Policy Strategies to Maintain and Improve Agricultural Production in Denpasar City

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Abstract Strengthening food security, particularly for rice commodities, by increasing production and productivity is one of the main objectives of agricultural development. The phenomenon of population growth coupled with high urbanization has resulted in increasing demand for rice in Denpasar City. Fulfillment from local rice production is only about 20%. To prevent local food (rice) production from declining and to maintain or even increase it, policies to increase productivity and production must be multidimensional, combining land protection measures, productive intensification, and the adoption of technology appropriate to the urban context (appropriate technology). The policy direction is set to: (i) curb the rate of land conversion and ensure certainty of production space; (ii) increase the productivity of production factors through technological innovation and good cultivation practices; (iii) strengthen climate-adaptive subak-based irrigation infrastructure; (iv) differentiate production sources through horticulture and urban farming; and (v) revitalize institutions and regenerate farmers to make the sector economically attractive and socio-ecologically sustainable. Policy recommendations for increasing production and productivity of food crops through the use of appropriate technology in Denpasar City need to be formalized in a regulation.

***Index Terms*— food security, production, rice.**

I. INTRODUCTION

Strengthening food security, particularly for rice, is one of the primary goals of agricultural development. Rice is a food commodity that holds a strategic position in agricultural development. Rice is considered a highly strategic political commodity, making domestic rice production a benchmark for food availability in Indonesia. Therefore, the Indonesian government plays a significant role in efforts to increase production and stabilize prices. Besides its strategic economic value, rice is also crucial as an instrument for maintaining stable food security for the Indonesian people (Muh. Firdaus, Lukman, and Purdiyanti, 2008). Demand for rice continues to increase in line with population growth, so Indonesia must achieve sustainable rice self-sufficiency to ensure food security and self-sufficiency.

Increased food production must be carried out sustainably to offset the increase in consumption due to population growth, ensuring food security. In Indonesia, improving food security has been one of the main national programs over the past decade. This is related to Indonesia's commitment as one of the signatories to the SDGs agreement, which stipulates that by 2015 every country is expected to reduce poverty and hunger by half compared to the conditions in 1990. Regional food security is a pillar of national food security, which must be achieved by regions that have food production potential. In the Sustainable Development Goals (SDGs), goal (2), namely "Ending hunger, achieving food security and improved nutrition, and promoting sustainable agriculture," recognizes the interconnectedness between supporting sustainable agriculture, empowering smallholder farmers, promoting gender equality, ending rural poverty, ensuring healthy lifestyles, and addressing climate change (KLHS Denpasar City 2025-2029).

The phenomenon of population growth has resulted in increasing public demand for food. The government, specifically the Ministry of Agriculture, has developed and implemented seven key strategies for strengthening agricultural development for food sovereignty (P3KP) to

increase rice productivity, including increasing land availability and utilization, improving agricultural infrastructure and facilities, developing and expanding seed/seedling logistics, strengthening farmer institutions, developing and strengthening financing, developing and strengthening bioindustry and bioenergy, and strengthening agricultural product market networks (Ministry of Agriculture, 2015).

Rice production in Indonesia plays a crucial role in meeting national food needs and supporting the country's economy. With a growing population, the demand for increased rice production is increasingly pressing (BPS, 2022). However, the challenges faced by The rice farming sector in Indonesia, such as limited land, climate change, and inefficient agricultural practices, demands innovation to increase productivity and production efficiency (FAO, 2021). Food crop farming (rice) has significant multifunctionality, and its successful development will significantly impact food security and farmer welfare.

Strengthening food security is one of the primary goals of agricultural development. Strengthening food security fosters agricultural technological innovation. Agricultural technological innovation plays a crucial role in increasing agricultural productivity. Agricultural technological innovation is not simply a new technology, but rather something that can drive societal renewal. In this context, agricultural technology is defined as more than technological innovation; it is the implementation of new agricultural ideas, practices, and concepts that provide new commercially valuable and effective pathways for improving farmers' livelihoods (Schilling, 2017).

