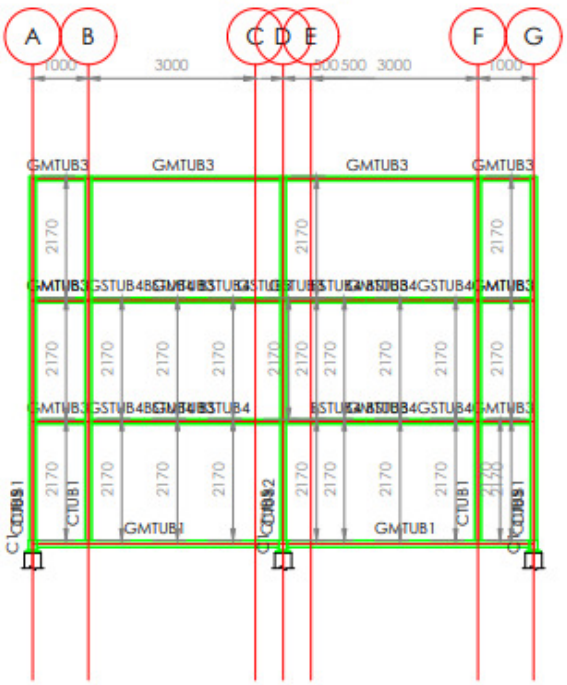
As stated by the company representative, For the Return of Investment or Return on Cost it takes 1 year and 6 months. The price range of the crops depends on the area. In cities and urban areas, the harvest price band is 350 per kilo. Province rate differs; harvested crop's price band is between 250 to 300 per kilo.

According to the company representative, it is the future for Urban Communities. Vertical farming can allow the cultivation of plants/crops on rooftops of houses and buildings or in the extra space of our property. Additionally, vertical farming also uses much less land. For some crops, compared to open-field crops, 10 to 20 times the yield can be obtained per acre in vertical farming. Other advantages are that vertical farms are enclosed structures not subject to extreme or inclement weather. Vertical farms are built in deserts, high-population urban areas, and other places where traditional open-field farming is impractical.

Furthermore, this will reduce transportation cost and environmental pollution. Additionally, they also discussed the advantages that this would provide for the customers, such as fresher produce, lower costs, and a more consistent supply of crops. The company representative points out that innovation is necessary to prepare for the future, as urban areas are becoming more populated and farmlands are decreasing. It is believed that this will eventually lead to a food crisis and that innovative solutions must be implemented to ensure Filipinos have access to the necessary agricultural supplies. Implementing modern technology in the agriculture

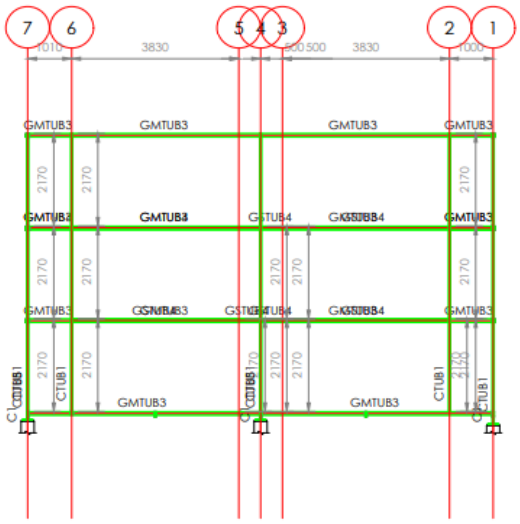
industry will not negatively impact farmers; vertical farming is not intended to compete with traditional farming. It focuses on the benefits of vertical farming technology and ensuring food security. Furthermore, the use of modern technology will create new job opportunities. The Company Representative stated that vertical farming is the future. People cannot just rely upon the current situation the country is in. They pointed out that there is an increasing population and infrastructure. As a result, it is vital to innovate Philippine agriculture with vertical farming and to give people ideas on contributing to the crisis that may be experienced over time.

