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Introduction and Potential of Protected Horticulture in the Philippines: A Review

Jaypee H. Estigoy*, Kyung Hwan Yeo†, Yoonhee Seo***, and Seonghoe Jang***†**

**Agricultural Science and Technology School, College of Education, Central Luzon State University, Science City of Muñoz, Nueva Ecija, The Philippines*
***National Institute of Horticultural and Herbal Science (NIHHS), Rural Development Administration (RDA), Wanju-gun, Republic of Korea*
****World Vegetable Center Korea Office, Wanju-gun, Republic of Korea*

필리핀의 시설원예 소개 및 잠재력

Jaypee H. Estigoy* · 여경환† · 서윤희*** · 장성회***†**

*Agricultural Science and Technology School, College of Education, Central Luzon State University
**농촌진흥청 국립원예특작과학원 채소과
***세계채소센터 한국사무소

ABSTRACT: Protected agriculture has great potential for the vegetable industry in the Philippines as it allows the application of modern cultivation techniques to mitigate adverse weather conditions and enable farmers to manage pests and diseases efficiently. Thus, to address the increasing demand for food in the Philippines, one strategy to increase vegetable production which is tested and/or proven is through the intensified use of protective structures. This review describes the magnitude and potential of agriculture in the Philippines, focusing on the protected cultivation of horticultural crops. The Philippines is far behind in greenhouse technologies compared to other Asian countries where thousands to millions of hectares are used for protected vegetable cultivation. Several studies have investigated the economic viability and applicability of low- and high-cost protective structures in typhoon-prone countries such as the Philippines, demonstrating that protective structures are feasible and profitable. Also, the impact of protected cultivation as compared to the open field has resulted in significantly higher yield and better quality of produce. Hence, the Philippine government with the assistance of the Republic of Korea agreed to improve the country's flagging vegetable industry and endeavor to attain the status of a food-secure country through the establishment of smart greenhouse technologies. Overall, despite the limitations due to the high cost of electricity and construction protected cultivation facilities including required technologies provide greater advantages for seasonal and off-seasonal vegetable crop production compared to that in the open field. Moreover, such technology can be applied to various geographical locations such as plains, hills, deserts, rural, and urban areas.

Key words: Horticultural crops, Protected agriculture, The Philippines, Protective structures, Vegetables

INTRODUCTION

The Philippines is essentially an agricultural country with a land area of 298,170 km^2 (World Bank, 2021), about 47% of which is earmarked for agriculture (Perlas,

†Corresponding author
(Phone) +82-63-238-6663
(E-mail) khyeo@korea.kr
(Phone) +82-63-238-6677
(E-mail) seonghoe.jang@worldveg.org
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2020). Many people in the country are dependent on agriculture as their primary source of income supporting themselves through farming activities. In 2020, a total of around 13.42 million hectares were devoted to agricultural crop cultivation (Statista, 2022), and this generated a gross value added (GVA) of about 1.78 trillion Philippine pesos (32.4 bn. USD) equivalent to 10.2% of the country's gross domestic product (GDP) (Statista, 2021). The Philippines Statistics Authority (PSA) reported in 2020 that the total number of Filipinos employed in agriculture over a five-year reference period was about 9.7 million (PSA, 2021). In Southeast Asia, although rice is the major crop produced and has a significant function in ending hunger and malnutrition (IRRI, 2020), the cultivation of vegetables is one of the main sources of income for millions of Filipino vegetable growers (FAO, 2014); the Crop Production Survey (CPS) estimated that from October to December 2021, 78,849 hectares were utilized for the production of major vegetables and other root crops (PSA, 2021).

Generally, Filipinos farmers produce vegetables in the open field, which is imperiled by hostile climatic conditions, pests, and diseases. These factors have impacted food security, food safety, and the quality of produce for a long period of time. Compared to nearby modern countries, the Philippines has not adopted modern technologies to solve the endless food crisis. Filipinos were rated as poor adopters of technology in a report by the Australian Center for International Agricultural Research (ACIAR, 2021). Protected cultivation of vegetables is a technology that is common in many countries for the production of various vegetables irrespective of the season. In the Philippines, protected cultivation is in the development stage, and is not normally practiced among farmers despite its potential for higher yield and safer produce (Gonzaga et al, 2017).