In principle, the main obstacle to future agricultural development is the availability of agricultural land. Agricultural land development is inseparable from the development of irrigation infrastructure. The limited agricultural land development in Indonesia is indicated by a 0.40% annual decline in agricultural land over the past two decades. (1980-2000). The expansion of rice fields was very slow, only 0.20%/year and the proportion was relatively small, namely 27% (2.59 million ha) in 2000 (Pasandaran et al 2004).

Based on land suitability and water availability, potential areas for irrigation development are very limited. This trend indicates significant challenges to increasing production and farmer welfare. Land holdings per farming household continue to decline due to the increasing population and the number of farming households. Empirical data related to Gross Domestic Product (GDP) and aggregate agricultural production provide some interesting information, as follows (Arifin 2003, Simatupang et al., 2004):

1. GDP and aggregate agricultural production experienced relatively high growth in the period 1967-1986 due to support for agricultural land and infrastructure development, extension institutions, rural cooperative institutions, subsidized credit, and price incentives.

2. Policy contradictions in the subsequent period, indicated by a decrease in budget allocations and incentives for the agricultural sector, have resulted in increasing obstacles to agricultural production development.

3. The primary source of production growth from 1967 to 1986 was land productivity, which then declined drastically from 1997 to 2001 and even experienced negative growth from 1997 to 2001 due to declining land productivity and agricultural labor.

In addition to issues related to the availability and development of irrigated land, access to and implementation of new superior varieties, and location-specific technology, agricultural production development also faces challenges related to development budgets and the provision of incentive systems to encourage production and farmer incomes.

In the urban context, the use of appropriate technology in agriculture refers to technological innovations adapted to local conditions, easy for farmers to operate, cost-effective, and environmentally friendly. This technology encompasses various forms, ranging from small-scale agricultural tools and machinery, such as transplanters, solar-powered irrigation pumps, and legowo rice planting tools, to post-harvest technologies such as grain dryers and machinery.

Denpasar, the capital of Bali Province, plays a central role in the regional economic, social, and spatial dynamics. In addition to its administrative and service functions, the agricultural sector, including irrigated rice fields, horticultural land, and the traditional subak system, plays a strategic role in supporting food security, rural-urban prosperity, and preserving Bali's agrarian culture. Although Denpasar has increasingly become a hub of urban activity in recent decades, agricultural areas within and around the city remain a vital source of local food for residents, local markets, and Balinese culinary tourism. Therefore, spatial changes and agricultural production performance need to be analyzed and addressed through forward-thinking policies.

However, land use developments and urbanization pressures in recent years have shown a trend toward shrinking agricultural land in Denpasar. Administrative data and field observations indicate a gradual decline in agricultural land and rice paddy areas over the past few years, indicating land conversion for housing, infrastructure, and other non-agricultural uses. This phenomenon is not simply a matter of land quantity but is also closely related to productivity, farmer regeneration, technology transfer, and the capacity of the local supply chain, which has implications for the availability of staple foods, particularly rice, at the city level. According to regional statistics publications, the area of agricultural land in Denpasar City has decreased, recorded at around 1,871–1,915 hectares in the most recent documented period, after several consecutive years of decline (Balipost.com).

The decline in land area in Denpasar is not solely a local issue; it is related to broader dynamics such as increasing pressure on demand for space due to urbanization, the attraction of residential and commercial development, and economic incentives that lead landowners to choose to sell or convert agricultural land. Furthermore, factors such as

limited access to modern agricultural technology, fragmented land ownership, aging farmers, and limited financial support also undermine the agricultural sector's ability to maintain and increase productivity. Regional performance evaluation reports also note measurable conversion of rice fields in certain years (for example, 43 hectares of conversion recorded in 2021 in several sub-districts), highlighting the urgency of policy interventions to stem the rate of agricultural land loss and improve the efficiency of remaining land.

Based on Regional Regulation Number 8 of 2021 concerning the Denpasar City Spatial Plan for 2021-2041, Denpasar City has a land area of 12,598.10 hectares. Of this area, 1,459.65 hectares are allocated for agricultural purposes, 1,378.54 hectares for food crops, and 81.10 hectares for horticulture. Meanwhile, the population of Denpasar City in 2024, according to data from the Denpasar City Statistics Agency (BPS), was 673,270 people, spread across four sub-districts: East Denpasar, West Denpasar, North Denpasar, and South Denpasar.

