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AGRICULTURAL PRODUCTION AND IMPORT TARGETS FOR FARMING DEVELOPMENT IN THE MALDIVES

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СІЛЬСЬКОГОСПОДАРСЬКЕ ВИРОБНИЦТВО ТА ІМПОРТ ЯК ЦІЛІ РОЗВИТКУ ФЕРМЕРСТВА НА МАЛЬДІВАХ

Food security is about providing equal access to sufficient safe and nutritious food to meet people's dietary needs for an active and healthy life. The analysis of import data in the Maldives in 2022 revealed that there is a high imbalance in agricultural production of locally grown crops due to the inefficient distribution of the constrained resources especially land and labor. So, the research aim was to identify the key challenges and means to facilitate food insecurity in order to improve farming in the Maldives. The study incorporated 10 core crops. The highest deviation is observed for

lettuce, melon, and watermelon because farmers' production covers less than 3% of the national demand. A more stable condition is detected for growing banana, beans, cucumber, pumpkin & squash where the local farmers can apply less fertilizers and invest less time and money to hit the import target. The most effective land and labor utilization is observed for Chinese cabbage, papaya, and tomatoes, since there are higher market prices for these crops from the tourism industry. The research findings also show that 50% of the farmers tend to grow banana owing to technological ease. Other crops are more labor-intensive, susceptible to pests and plant diseases and imply higher input costs. In order to enhance food security in the Maldives the study proposes an implementation of the IT-based "GOVAAN APP" (GA) which provides technical backing to uplift the farmers to a higher new level in terms of technology, close agricultural guidance, and monitoring of the fields for increasing the national agricultural production capacity. GA is an online application that farmers can access through their mobile phones. The offered farming methods should include fertigation, grow bags, hydroponics, and irrigation systems designed for producing premium quality crops and reducing the wastage of the inputs. Besides, GA can share instructions on harvesting and packing crops as well as maintain market logistics. These approaches will decrease the country's import dependency, generating more employment opportunities and income for the farming communities.

Продовольча безпека означає забезпечення рівного достатнього доступу людей до безпечної та корисної їжі для підтримки активного і здорового життя. Аналіз даних імпорту Мальдів у 2022 році переконує в значному дисбалансі аграрного виробництва місцевих культур через неефективний розподіл обмежених земельних і трудових ресурсів. Відтак дане дослідження мало на меті визначити ключові виклики та засоби зниження продовольчої небезпеки задля вдосконалення фермерства на Мальдівах. Розглянуто 10 провідних сільськогосподарських культур. Найбільше відхилення зафіксовано для салату, динь та кавунів, адже врожаї фермерів становлять лише до 3% від попиту в країні. Більш стабільне становище спостерігається у вирощуванні бананів, квасолі, огірків і гарбузів, на які місцеві фермери витрачають менше добрив, інвестують менше часу та грошей, щоб досягти показників імпорту. Найбільш

ефективне використання землі та праці стосується китайської капусти, папаї і томатів, оскільки попит від туристичної індустрії встановлює на них вищі ринкові ціни. Результати дослідження також відображають, що 50% фермерів задіяні у вирощуванні бананів через менш вимогливі технології. Решта культур передбачає більші витрати праці та виробничих ресурсів, щоб протидіяти шкідникам та хворобам рослин. Для посилення продовольчої безпеки на Мальдівах пропонується впровадження IT-додатку “GOVAAN APP” (GA), що покращує технічне забезпечення фермерів за рахунок нових технологій, консультаційного супроводу та моніторингу полів на користь підвищення обсягів сільськогосподарського виробництва в країні. GA є онлайн додатком, до якого фермери матимуть доступ через свої мобільні телефони. Запропоновані аграрні методи повинні включати фертигацію, мішки для вертикального вирощування рослин, гідропоніку та системи зрошення, розроблені для виробництва високоякісних культур і зменшення втрат ресурсів. GA також може поширити інструкції для збирання і пакування врожаю та підтримувати маркетингову логістику. Ці підходи зменшать залежність країни від імпорту, створюючи більше можливостей для працевлаштування і одержання доходів у фермерських громадах.