Crop commodities in the Philippines are very low in terms of yield compared to neighboring countries (Dogello and Cagasan, 2021). Thus, Filipinos are at a higher risk for low consumption of vegetables than others in the Southeast Asian region (Peltzer and Pengpid, 2012). In general, low agricultural productivity can be alleviated through government-supported programs such as full access to credit or agricultural loans, and agriculture-related microfinancing for agricultural producers, fisherfolks, and stakeholders since most farmers are incapable of fully financing their crop production costs. Moreover, crop insurance can protect farmers from losses due to natural calamities and biological infestations (Dogello and Cagasan, 2021).

The World Health Organization (WHO) recommends consuming a minimum of 200-250 g of vegetables daily to meet the nutrient demand. However, vegetable consumption per capita in the Philippines is below the dietary guidelines (Our World in Data, 2017). Overweight and malnourishment in Filipinos is most likely due to imbalanced nutrition. Thus, the vegetable industry in the Philippines is an important and promising business, with high potential for local consumers and international markets.

Producing horticultural crops including vegetables under a protected cultivation system should be required for most vegetable farmers in the Philippines when considering food safety, better yield quality, and food security. Indeed, the Philippines is vulnerable to natural calamities including frequent and strong typhoons. Heavy rainfall varies from 965 to 4,064 mm annually (DOST-PAGASA), furthermore, there are scorching temperatures during summer, pests and disease outbreaks. Furthermore, poor vegetable varieties are cultivated, and farmers have limited skill sets. A further exasperating problem is that farming populations are aging in spite of increasing population numbers. Despite a growth rate of 1.36% (World Population Review, 2022), 24% of farmers are within the 55-64-year-old range while 16% are more than 65 years old (Palis, 2020).

Moreover, protective structures such as highly equipped greenhouses require a high investment cost for the initial structure, reflecting technical aspects such as managing temperature, humidity, and irrigation systems together with proper operations (Gruda et al., 2019). Nonetheless, using a protective structure for horticultural crop cultivation in the Philippines have the potential to open up extraordinary opportunities for many related industries since various technologies such as organic production, hydroponic and aquaponic systems, and smart farming techniques can be applied to the protective structure.

THE MAGNITUDE OF PROTECTED CULTIVATION

Agriculture has always been considered to be the backbone of the Philippine economy (Business Mirror, 2021). However, based on the Department of Agriculture (DA) statement, the import-dependency of agricultural products in the country gradually increased in 2016, 2017, and 2018 at 22.5%, 22.7%, and 29.2%, respectively (PSA, 2020). According to the World Bank data, the country imported vegetables valued at USD1034.09 million from the United States (WITS, 2019), and also imported from the ASEAN countries including Malaysia, Indonesia, Vietnam, and Thailand (JICA, 2019). One strategy that can be used to increase the production of vegetables in the Philippines is the intensified use of protective structures. But although protected cultivation was introduced into the Philippines about 40 years ago, greenhouse technology has not been upscaled.