By comparing the environmental carrying capacity of food supply with the population's food consumption, information on the status and distribution of food carrying capacity can be illustrated through food production and consumption modeling. Data on food energy production in Bali Province in 2018, comprising agricultural crops, plantations, livestock, inland fisheries, and marine fisheries, accumulated a total food energy production of 3,412,596,680,191.09 kcal. The availability of food to meet the minimum daily physical needs, according to the population of Bali Province, is 2,407.40 kcal/capita/day. This indicates that the achieved production and productivity are not sufficient to independently meet the rice consumption needs of the population of Denpasar City.

Rice, horticultural, and annual crop production in Denpasar is recorded periodically in the Denpasar City Statistics Office (BPS). Although the city is not designated as a primary agricultural area, rice paddies and horticultural gardens within the city contribute to several local food commodities. However, productivity per hectare for some commodities remains below the provincial or national average, influenced by traditional cultivation practices, limited use of fertilizers/high-quality seeds, and seasonal irrigation water constraints. Disaggregation of production data by sub-district reveals variations in performance reflecting heterogeneity in land conditions, infrastructure access, and the quality of farmer organizations.

The subak system and farmer groups remain important elements of water management and agricultural cultivation in Bali, including in some areas of Denpasar City. However, urbanization and land use transformation have resulted in changes in local institutional structures. Many subaks have experienced fragmentation, land loss, or land conversion, reducing their collective capacity. On the labor force side, there is a trend of aging farmers and difficulties attracting young people into the agricultural sector, common challenges in many developing urban areas. Addressing this requires policies that attract the younger generation and strengthen the role of modern agricultural extension services.

Based on preliminary data analysis and local studies, the main issues hampering agricultural production in Denpasar City include: 1) Agricultural land conversion, which reduces the stock of productive land and disrupts the continuity of water resource management and agricultural installation networks; 2) Low adoption of appropriate technology and intensification practices; many farmers still rely on traditional, efficient practices at a certain scale but have not maximized the potential for increasing productivity per hectare through superior varieties, integrated pest management, balanced fertilizer use, or light mechanisms; 3) Limited capital, access to extension services, and infrastructure also slow technology diffusion; 4) Lack of integration between production, storage, and market access makes small producers vulnerable to price fluctuations and margin losses; 5) The lack of cold storage facilities for horticulture and long distribution chains for urban needs reduce incentives for local production; 6) Climate change and issues with irrigation water availability directly impact water availability for rice fields and horticultural land.

Considering Denpasar's strategic position as an urban center and a region still rich in agricultural resources, policy intervention is urgent. Without integrated action, the decline in agricultural area and productivity will increase the city's dependence on external supplies, increase food price vulnerability, and weaken socio-cultural aspects associated with traditional agricultural practices. Therefore, policies to increase agricultural production in Denpasar must be multidimensional, combining land protection measures, productive intensification, adoption of technologies appropriate to the urban context, and strengthening market institutions.

The purpose of this paper is to provide operational, evidence-based, and contextual policy recommendations for sustainably increasing agricultural production in Denpasar City. This is achieved by assessing the existing condition of land and agricultural production in Denpasar and identifying the main causes of declining production capacity. Developing short- and long-term policy options to curb land conversion, increase productivity per hectare, strengthen market access and add value to local agricultural products. Presenting a roadmap for implementing the recommendations, including policy priorities, funding mechanisms, and performance indicators for monitoring and evaluation.

The scope of the analysis is limited to the administrative area of Denpasar City, focusing on the primary commodity of rice and potential urban agricultural practices. The methodology used in this paper is a review of literature and official documents (BPS Denpasar City publications, Denpasar City KLHS 2025-2029, Regional Evaluation Reports), secondary data analysis, and a synthesis of policy practices from other relevant city cases. The data collection

method used in this paper is secondary data, namely data and information obtained from various official and relevant sources. Reference sources include laws and regulations and scientific articles that have a direct relationship to the topic of discussion. The initial stage of the research includes the preparation of a framework that serves as a conceptual basis for the analysis process. Next, the collected data is tabulated and systematically integrated to ensure its completeness, consistency, and structure according to the analysis needs.