Keywords: *food security, imported crops, farming production targets, land and labor resources, IT app for agriculture.*

Ключові слова: *продовольча безпека, імпортована агропродукція, виробничі цілі фермерства, земельні та трудові ресурси, IT додатки для сільського господарства.*

Statement of the problem generally and its connection with important scientific or practical tasks. Food security and eradicating world hunger is a global issue. The main sustainable development goals are based on working towards ending hunger, food security, improving nutrition, and promoting sustainable agriculture. Reports show world hunger is rising, affecting nearly 10% of people globally [1]. The undernourished and poverty population grew by as many as 150 million from 2019 to 2022, primarily

driven by military conflicts, climate change, and the COVID-19 pandemic, which pushed down the agricultural production of many countries. This shows that the prosperity of a nation depends on food and nutrient security. In other words, food security is the main driving force behind the economic development of a country [2]. The World Summit on Food Security, held in 2009, stated that “Food security” means equal access to sufficient safe and nutritious food to meet people’s dietary needs for an active and healthy life [3]. The Food and Agriculture Organization further classifies the dimensions of food security, including food availability, supply sustainability, food quality, safety, and access to food. Food security and economic growth go hand in hand. Stable and robust food security improves human development, increasing food access and reducing hunger. According to reports, Asia’s population is projected to be 5.16 billion by 2050, which requires 20% more food production to meet the increase in population food demand [4; 5].

In the Maldives, fruits and vegetables, including watermelon, pumpkin and squash, banana, cucumber, papaya, melons, lettuce, Chinese cabbage, bush beans, and tomato, are the leading imported food products. More than 60% of these crops are imported for resort purposes, whereas the rest are used for local consumption. The country’s agricultural sector remains highly fragmented, with stagnant growth, underdeveloped infrastructure, poor production, and market systems. According to reports, the agriculture sector’s GDP contribution was, on average, 1.3% in 2014-2018 [6]. This number had dropped to 1.1% of GDP by the end of 2022. Over the past 25 years, the country has been experiencing the increase in the import dependency. The total Government debt had surpassed 80% of GDP by the end of 2022 [7]. Statistics showed a rising inflation rate from 0.6 % to 2.9% within the second quarter of 2022. Thus, over the past three years, the increased dependency on imported food had a negative impact on the food and nutrient security of the country.

International military and trade conflicts cause a strong ripple effect on the Maldivian economy. Growth in petrol prices and their spill-over products related to

transport services as well as hikes in food prices resulting from the Russian invasion of Ukraine has led to a rise in poverty among the rural population in the Maldives [8]. The increase in prices of agricultural inputs, transport costs, and reduced market access reduced smallholder communities' farming activities, leading to lower calorie intake per day. The island communities have been disadvantaged since the beginning. The increase in inflation, high consumer price index, and other financial risks deteriorated the situation by decreasing the agricultural production of the farming communities. Besides, there is a high inequality in government expenditures and economic activities between atolls and the capital city. Maldives' poverty rate hit 19.8% in 2020 due to the COVID-19 pandemic, which improved to 5.4% in 2021 [6; 7]. However, this percentage is expected to worsen since the government aims to increase the GST rate from 6% to 8% in 2023 [7; 9].

The above numbers will negatively impact the country's agricultural production, where 90% of the rural population practices subsistence agriculture as means of living, food, and nutrient security. Commercial agriculture of the country depends on producing high-value crops such as banana, papaya, chili, cucumber, and pumpkin, mainly targeted to the resort market. Over the past three years, food import has increased since commercial agricultural farms, and local farming communities cannot meet the local demands.

According to FAO, there are five crucial steps that the governments of all developing nations must take to achieve and ensure food security. This includes providing arable land to farming communities, giving access to water resources through irrigation, maintaining suitable farming tools and machinery to increase efficiency, providing access to quality fertilizers, and ways to address farm-related issues such as disease and pest control. These five determinants will drive the community to achieve food security and enhance the economic growth of these communities, which will have a more significant positive effect on the nation's whole economy [5]. Based on this, we should study how to increase the agricultural production of certain highly imported

dependent crops and how much land and labor resources are required to fulfill national goals of sustainable agriculture and food security.

Analysis of recent research and publications. To start this research, we need to explore food security issues and identify effective ways to face the relevant challenges observed in neighboring countries.