Upscaling would potentially safeguard the year-round

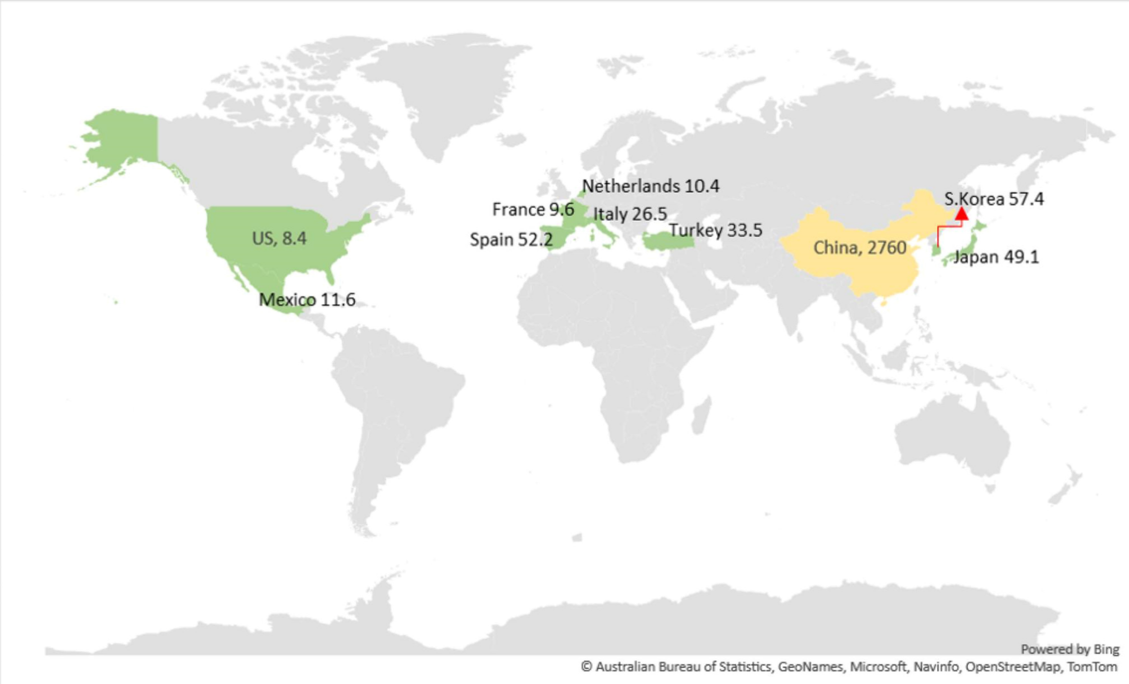

Fig. 1. The estimated hectarage of 10 major countries with protected agriculture in the world. China has the largest area of protected agriculture. Unit: kilohectare; kha. Source: Kacira, 2011; Nair and Barche, 2014.

production of common and high-value vegetables in the Philippines, hence aiding in sustaining the supply of food. The climatic conditions in the Philippines are extremely unfavorable to crop cultivation in the open field, resulting in the inconsistency of crop productivity and quality. In the wet season (June to November), excess rains and high winds are serious issues for growing vegetables in the field causing flooding and field damage (Castillo *et al*, 2021). Protected cultivation ensures the protection of the crops from extreme weather conditions as it can relieve the harmful effect of unfavorable environmental conditions for proper plant growth and development. Globally, the area used for protected agriculture for horticultural crops is estimated at 5, 630,000 ha (Cuesta Robles, 2019). In 2011, China had the greatest land area of protected cultivation, with more than 2,760, 000 ha; this area is continuously being increased every year. The second largest area is found in South Korea with more than 57, 444 ha, followed by Spain with 52,170 ha (Figure 1). The Philippines thus has great potential and opportunity for the development of protected cultivation of vegetables.

VEGETABLE PRODUCTION IN SOIL UNDER THE PROTECTIVE STRUCTURE

Most of the Philippines' vegetable crops are cultivated in the open field, leaving the plants exposed to various chemical elements in the surrounding environment. In general, organic vegetable growers in the Philippines, particularly in Central Luzon are small-hold farmers with less than 2 ha of farmland. In a survey conducted in Central Luzon, Philippines, 16.8% of the 72 organic vegetable growers responded that cultivating organic vegetables under protected structures is unaffordable, and it is disadvantageous for farmers due to a lack of knowledge of greenhouse cultivation techniques (Porciuncula, *et al*. 2015).

Economic analyses of the greenhouse technology demonstration farm in the Central Luzon State University, Philippines using the Israel Negev model showed that the farm was profitable for growing high-value crops such as honeydew melon (Sace, 2002). The study revealed that the payback period would be achieved within 3.34 years for ten cropping seasons with an expected 30% internal rate of return (IRR). This means that the project's initial investment would have earnings of a 30% compound growth annual rate. In addition, a recent study reported that protected cultivation contributes to increased yield and quality of products as well as income for vegetable growers (Castillo, *et al.* 2021). Moreover, several vegetables including tomato, sweet pepper, and lettuce were grown under a protective structure and proved to induce a higher gross margin compared to those from open fields. Recently, Basquial, *et al*. (2021) investigated the effect of low-tunnel and mulch on the growth and development of lettuce for alleviating cold stress in Benguet Province, the Philippines. The study showed that lettuce grown in a low-tunnel exhibited a better performance compared to the control grown without the low-tunnel.

Researchers in the Philippines attempted to evaluate the feasibility of vegetable production under protected cultivation in the Eastern Visayas. They found that low-cost protective structures for vegetable cultivation are economically feasible once growers are technically skilled in production management (Armenia, *et al.* 2013). Generally, greenhouse design is affected by regional climatic conditions. Regardless of the design and type of the protective structure tested, however, higher yields of vegetable crops were observed for vegetables grown in the protective structures compared to those grown in the open field (Capuno, *et al.* 2015). As the country is continuously hit by typhoons and heavy rainfall associated with flash floods, vegetable crop production in the open field is constrained, thus resulting in low yield and quality of produce. A comprehensive study on the effect of low-cost protected cultivation on the year-round production of vegetables in the Philippines showed that four crops - tomato, sweet pepper, bitter melon, and lettuce - generated significantly higher yields under the protected cultivation condition compared to those directly exposed to heavy rains in the open field (Gonzaga et al, 2016).