3.3 FLOOR PLAN



ELEVATION ON GRID 7

(SCALE 1:100)



ELEVATION ON GRID A

(SCALE 1:100)

3.5 STRUCTURAL ANALYSIS

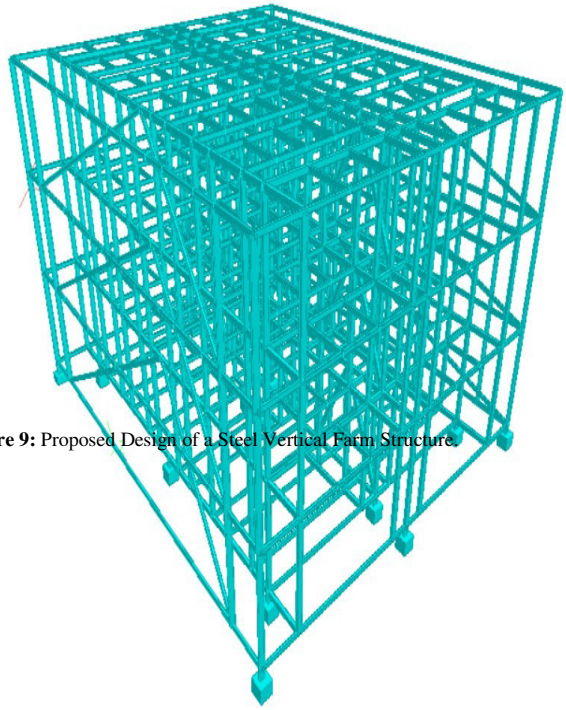
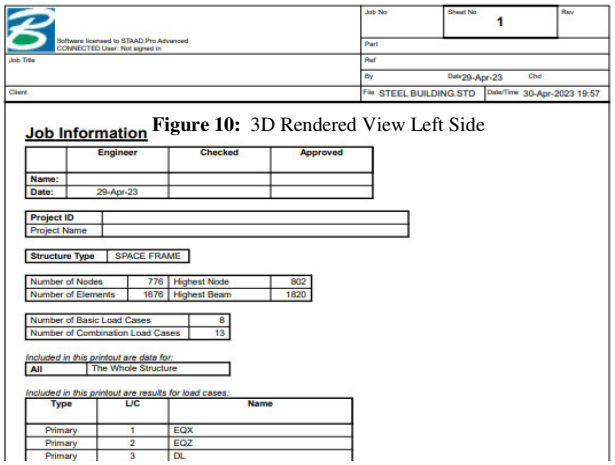


Figure 9: Proposed Design of a Steel Vertical Farm Structure.



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Job Title		Job No	Sheet No 1 / Rev
		Part	
		Ref	
Client		By / Date 29-Apr-23 / Chd	
		File STEEL BUILDING.STD / Date/Time 30-Apr-2023 19:57	

Job Information

	Engineer	Checked	Approved
Name:			
Date:	29-Apr-23		

Project ID	
Project Name	

Structure Type	SPACE FRAME

Number of Nodes	776	Highest Node	802
Number of Elements	1676	Highest Beam	1820

Number of Basic Load Cases	8
Number of Combination Load Cases	13

Included in this printout are data for:

All	The Whole Structure

Included in this printout are results for load cases:

Type	L/C	Name
Primary	1	EQX
Primary	2	EQZ
Primary	3	DL

Figure 10: 3D Rendered View Left Side

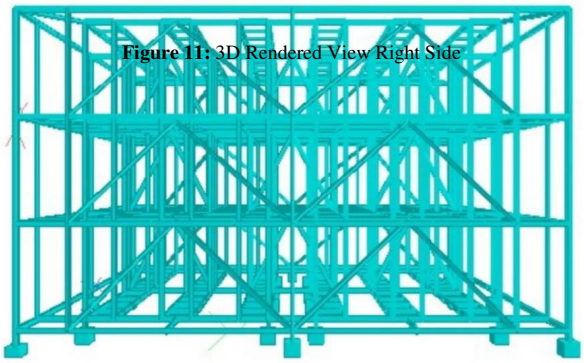

Figure 11: 3D Rendered View Right Side

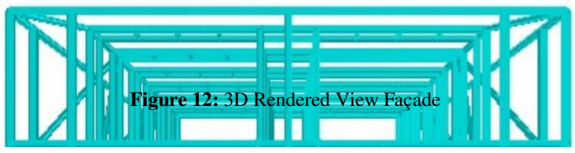

Figure 12: 3D Rendered View Façade

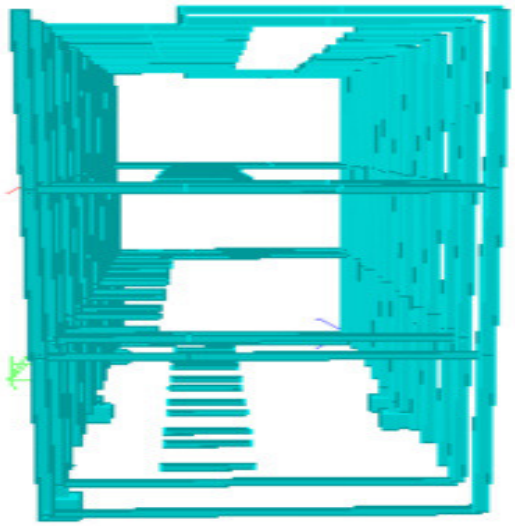

Figure 13. 3D Rendered of Tower

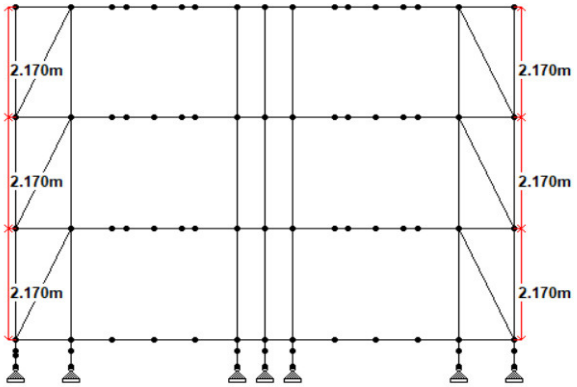

Figure 14. Size Meter per Floor

It is a 3-storey lattice steel structure with a height of 6.51m, a width of 9m, and 10.67m in length. The structure has an area of 96.03m^2 and Total Volume of 625.16m^3 the steel structure contains 12 towers that can hold up to 35 xps board each Each tower has a 21-foot height, a width of 3 feet, and a length of 10 feet. Overall, it has 75,600 slots for crop equivalenting in 4 hectares in traditional farming.

Results

			Horizontal	Vertical	Horizontal	Moment		
	Node	L/C	Fx kN	Fy kN	Fz kN	Mx kN-m	My kN-m	Mz kN-m
Max Fx	723	8 ULC, 1.2 DEAD + 1.6 LIVE	10.209	78.795	-0.079	0	0	0
Min Fx	724	12 ULC, 1.2 DEAD + 1 LIVE + 1.0 WIND (1)	-20.607	121.179	0.018	0	0	0
Max Fy	692	8 ULC, 1.2 DEAD + 1.6 LIVE	-2.535	183.862	6.945	0	0	0
Min Fy	723	5 WX	-14.297	-68.277	0.094	0	0	0
Max Fz	692	8 ULC, 1.2 DEAD + 1.6 LIVE	-2.535	183.862	6.945	0	0	0
Min Fz	689	13 ULC, 1.2 DEAD + 1 LIVE + 1.0 WIND (2)	-0.572	27.858	-19.764	0	0	0
Max Mx	678	1 EQX	-0.281	-4.845	-0.293	0	0	0
Min Mx	678	1 EQX	-0.281	-4.845	-0.293	0	0	0
Max My	678	1 EQX	-0.281	-4.845	-0.293	0	0	0
Min My	678	1 EQX	-0.281	-4.845	-0.293	0	0	0
Max Mz	678	1 EQX	-0.281	-4.845	-0.293	0	0	0
Min Mz	678	1 EQX	-0.281	-4.845	-0.293	0	0	0

Displacement

	Horizontal	Vertical	Horizontal	Resultant	Rotational		
L/C	X mm	Y mm	Z mm	mm	rX rad	rY rad	rZ rad
12 ULC, 1.2 DEAD + 1 LIVE + 1.0 WIND (1)	25.854	-0.031	0.076	25.855	0	0	-0.003
8 ULC, 1.2 DEAD + 1.6 LIVE	-3.796	-0.059	-0.111	3.798	0	0	0
6 WZ	0.033	2.189	3.39	4.035	0	-0.001	0.002
8 ULC, 1.2 DEAD + 1.6 LIVE	-0.053	-5.778	-0.087	5.779	0	0	0
13 ULC, 1.2 DEAD + 1 LIVE + 1.0 WIND (2)	-0.405	0.26	7.893	7.907	0	0	0
12 ULC, 1.2 DEAD + 1 LIVE + 1.0 WIND (1)	17.99	1.617	-0.816	18.081	-0.001	0	0
6 WZ	0	0	0	0	0.009	0.002	0
8 ULC, 1.2 DEAD + 1.6 LIVE	-0.011	-2.18	0.083	2.182	-0.003	0	0
6 WZ	0.061	0.012	3.69	3.69	0.002	0.002	0
12 ULC, 1.2 DEAD + 1 LIVE + 1.0 WIND (1)	19.625	-1.863	0.074	19.714	-0.001	-0.002	-0.002
8 ULC, 1.2 DEAD + 1.6 LIVE	-0.153	-3.956	-0.024	3.959	0	0	0.003
12 ULC, 1.2 DEAD + 1 LIVE + 1.0 WIND (1)	0	0	0	0	0	0	-0.006
12 ULC, 1.2 DEAD + 1 LIVE + 1.0 WIND (1)	25.854	-0.031	0.076	25.855	0	0	-0.003