Sri Lanka comprises 45.5% of agricultural lands, where 30% of the country's population depends on agriculture, contributing 7.4% of the national GDP [10]. The country produces many crops such as wheat, rice, and other staple food and is widely known as one of the major exporters of rice in Asia. The unstable political situation and ban on agricultural-related inputs resulted in a devastating negative impact on the production of farming communities as their agricultural outputs shrank by 20% within the previous six months. Given the exponential increase in imported food, the price index reached a 10-year maximum in 2021 [10]. 61% of Sri Lankan households now have to implement food-based coping strategies due to insufficient food or money to buy food. Moreover, around 50% of households could only take one meal per day with a limited portion. Reports show that about 150000 tons of corn are imported to the country annually to supplement local production [11]. A country that has achieved and maintained upper-middle-income status now consists of a poverty-stricken community of half a million people. The country's inflation amounted to 69.8% in September 2022. Hunger and starvation are most prevalent among the self-sufficient farming communities and were sustained a few years back by exporting tea, rice, and wheat. According to the World Bank, urgent measures need to be taken to uplift the farming production capacities by providing them with input supplies, agricultural land, and technical support to eradicate poverty in Sri Lanka and reduce its import dependency [10; 11].

Bangladesh is one of the poorest Asian countries where most of the population depends on rice calorie intake. The country produces many grains, but more is needed to meet the population's food and nutrient needs, forcing the government to depend heavily on imports. Over the past few years, owing to external shocks, the country experienced a

downfall in the production of rice and grains. The high inflation and increase in oil prices burdened the poor farming communities and put significant pressure on monetary reserves and the currency. This has driven a large part of the population into poverty. The government of Bangladesh is taking necessary action, such as strengthening supply chains, livestock, infrastructure for processing food, and all logistical systems. Also, financial support is being given to the farming communities to enhance production and provide smallholder farmers with fertilizers [12].

The Philippines also highly depends on imports and is considered the most food insecure country among Asian countries. Philippines' agriculture contributes less than 2% of GDP to its economic growth. Reports show that 2.5 million families suffer from involuntary hunger, and the number of citizens who cannot afford a healthy diet rose in 2020 [13]. In this regard, the government is taking measures to uplift the farming community's insecurity and enhance the production capacity of the farmers [13]. Nepal is an agricultural production-based economy compared to the Philippines, contributing 27.7% to the GDP. The farm sector ensured the food security and stability of the country's population, where more than 60% of the population is employed in the agricultural industry. However, the country has shown a significant dependency on imports [14]. It reveals a 65% jump in critical farm products between 2015 and 2020, of which 75% was rice. Scientists offer farmers access to agricultural infrastructure and irrigation to address the high import dependency. Nepal has already implemented policies to foster farmers through insurance and guaranteed markets for their production to improve the economic condition of the farming population [14].

The Maldives has experienced remarkable economic growth during the past three decades creating job opportunities and addressing the economic inequality between the capital city and rural island population. In 2014 real GDP per capita reached \$503.43, the highest in South Asia [8]. The food and nutrient security of the communities were ensured by horticultural and agricultural local crops such as maize (*Zea mays*), sorghum (*Sorghum vulgare*), finger millet (*Eleusine coracana*), and starchy crops including

breadfruit (*Artocarpus altilis*), sweet potato (*Ipomoea batatas*) and taro (*Colocasia esculenta*). Between 1995 and 2021, the Maldives' population doubled and exceeded 520000. At present most people depend on locally grown fruits and vegetables as their primary source of nutrients. Previously over 80% of the men residing in island communities earned an income from fishing, and fish was the country's leading food [8]. However, over the past few years, the situation has changed. With the increase in population, the nation experienced a drastic urbanization within the island communities and in the capital city, which decreased the availability of staple foods and crops due to clearing lands for urban development. Opened international trade led to a flow of imports, increasing the country's dependency on imports. Now more than ever, the Maldives is susceptible to external shocks such as climatic conditions, pandemics, war, and conflicts. Little or no research has been done on understanding how much the country depends on food imports and how vulnerable the government is to external shock [8; 15; 16]. A limited study is done on the availability of natural resources such as land and labor to understand how these resources can be used in the best possible manner to increase the production of heavily imported crops. Hence, this research will analyze the most recent import data and the country's local production to explore resources and means required to meet the challenge of nutrition insecurity.