CURRENT PROTECTIVE STRUCTURE USING HYDROPONIC SYSTEMS IN THE PHILIPPINES

Hydroponics is an increasingly popular technique in the Philippines for producing crops. Hydroponic technology has been generally operated by research institutes, state colleges, and universities, with only a few small-scale farmers taking on this technique because it is an expensive business venture (Sace and Natividad, 2015; Peñaranda, 2007). Hydroponic technology is relatively new and at the beginning stages of rebuilding, boosting, and giving an immediate solution to the vegetable industry in the Philippines (Santos and Ocampo, 2005). Numerous governmental projects have been recently launched under a partnership with Korean governmental agencies (Table 1); i.e., the Department of Agriculture, The Philippines-Korean International Cooperation Agency, Korea (DA-KOICA), and the DA-Korean Program on International Agriculture (DA-KOPIA). Likewise, the Department of Science and Technology-Philippines Council for Agriculture, Aquatic, and Natural Resources Research and Development (DOST-PCAARRD) (Figure 2) and the Bureau of Agricultural Research (BAR) also financially supported protected cultivation-related projects. Although the construction and operation of smart greenhouses were initiated by the government a decade ago, its sustainability or maintenance was an issue from the beginning. Construction of the newly fabricated first-ever Philippine smart greenhouses was supported by the KOICA to increase farmers' profit and improve competitiveness in greenhouse technology.

Currently, the number of small-scale farmers who are using hydroponic systems is rapidly increasing as they gain cultivation knowledge for leafy vegetables such as lettuce, pak choi or bok choy, mustard, kale, swamp cabbage, etc. Small-scale farmers and some capitalists started cultivating crops from the Kratky method where plants are planted in a non-circulating tank filled with nutrient solution (Kratky, 2010) to a simple recirculating hydroponic system using nutrient film technique (NFT) (Silva et al., 2021) in their backyard with a basic protective structure to protect plants from biotic and/or abiotic stresses. Later, the small-scale farmers became entrepreneurs who responded to a mandate on revolutionizing the agriculture industry in the country to secure vegetable supply (Table 2). The production system varies from low-cost or low-maintenance bamboo greenhouse to sophisticated or high-cost container van production or plant factory systems (Figure 3; Figure 4). The protected cultivation in the Philippines is typically operated in the backyard with minimal space where it can contribute significantly to vegetable and fruit supply. The increasing awareness of growers about hydroponic technology through the effort of the government has allowed them to respond to the challenge, and eventually venture into protected agriculture in the achievement of common goals such as food abundance in the country.

CROPS GROWN UNDER PROTECTED STRUCTURES IN THE PHILIPPINES

The commonly studied crops under protective structures in the Philippines are presented in Figure 5. Several results determining the crop productivity of fruits and vegetables under protective structures have been reported (Aganon et al., 2004; Sace and Estigoy, 2015; Gonzaga et al., 2016; Gonzaga et al., 2021; Basquial et al., 2021; Poliquit and Aquino, 2022). Increased yield of selected crops grown under protected cultivation systems has been shown in spite of their different designs and operating systems in various locations. The economic analyses of protective

Table 1. Current Philippine government projects related to protected agriculture and their international collaborators.