The analysis process involves formulating various policy alternatives based on relevant theoretical approaches and analytical frameworks. Each alternative is then evaluated using predetermined criteria. Policy priorities are determined through a scoring method by key individuals with competency and experience in the relevant fields. The assessment criteria cover aspects of effectiveness, efficiency, and the potential long-term impact on increasing agricultural production in Denpasar City.

The final stage of the analysis uses a logic model approach to assess programs and activity targets that contribute to achieving the master policy. This approach serves as a tool in designing, implementing, and assessing program effectiveness, allowing all stages of planning, implementation, and evaluation to proceed in a more focused and measurable manner.

The government has undertaken various efforts to increase rice productivity, including the provision of superior rice seeds. Superior rice seeds play a crucial role in national food self-sufficiency. The use of superior seeds is inseparable from seed procurement from upstream to downstream, encompassing cultivation, harvesting, distribution, and marketing to farmers, in accordance with the six rights (6T) principle: right time, right quantity, right type, right place, right price, and right quality. Strengthening food security, particularly by increasing rice production, also requires the development of agricultural technology innovation. Agricultural technology innovation plays a crucial role in increasing agricultural productivity. Agricultural technology innovation is not simply a new technology but rather something that drives societal renewal.

II. Discussion

A. Overview

Denpasar City, the capital of Bali Province, is home to economic activities in the services, trade, and tourism sectors. Although the agricultural sector's contribution to the GRDP is relatively small compared to other sectors, it still plays a strategic role in ensuring local food security and maintaining the region's cultural and ecological functions through the historic Subak system. Pressure on agricultural land due to urbanization and tourism infrastructure development has been a key factor changing the dynamics of agricultural production in Denpasar City.

Statistics show that Denpasar City's land area has decreased from 1,958 hectares in 2020 to 1,658 hectares in 2024. This decrease of approximately 18.09% over five years reflects a significant trend of land conversion. This land conversion generally occurs on the outskirts of urban areas, located close to residential areas and tourism corridors, where the economic value of land for non-agricultural purposes is much higher than its value for food production.

The decrease in harvested area will undoubtedly impact total rice production. Rice production figures for 2020-2024 are as follows:

TABLE I
LAND AREA AND AGRICULTURAL PRODUCTION IN DENPASAR CITY

Year	Exsiting padifield area (Ha)	Production (ton/year)				Note
		Rice	Vegetable	Spinach	Water Spinach	
2020	1985	27,912	3,197	558	5,894	
2021	1915	25,338	3,225	611	5,526	
2022	1871	28,236	2,964	619	4,854	
2023	1680	26,763	2,731	616	7,061	
2024	1658	24,085	2,667	622	4,839	

Source: Department of Agriculture, 2024

This trend indicates a gradual decline closely related to reduced planted area and other factors such as climate variability, water availability, and cultivation practices. Productivity per hectare remains relatively stable at around 7-8 tons of dry grain per hectare, indicating that technical productivity has not experienced a sharp decline, but production scale is decreasing due to shrinking land area.

The Ecosystem Services Index (EIS) for Food Supply (IJE) on a 30" x 30" grid is used to determine the proportion of the quantitative distribution of food energy production, which is then used to determine the Environmental Carrying Capacity (ESC) status for Food Supply. High EIS values for Food Supply are generally influenced by the presence of agricultural land cover in the form of rice fields, forests, dry fields, and plantations. Statistical data shows that food energy production in each district/city in Bali Province in 2018 consisted of agricultural crops, plantations, livestock, inland fisheries, and marine fisheries. If all food energy production is accumulated, the total food energy production in Bali Province in 2018 was 3,412,596,680,191.09 kcal. Meanwhile, Denpasar City only contributed 234,545,905,720 kcal, or 6.87% (KLHS Denpasar City 2025-2029).

The next step after modeling food energy production is developing a food energy consumption model. This model is based on the average energy consumption of the Bali Province population, which is 2,407.40 kcal per capita per day. This figure represents the standard daily energy requirement calculated based on average community consumption and refers to balanced nutrition guidelines.