Research aims. This research aims to analyze food security and agricultural imports in the Maldives and examine land and labor resources involved in farming to increase local farmers' outputs, fulfill their potential, and meet production targets.

Presentation of the primary research material. The presented study used the import data of 2022 and focused on the crops which can be grown in the Maldivian soil and climate and are in great demand among local people and the tourism sector. Data for 2020 and 2021 are irrelevant as the world has experienced high import and export instability in these two years due to the lockdown of borders and international transport restrictions forced by the COVID-19 pandemic.

The analysis of the data is divided into two major parts. The first part of the study examined the current situation in terms of land and labor. The second part of the study explored the means to meet the import production target. The Maldivian economy earns more than \$3 billion annually from tourism. However, the country’s dependency level on other countries for the necessities such as food and nutrition is at alarming percentage. The most concerning thing observed in the import data is that the government has imported a vast amount of locally grown crops, which Maldivian farmers grew abundantly (see Figure 1). The country’s poor investment in agriculture during the past years has not built the capacity of farmers to meet the resort market demands. Thus, the country imported enormous amounts of fruits and vegetables to keep up with the growing food demand from the population and tourism sector, which requires premium quality produce.

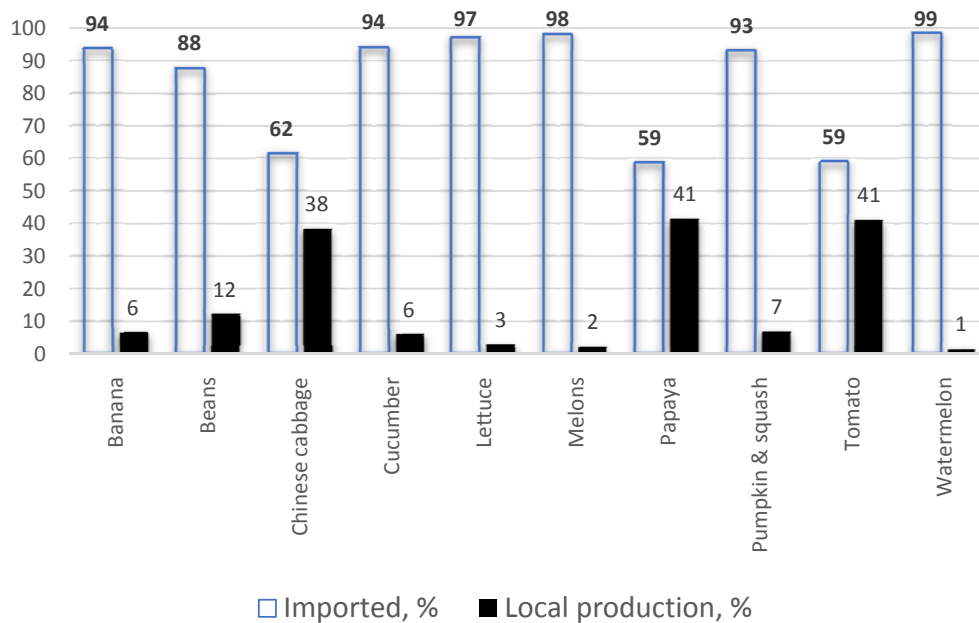


Figure 1. Imported vs. produced fruits and vegetables in the Maldives in 2022

Source: compiled by the author based on data derived from [17]