Year	Government Projects	Amount (USD)	Funding Agency	Crops	Location	Reference
2013	Central Luzon State University Hydroponics and Aquaponics Technology	218,000	DOST-PCAARRD	Cherry & beef steak tomatoes, Honey melon, Sweet pepper, Herbs, Cucumber, Zucchini, Lettuce	Science City of Muñoz, Nueva Ecija	DOST-PCAARRD
2018	Smart Aquaponics Greenhouse system with IoT for the Philippines	44,000	DOST	Lettuce, Tomato, Bell peppers	Payatas, Quezon City	Philippine Information Agency (pia.gov.ph)
2019	Indoor Vertical Farming System	91,000	DA	Strawberry, Lettuce, Tomato, Swamp Cabbage	CLSU, Science City of Muñoz, Nueva Ecija	CLSU Annual Report 2020
2019	1st Smart Greenhouse Hydroponics Philippines (3450m^2)	2.43M	KOICA	Strawberry, Tomato, Lettuce	Baguio City	Philippine Information Agency (pia.gov.ph)
2020	TAU SMART Agriculture	N/A	TAU	Tomato, Eggplant, Cucumber, Honeydew melon, Strawberry, Leafy vegetables	Camiling, Tarlac	tau.edu.ph
2021	1st Urban Farming Hydroponic Hub	N/A	DA	Lettuce and other leafy vegetables	Quezon City	Philippine Information Agency (pia.gov.ph)
2021	10 Smart Hydroponic Greenhouses	100,000	DA-KOICA	Sweet pepper, Tomato, Mushroom	Western Visayas	Philippine Information Agency (pia.gov.ph)
2021	Modernized Greenhouse Hydroponics	17,000	DA	Strawberry, Tomato, Leafy vegetables	Tuba, Benguet	da.gov.ph
2021	4 Twin Tunnel Greenhouses	17,000	DA	Strawberry and leafy vegetables	Sto. Tomas, Baguio City	da.gov.ph
2021	11 Smart Greenhouse- DA Region 10	1.8M	DA-MAFRA	Strawberry, Cherry tomato, White potato	Malaybalay City	Philippine Information Agency (pia.gov.ph)
2022	13 Greenhouses (not hydroponics)	1.2M	KOPIA	Tomato, Green pepper, Cucumber	Zaragoza, Nueva Ecija	philrice.gov.ph
2022	Precision and Digital Agriculture Center (PreDiCT)	0.9M	DA-BAR	Lettuce, Strawberry, Tomato	CLSU, Science City of Muñoz, Nueva Ecija	bar.gov.ph
2022	Indoor Hydroponics System	54,700	DA-BAR	Lettuce, Kale, Basil, Tomato	Makati City	da.gov.ph
2022	BPSU Automated Soilless Culture System	91,000	DA	High-value vegetables	BPSU Abucay, Bataan	bar.gov.ph

Notes: DA, Department of Agriculture; KOICA, Korean International Cooperation Agency; KOPIA, Korean Program on International Agriculture; MAFRA, Ministry of Agriculture, Food and Rural Affairs; DOST, Department of Science and Technology; BAR, Bureau of Agricultural Research; PCAARRD, Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development; CLSU, Central Luzon State University; TAU, Tarlac Agricultural University; BPSU, Bataan Peninsula State University.

structures and greenhouses are feasible and profitable (Sace, 2002; Aganon and Aganon, 2009; Aremia et al, 2013; Capuno et al, 2015; and Castillo et al, 2021), and the utilization of household greenhouses and environmental control techniques enhance yield and quality of produce (Mojica et al., 2017; Pascual, et al., 2018; Pascual et al. 2019; Rivera, 2016). Out of 19 crops studied, 42% are fruit vegetables such as tomato, eggplant, muskmelon, sweet & chili pepper, and strawberries followed by vegetables with 32% leafy greens and cucurbits, 16% for herbs and spices such as peppermint and sweet basil, and 5% for root crops and bulbs.

Fig. 2. A government project funded by the DOST-PCAARRD implemented by the CLSU 2013-2018. The first greenhouse hydroponic cultivation project in the Philippines was headed by Dr. Chito F. Sace. (Left, Hydroponic greenhouses; Middle, Lettuce grown in a vertical A-frame growing pipes; Right, Honey melons grown in a low-cost recirculating hydroponic system) Photo source: CLSU Hydroponics and Aquaponics FB page. (https://www.facebook.com/clsuhydroponics.aquaponics)

Table 2. Private growers & entrepreneurs venturing into low-cost to high-cost hydroponic production systems in the Philippines.