The main factor influencing food energy consumption is population size, so the distribution of food energy consumption in a region tends to follow the population

distribution pattern. The higher the population, the greater the total energy consumption required to meet the community's food needs. This situation makes areas with high population densities the centers of food demand.

Based on the accumulated food energy consumption in each district/city, as shown in the table below, food energy consumption in Bali Province reached 3,771,513,861,047.00 kcal. Food energy consumption in Denpasar City was 817,716,514,497.00 kcal, or 21.68%, the highest in Bali.

TABLE II
LAND AREA AND AGRICULTURAL PRODUCTION IN DENPASAR CITY

No	Regency	Total of consuming energy (kkal)	Percentage (%)
1.	Jembrana	243.053.090.105,00	6,44
2.	Tabanan	389.677.532.470,00	10,33
3.	Badung	577.223080.405,00	15,30
4.	Gianyar	446.458.312.389,00	11,84
5.	Klungkung	156.667.116.094,00	4,15
6.	Bangli	198.761.287.499,00	5,27
7.	Karangasem	364.471.994.285,00	9,66
8.	Buleleng	577.484.933.303,00	15,31
9.	Denpasar	817.716.514.497,00	21,68

Sumber : KLHS Kota Denpasar 2025-2029

The largest food energy consumption is concentrated in urban areas and regions with high levels of urbanization. A map of food energy consumption modeling in Bali Province in 2018 shows that consumption is spread across Denpasar City, Badung Regency, and Gianyar Regency. These three regions share common characteristics: densely populated areas, centers of economic growth, and relatively high levels of mobility and urbanization. This situation has important implications for regional food security planning. Areas with high food consumption require a stable and sustainable supply to prevent potential food insecurity. Furthermore, limited agricultural land in urban areas like Denpasar increases dependence on food supplies from other regions. Therefore, efficient food distribution strategies, strengthening supply chains, and developing reliable logistics systems are crucial to ensuring food availability in these areas.

From a policy perspective, these conditions can be used to determine regional priorities for food program interventions. Denpasar can be a focus for strengthening food distribution infrastructure, increasing strategic food reserves, and promoting local food diversification to reduce dependence on external supplies. Furthermore, areas with high consumption can also be directed to develop urban farming and precision agricultural technologies to increase production efficiency within limited land areas. Trends indicate that the increasing population in urban areas of Bali, particularly Denpasar, has the potential to increase future food energy needs. This requires adaptive food production planning based on long-term demand projections to maintain a balance between production and consumption.

Based on food energy production and consumption data, we can calculate the difference between the two to identify areas experiencing a food energy surplus and a food energy deficit, in accordance with their environmental carrying capacity. Accumulating the difference between food energy production and consumption, Bali Province generally experiences a food energy deficit of -358,917,180,855.92 kcal. Meanwhile, Denpasar City's food deficit reached -583,170,608,777.00 kcal, the highest deficit in Bali.

TABLE III
DIFFERENCE BETWEEN PRODUCTION AND CONSUMPTION OF FOOD ENERGY BY DISTRICT/CITY IN BALI PROVINCE IN 2018

No	Regency	Total food production consumption energy from food (kkal)	Total consumption from food (kkal)	Total of minus Production and Consumption (kkal)	Note
1.	Jembrana	296.962.079.841,95	243.053.090.105,00	53.908.989.736,95	Surplus
2.	Tabanan	602.464.304.341,50	389.677.532.470,00	212.786.771.871,50	Surplus
3.	Badung	426.429.261.783,38	577.223.080.405,00	-150.793.818.621,62	Deficit
4.	Gianyar	543.177.895.400,63	446.458.312.389,00	96.719.583.011,63	Surplus
5.	Klungkung	163.498.832.956,50	156.667.116.094,00	6.831.716.862,50	Surplus
6.	Bangli	173.948.322.824,13	198.761.287.499,00	-24.812.964.647,87	Deficit
7.	Karangasem	391.943.599.563,00	364.471.994.285,00	27.471.605278,00	Surplus
8.	Buleleng	579.626.477.760,00	577.484.933.303,00	2.141.544.457,00	Surplus
9.	Denpasar	234.545.905.720,00	817.716.514.497,00	-583.170.608.777,00	Deficit
	Provinsi Bali	3.412.596.680.191,09	3.771.513.861.047	-358.917.180.855,91	Deficit

Sumber : P3E Bali Nusra (2021)

Rice production and consumption data in Denpasar City from 2020-2024 shows that the fulfillment of rice consumption from local food production shows a downward trend, although there was an increase in 2023. However, in general the fulfillment level is in the range of 23% of food consumption.