Figure 1 reveals that the country must noticeably boost its agricultural production of the most imbalanced crops, such as lettuce, melon, and watermelon because farmers’

production covers less than 3% of the national demand. This situation is rooted in the availability of natural resources such as water, access to alternative farming methods, and labor constraints. Melons and lettuce are susceptible to pest and plant diseases and require regular fertilizer application and attention. Watermelon is a crop that requires hand pollination and regular pruning to get a higher-quality yield. However, farmers cannot attend their fields as most are involved in off-farm activities. Besides, 90% of the Maldivian farmers are rain-fed. Thus, during the dry season farmers without access to water or an irrigation system cannot produce watermelon which needs watering twice a day. More stable condition is observed for growing bananas, beans, cucumber, pumpkin & squash. It is explained by the fact that these crops require less attention, time, and input cost to produce a yield. Most farmers do not apply any fertilizers in growing bananas, and crops such as beans are grown in their home gardens and fields without effort. Pumpkins and squash resist pest and plant diseases and do not require daily watering. Hence, the entire production they can yield at the end of each harvesting cycle is higher. The most promising results for addressing import targets are growing Chinese cabbage, papaya, and tomatoes. Maldivian farmers produce approximately 40% of these crops because crops such as papaya can be easily grown in Maldivian soil. Papaya is a crop that has a vast resort market, and the market price of this fruit is also higher than of other crops. Once planted in the field, these crops can be harvested for almost 11 months and easily sold due to their high market value. Most of the tomato and Chinese cabbage production is produced by the farmers who have access to control methods of farming such as greenhouse and hydroponic systems supported by the donor agencies like IFAD, UNDP, and FAO in mitigating poverty, food, and nutrient security.

The insufficient quantities produced by the local farmers clearly show the importance of utilizing the available agricultural resources most efficiently and effectively to reduce the experienced dependency on agricultural imports. For this to achieve, we need to analyze the available land and labor resources required to produce high-demand crops. Figure 2 clearly illustrates an unequal land distribution under the

target crops. The largest share of land is distributed under growing bananas. But given the low performance of these farm areas, there is an urgent need to invest time and money in enhancing the production of bananas. Fields are left to grow independently where the farmers apply minimum or no fertilizers. Most of the banana plantations are left unattended, where bats attack the banana bunches at the fruiting stage. As a result, it loses its market value and reduces the amount that these fields can produce. The second share of agricultural land in the Maldives belongs to pumpkin & squash, which provide only 7% of the national demand.

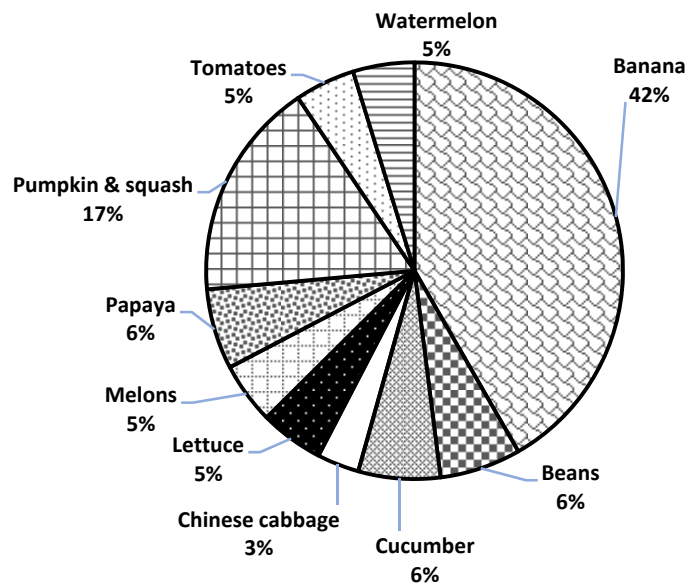


Figure 2. Distribution of lands (in %) available for agricultural purposes in 2022

Source: compiled by the author based on data derived from [17]

Insufficient production of cucumber and lettuce goes hand in hand with relatively small areas under these crops. One of the main reasons for this low production is that these crops need more nutrients and water. In the Maldives, less than 1% of the farmers have well-established irrigation systems, which hinders crop growth. Lettuce and cucumber have a high resort market. Cucumber is a crop that requires close monitoring