Date	Growers/Entrepreneurs	Crop	Location	References
2021	Plant Habitat	Lettuce	San Fernando City, Pampanga	agiculture.com.ph
2021	Growtech Farms	Strawberry, Lettuce	Novaliches, Quezon City	da.gov.ph
2021	Hydrolettuce. ph	Lettuce	Antipolo City	jedsilverlake.medium.com
2021	Serrano Agri-Ventures Farm	Lettuce	Morong, Bataan	mb.com.ph
Undated	J&G Backyard Lettuce	Lettuce	Antipolo City	agiculture.com.ph
Undated	Pick A Cup	Lettuce	Bacnotan, La Union	facebook.com
2019	NXT LVL Farms	Lettuce	New Manila, QC	nxtlvlfams.xyz
Undated	Urban Greens	Lettuce	Makati City	aaturbangreens.com
Undated	Katanim Store	Lettuce	San Mateo, Rizal	jedsilverlake.medium.com
2021	Lettuce in a Cup	Lettuce	Bulacan	jedsilverlake.medium.com
2021	Bukid Amara	Lettuce and ornamentals	Lucban, Quezon	tribune.net.ph
2018	Happy Growers	Lettuce	Gumaca, Quezon	snaphydroponics.info
2017	Zennor Hydroponics Farm	Leafy vegetables, herbs, Tomato, Zucchini, Honeydew melons, Bitter melon, Cucumber	Palauig, Zambales	businessnews.com.ph
Undated	Turbulent Model Farm	Cherry tomato, Bell pepper	Tagaytay City	da.gov.ph

THE PHILIPPINES ASPIRES TO PROTECTED CROP CULTIVATION THROUGH SMART FARMING

In the 1st quarter of 2021, the Congressional Policy and Budget Research Department of the House of Representatives reported that the Philippines ranked 17th in the world as the country most affected by extreme weather conditions according to the Global Climate Risk Index (CRI) because of its geographical orientation (CPBRD, 2021). Government officials and growers have been responsive to the potential and importance of protected cultivation technology to boost the yield and quality of the vegetables. Smart agriculture with sustainable farming intensification is a method to advance crop productivity that integrates digital technologies (Queiroz et al., 2020) such as the Internet of Things (IoT) (Shi et al., 2019; Khoa, et al., 2019), and Artificial Intelligence (AI) (Khoa, et al., 2019) while reducing farm input costs.

The DA recently proposed 4 pillars and key strategies for achieving food security through the transformation of Philippine agriculture, making the country resilient with empowered and prosperous farmers and fisherfolks. The 4 pillars that were conceptualized correspond to food security; consolidation, modernization, industrialization, and professionalization where food should be accessible, available, utilizable, and stable. In 2022, the DA in the Philippines framed the “One DA Reform Agenda” including 18

Fig. 3. A low-cost protective structure for growing lettuce using a fine mesh net and plastic film with the bamboo framework. Photo source: Agriculture Magazine (Plant Habitat).

Fig. 4. A containerized indoor vertical hydroponic farm using an ebb and flow system. Photo source: www.nxtlvlfarms.xyz (NXT LVL Farms).

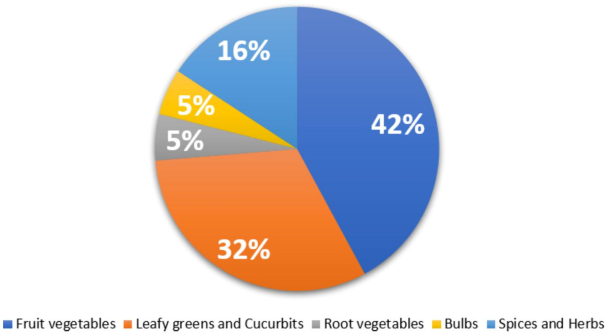

Fig. 5. Crops commonly studied in the Philippines under a protective structure. The percentage of studied crops under greenhouse facilities is presented. Fruit vegetables (Pascual et al., 2019; Poliquit & Aquino, 2022; Castillo et al., 2021; Capuno et al., 2014; Gonzaga et al., 2021); Leafy greens and cucurbits (Aganon and Aganon, 2009; Sace and Estigoy, 2015); Root vegetables (Crops Research Division, DOST-PCAARRD); Bulbs (Pascual et al., 2018); Spices and herbs (Mojica et al., 2017).

key strategies to address global agricultural concerns. Some of the strategies addressing concerns about protected agriculture are as follows; (1) Technology development or adaptation and innovation including innovative projects and digitalization of farming techniques and agribusiness activities by using data analytics; (2) Farm mechanization and infrastructure development such as farm-to-market roads, irrigation systems, postharvest facilities, storage, tolling, processing, and marketing facilities; (3) Climate change adaptation and mitigation measures by institutionalizing departments on climate risk and introducing vulnerability assessments in the regions and provinces to generate up-to-date information during the typhoon season and other natural disasters to better respond and; (4) Food safety regulations by refining laboratory and research facilities, building up traceability systems, and merging sanitary and phytosanitary control steps.