Beam Results

	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kN-m	My kN-m	Mz kN-m
Max Fx	1470	8 ULC, 1.2 DEAD + 1.6 LIVE	111	183.862	2.535	-6.945	0	3.473	1.267
Min Fx	1527	5 WX	715	-68.277	14.297	-0.094	0	0.047	7.149
Max Fy	1768	12 ULC, 1.2 DEAD + 1 LIVE + 1.0 WIND (1)	784	-29.968	35.048	14.362	-0.157	-2.702	9.506
Min Fy	148	12 ULC, 1.2 DEAD + 1 LIVE + 1.0 WIND (1)	786	-29.678	-37.608	-15.059	-0.433	-2.788	9.721
Max Fz	1467	13 ULC, 1.2 DEAD + 1 LIVE + 1.0 WIND (2)	60	27.858	0.572	19.764	0	-9.882	0.286
Min Fz	124	12 ULC, 1.2 DEAD + 1 LIVE + 1.0 WIND (1)	784	15.196	-35.042	-17.305	0.18	-2.962	9.097
Max Mx	557	12 ULC, 1.2 DEAD + 1 LIVE + 1.0 WIND (1)	319	-0.172	6.532	-16.666	1.128	4.878	2.874
Min Mx	547	12 ULC, 1.2 DEAD + 1 LIVE + 1.0 WIND (1)	30	-0.128	-7.512	16.712	-1.194	-3.457	-0.858
Max My	557	12 ULC, 1.2 DEAD + 1 LIVE + 1.0 WIND (1)	319	-0.172	6.532	-16.666	1.128	4.878	2.874
Min My	1467	13 ULC, 1.2 DEAD + 1 LIVE + 1.0 WIND (2)	60	27.858	0.572	19.764	0	-9.882	0.286
Max Mz	1754	12 ULC, 1.2 DEAD + 1 LIVE + 1.0 WIND (1)	716	-33.237	-14.044	0.044	-0.024	0.03	11.721
Min Mz	1753	5 WX	715	19.528	-11.6	-0.077	-0.002	0.049	-9.374

Reactions

IV. DISCUSSION

4.1 Conclusion

This research focuses on assessing the viability of vertical farming structure in Balibago, Angeles City, Pampanga. The study's findings show that residents living in Balibago have not yet learned about vertical farming but are willing to know about it. The majority of them responded that they are eager to adopt it in the future. An overall mean of 3.39 implies a very positive perception of vertical farming.

This study found that vertical farming is a viable option for Balibago, Angeles City, Pampanga. It offers a cheap and ecologically sustainable way to address the city's demands for food security. Moreover, the city's geographical location and diverse climate make it suitable for implementing vertical farming. The city's population growth and land scarcity could also be addressed by vertical farming, as it offers a way to increase food production without expanding the city's agricultural land.

Finally, vertical farming has the potential to create jobs and stimulate the local economy, as the production of crops could be done in-house and sold to the local market. Thus, this study concludes that vertical farming is a viable option for Balibago, Angeles City, Pampanga.

We need to innovate in the present for the future. It may not be necessary at this time but

due to increasing population and demand endangering the food security eventually, this will become a solution to the foreseen food crisis and sustain the daily needs of the Community in terms of agricultural supply.

ACKNOWLEDGMENT

This study would not have been possible without the guidance and help of several individuals who in one way or another contributed and extended their valuable assistance in the preparation and completion of this study. The researchers would like to extend their deepest gratitude and appreciation to the following individuals.

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