and farmer attention from sowing to harvesting. Cucumbers must be grown using fertigation or hydroponic methods to maintain high quality. Most farmers grow cucumbers on land, leading to poor quality yield and the spread of diseases. Maldivian leafy vegetable farmers who farm in open fields lose more than 90% of their produce due to uncontrollable pest and plant disease issues which they cannot detect and treat at the early stage as a preventive measure. Lettuce is a leafy vegetable that cannot grow on open land because of pests and plant diseases. Moreover, lettuce is a short shelf-life crop that must be stored at a specific temperature until sold. These difficulties reduce the production of lettuce though there is the availability of land resources to these farmers. The most effective land utilization is observed for Chinese cabbage, papaya, and tomatoes, close to hitting their import targets. It happens because crops such as papaya plants give a higher yield of production per plant compared to other crops, and the papaya farmers are motivated to invest their time and money in growing papaya as there is a higher market price for this crop. Chinese cabbage, similar to lettuce, is challenging to grow, but since it has a higher market price and longer shelf life than lettuce, farmers pay more attention to producing a higher yield. As discussed above, the growing method used by tomato farmers increases the quantity and quality of tomato yield.

The low production of crops is justified by Figure 3. It shows that almost 50% of the farmers are banana farmers, whereas the percentage distribution of farmers who grow other crops is significantly lower. Banana is a popular crop in the Maldives, where every household of island communities grows it in their backyard. Farmers need to apply less or nil fertilizers and no time investment. Once planted, farmers are required to attend to these crops once or twice a month for pruning. Once the banana plantation is at the harvesting stage, harvests can be continued for 11 months at a stretch, giving farmers an advantage over the other crops. Disease and pest issues are minor for banana. Hence, the profit they gain is higher than the time and money invested in this crop. For other crops, such as watermelon and papaya, only 6–7% of labor is available for growing them. One papaya plant is estimated to need 20–25 liters of water at the growth stage,

which gradually decreases when it reaches its fruiting stage. The extensive demand for water and the time needed to produce watermelon forced farmers not to choose this crop. On the other hand, just 4% and 6% of farmers decide to grow leafy vegetables such as Chinese cabbage and lettuce. These two crops are new crops introduced into the local agricultural sector by the tourism industry. Most farmers who grow these crops have yet to gain experience in developing them efficiently. Chinese cabbage and lettuce require mediums other than land to produce a high quantity of quality yields. Other farming methods, such as hydroponic and fertigation, are way too expensive for the farming communities to invest in based on the fragmented agriculture systems without guaranteeing a buyer for their product. The Maldives faces unpredictable weather conditions, so growing tomatoes in an open field will be difficult. They need technology-based farming methods. The analysis shows that this crop requires less land and labor to meet the import production target. Hence, controlled growth media such as a greenhouse, hydroponic systems, and fertigation could be adopted as it requires less labor and less land to produce a higher quality yield.

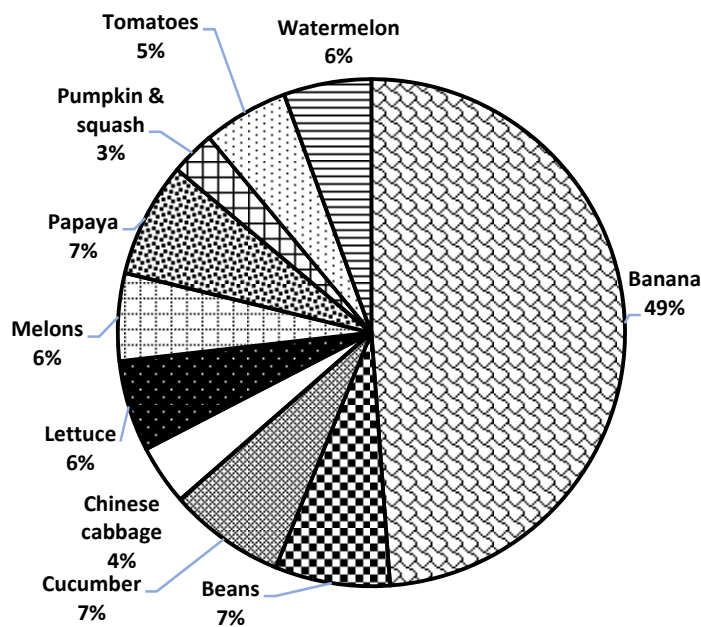


Figure 3. Involvement of farmers (in %) in agricultural production in 2022

Source: compiled by the author based on data derived from [17]

When recruiting, more farmers need to be equipped with skills and knowledge to grow the crops with more market targets, which have been imported chiefly. Distributing and allocating land and labor to increase production, based on the market demand, will help the nation to use the available resources more effectively and efficiently. “GOVAAN APP” (GA) provides all the above-described support in enhancing the production capacity of the farmers. Subsidized credit facilities are provided along with the technical backing to uplift the farmers to a higher new level in terms of technology. This is a mobile phone application that farmers can access through their phones while they are working in the fields or anywhere. The below strategies are proposed to increase the crops’ production and quality via GA.