According to FAO statistics, the incidence of moderate to severe food insecurity is an indicator of SDG that provides clear evidence of individuals' deprivation from accessing nutritious and sufficient food even if hunger is not an issue (Figure 6). The data indicates that an additional 18.5% or 1.4 billion individuals have experienced food insecurity at moderate levels. Approximately 2.4 billion individuals or 30% of the world population suffered from moderate to severe food insecurity in 2020 (FAO, 2021).

The DA's agenda will be crucial in achieving sustainable Philippine agriculture. The DA is working together with the Department of Science and Technology (DOST) under its crop R&D programs on crop production system

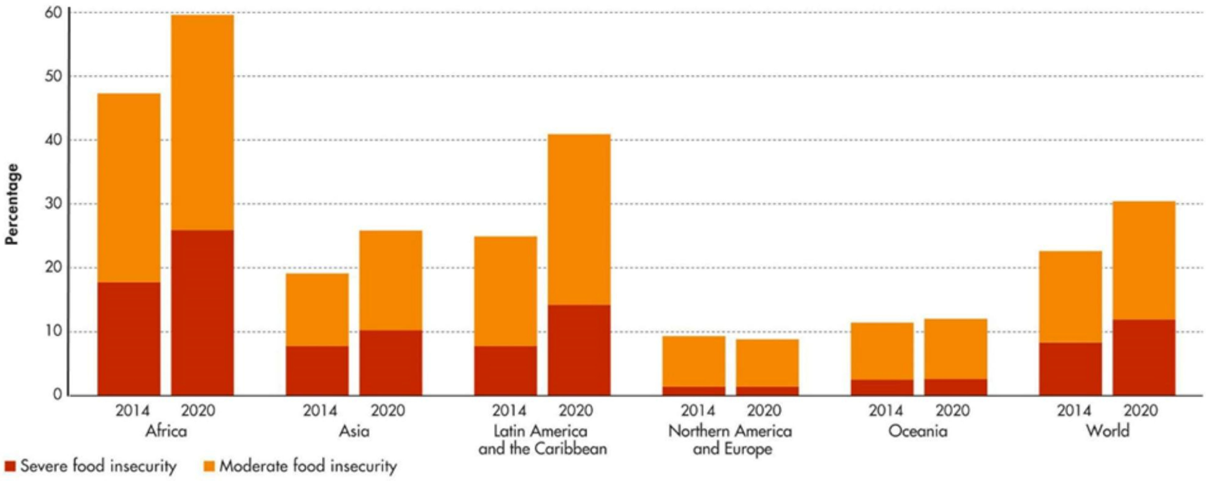

Fig. 6. Food insecurity levels are based on the food insecurity experience scale by region. The prevalence of undernourishment (PoU) suddenly upsurged at the global level 2019-2020 because of the COVID-19 outbreak. Source: FAOSTAT (2021).

Table 3. The major challenges of protected vegetable cultivation as well as its advantages.

Limitations	Benefits
High construction costs and supply of covering materials and equipment are expensive.	All-year-round production
High electricity cost.	Higher yield and enhanced crop productivity
Limited technical knowledge in greenhouse control systems.	quality and higher value of produce
Intensive operations with minimally skilled laborers.	Reduction of chemical pesticide usage
The uncertain marketing of the crops produce.	Very minimal incidence of weeds
Lack of standard design in the tropics.	Efficient use of water
Limited capital of growers	Can cultivate indigenous plants and medicinal herbs
	Increased yield per unit area with premium quality
	Protection from biotic and abiotic hazards

research, including smart farming approaches, and off-season cultivation/production, which can be done under a protective structure with climate-resilient technologies.

The DOST-Philippine Council for Agricultural, Aquatic and Natural Resources and Development (PCAARRD) initiated funding of a novel project in the country entitled “Hydroponics System as Smart Farming Technique for Vegetable Crops Production” to develop and promote hydroponics as a precise and smart farming technique for vegetable production, targeting cucumber, tomato, and bell pepper for an increase of yield per unit area up to 5 times higher than the conventional/open field production (Sace et al., 2014). The project has been successfully executed and produced output that promoted the development and/or application of new technologies throughout the Archipelago in the country.

Therefore, the Philippines can be a member containing a great potential to collaborate with Asian neighbor countries to boost the vegetable industry in the Asia-Pacific region. The government should enhance financial support for the development of modern greenhouse technologies, raising the capability of researchers and farmers through international training and seminars. Population growth is an important driver of increased food demand. Furthermore, land available for cultivation is diminishing rapidly, resulting in risky food security. Increasing crop productivity is a must rather than an option.

Taken together, the production of vegetable crops should be under a protective structure as it has been proven to improve the quality and quantity of the produce. Relevant technologies required for protected cultivation systems can contribute to an increased yield of vegetables and other crops (Reddy, 2016). Gonzaga et al, (2017) also concluded that higher yields of vegetables can be realized in both wet and dry seasons with an aid of protected cultivation technologies in the Philippines.

LIMITATIONS AND BENEFITS OF PROTECTED CULTIVATION

Conventional or open field cultivation of vegetables cannot guarantee good yield, high quality, and food safety due to exposure of vegetables to biotic and abiotic factors, causing reduced quality and yield. Cultivating vegetables under protective structures ensures weather impact mitigation, resulting in consistent production with better quality of produce (Chavan et al, 2022; Table 3). The practice of protected cultivation creates a suitable environment for crops where the micro-climatic conditions are partly or entirely controlled during the growth period (Mishra et al., 2010; Liao et al., 2020). Liao et al, (2020) suggested that the government authority should implement subsidizing farms to enhance farmers' capability to adopt protected cultivation facilities if capital among farmers is a constraint.

적 요

1. 필리핀은 국토 면적의 47%가 농업에 이용되며 인구 대다수가 농업에 의존하고 있는 대표적인 농업 국가이다. 그 중 채소 재배는 필리핀 농가의 주된 수입원이지만, 채소 작물은 주로 노지에서 재배하고 있다. 노지 재배는 시설 재배에 비해 기후 및 주변 환경의 영향을 받는데, 필리핀의 고온 다습한 기후, 극한의 환경 조건(가뭄, 홍수)은 채소 재배에 불리하여 생산력이 낮고, 품질이 좋지 못하다. 이로 인해 증가하는 채소 수요를 충족시키지 못하고 있다.

2. 시설원예는 불리한 환경 조건의 피해를 줄일 수 있고, 기상조건으로부터 농작물을 보호할 수 있어, 필리핀의 채소 생산을 늘리기 위한 대안이 될 수 있다. 시설 원예 하에 재배된 채소 작물을 시설에서 재배했을 때 수확량은 노지에 비해 월등히 높다고 보고되었으며, 고부가가치 작물을 재배하는 데 도움을 주었다. 시설 재배는 농산물의 생산량과 품질의 향상에 기여함으로써 궁극적으로 농가 소득의 증가를 유도한다.

3. 필리핀에서 수경재배는 초기 높은 투자비용으로 인해 연구기관, 소수의 농가에서만 운영되어 왔으며, 최근 한국 정부기관의 협력(KOICA, KOPIA) 하에 시설 재배 관련 프로젝트가 진행되었다. 시설원예의 재정적 지원에 있어 가장 큰 쟁점은 지속가능성이다. 필리핀에서 시설원예의 확대를 위해 주변 국가와의 협력구조 형성, 연구자와 농가의 역량강화, 정부 투자 및 재정적 지원, 인프라(전기시설, 건축비용, 등)구축 등이 요구된다.

4. 필리핀 정부(농무부)는 필리핀 농업 변혁을 통한 식량안보 달성을 위해 4가지 핵심 전략(식량의 접근성, 이용가능성, 활용성, 안정성)을 제시하였으며, 그 중 시설 재배와 관련된 세부 전략[①농업기술의 혁신과 디지털화 추구 ②농업 인프라 개발(농업 기계화, 관개 시스템, 가공 및 마케팅 시설 구축 등) ③기후변화 및 재난 대응을 위한 부서 제도화 ④식량 안전 규정, 위생 및 검역 통제]을 세워 국제 식량안보와 지속가능한 농업을 위해 노력하고 있다.

5. 시설 재배는 필리핀 채소산업에 있어 큰 잠재력을 가진다. 필리핀에서 온실 등의 시설에서 재배된 작물은 각기 다른 지리적 환경(평원, 언덕, 사막, 농촌, 도시 등), 시설 설계, 운영 체계에도 높은 생산량을 보임으로써, 필리핀에서의 시설 재배는 수익성이 있고, 실현 가능함을 입증하였다. 시설 재배는 노지 재배에 비해 기후의 영향을 적게 받으므로, 우기와 건기 모두 채소 수확량을 높일 수 있으며, 안정적인 생산으로 국민 채소 섭취량 증가에도 기여할 수 있다.

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