Firstly, when it comes to Chinese cabbage, cucumber, lettuce, melon, and tomatoes, farmers are provided with technology-based farming methods, including fertigation, grow bags, and hydroponics to grow 70% more yield using the available land resources. Lettuce can only be grown in a hydroponic system to achieve the premium quality demanded by the customers. Using cucumber nets for vertical growth and technology-based mediums will improve the quality of these vegetables as they will not be exposed to pests and diseases at the growth stage. What is more, based on the land size and credit package, the plans will be established in the farms, training will be provided, and sowing will be done for the farmers with the help of agronomists who also introduce relevant training and assistance. Daily monitoring of the fields will be logged on GA, and notifications will be sent to farmers. The whole system will be handed over to the farmers once they are fully trained and confident to continue independently.

Secondly, regarding beans, papaya, pumpkin & squash, and watermelon, establishing an irrigation system in these fields with the help of GA will support the farmers in growing these crops more efficiently and with higher quality quantities. It is especially beneficial for the farmers whose production could be better due to the unavailability of rainwater. Once the farmers clear land, they are instructed about the distance, dimension, and number of pits they must prepare. This will increase the

farmers' production at the end of each harvesting cycle. Besides, GA gives instructions on preparing pits with cow dung and quality seeds suitable to the soil and environmental conditions. This will prevent farmers' loss of inputs at the initial farming stage due to a lack of low germination. Furthermore, it will also help the farmers grow healthy crops and yield better quality. GA agronomists will monitor field progress daily, and proper recommendations will be suggested to the farmers if required.

Thirdly, when it comes to chemical and fertilizer application, once the farmers do the sowing, they will be given a sheet on when and what fertilizers or chemicals must be applied. This will reduce the misuse of fertilizers and the wastage of inputs. Farmers will be recording each task accordingly. If any disease or issue is identified, a picture will be taken via the app, and the agronomist will be notified.

Finally, regarding harvesting and handling, seven days before the estimated harvest date, the GA agricultural experts will check the progress of each crop. Instructions on when to harvest and the signs of the harvest stage of each crop will be sent to the farmer. Packing materials and how to pack will be shared with farmers. Once the farmer harvests, details of the harvested product and the location where this crop is gathered will be recorded on the app. As soon as this information enters, the GA market team and logistics will sell the product to the nearest available buyer. When the farmer harvests, the GA finance team will be notified. The market team, through GA, will arrange a buyer, and the payment for the crop will be transferred within five days.

Conclusions and prospects of further investigations. The Maldivian food and nutrient security depend on imports from neighboring countries. Hence, given the availability of the land resource, it needs to be distributed so that more land is allocated to the crops with a higher import target. This urgent matter must be addressed at the national level since this makes the country highly susceptible to external shocks.

Agriculture is the primary source of employment and income generation in low- and middle-income countries. This shows a need to recruit new farmers into the sector, especially young, educated people with energy and business minds. Such employment

opportunities for the youths are bound to contribute to a more equitable income distribution and improve national food and nutrition security. Given the situation in the Maldives, there is a need for the integration of intelligent agricultural technologies to overcome the challenges faced by the industry to boost farmers' production.

So, we offer to implement agricultural IT such as the "GOVAAN APP". GA builds a farming community that co-exists with the available natural resources, moving towards social and economic sustainability. Unlike other avenues, it develops the farmers in terms of skills, technology, and agricultural capital and also guarantees a market for their production. GA strategies give the involved farmers an advantage over those who don't use GA.

The future of farming in the Maldives is hopeful with these strategies, which will ensure the high quality and quantity of the grown crops. They will push farmers' production to a new height, thus decreasing the country's import dependency, generating more employment opportunities and income for the farming communities, and finally propelling them to economic sustainability. Therefore, implementing these strategies is worth further scientific investigation.

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