TABLE IV
RICE PRODUCTION AND CONSUMPTION IN DENPASAR CITY 2020-2024

No	Year	Production total	Rice needed	Rice Production (Ton)	Rice Production (konversi)/Ton	Percentage %
1	2020	725.314	75.962	27.912	17.476	23,01
2	2021	726.599	76.097	25.338	15.864	20,85
3	2022	726.800	76.118	28.236	17.679	23,23
4	2023	748.400	78.380	26.763	16.756	21,38
5	2024	755.570	79.131	24.085	15.080	19,06

Sumber data : Dinas Pertanian Kota Denpasar,2024

In general, agricultural production can be defined as the process of producing agricultural commodities, including food crops, horticulture, plantations, and livestock, through

the utilization of production factors such as land, labor, capital, and technology to meet human needs. Agricultural production encompasses all forms of human endeavor in processing natural resources, particularly land and water, to produce agricultural commodities that are beneficial for meeting the needs of the community (Mubyarto, 1987).

Agricultural production can be viewed from several perspectives: 1). From an economic perspective, agricultural production is the activity of transforming inputs into outputs, involving a combination of land, water, labor, fertilizers, seeds, and technology to produce agricultural products. The value of production is calculated not only from the quantity of the harvest (physical output), but also from the economic value generated in the form of selling prices in the market. From an economic development perspective, agricultural production is a crucial component of primary sector development, as agricultural products serve not only as a food provider but also as a basis for industrial growth and improving social welfare (Todaro & Smith, 2015). 2) From a social perspective, it is a source of livelihood for farmers, families, and rural communities. The level of agricultural production is directly related to farmer welfare, social stability, and community food security. 3) From an ecological and environmental perspective, agricultural production depends on limited natural resources, such as land, water, and ecosystem fertility. Therefore, sustainable agricultural production requires wise management to avoid environmental damage.

In practice, agricultural production indicators can be measured through several indicators, including: 1) Harvested area, which is the total area planted and harvested; 2) Productivity (tons/ha), which is the average yield per unit area; 3) Total production (tons/GKG), which is the overall yield of a commodity in a specific area; 4) Production value (Rp), which is the economic value of production based on market prices.

In the context of agricultural statistics, harvested area is defined as the area of agricultural land that actually produces and is harvested within a specific period, generally measured in hectares. The concept of harvested area differs from planted area, as harvest only takes into account areas that are successfully harvested, while planted area includes all planted areas, including those that fail to yield. The Central Statistics Agency (BPS, 2023) emphasizes that harvested area can be calculated more than once a year if the land experiences multiple cropping. For example, one hectare of rice fields planted and harvested twice a year would be recorded as two hectares of harvested area. This makes the harvested area indicator crucial for measuring land use intensity and agricultural productivity levels.

Within the policy framework, harvested area is a key variable in calculating total production (harvested area x productivity per hectare). Therefore, changes in harvested area have direct implications for regional food availability, food security, and potential production surpluses or deficits. A decrease in harvested area due to land conversion or crop failure will impact local food production capacity. Conversely, increasing harvested area through irrigation optimization, crop intensification, or agricultural land protection will strengthen regional food security.

TABLE V
RICE HARVEST AREA (HECTARES) IN DENPASAR CITY IN 2020-2024

No	Year	Harvest Area (ha)
1.	2020	3.151,56
2.	2021	3.354,51
3.	2022	4.005,18
4.	2023	3.611,13
5.	2024	3.463,74

Source: BPS Bali Province, 2024

The analysis shows that the agricultural sector in Denpasar City faces a number of fundamental, interrelated problems, preventing it from optimally meeting food consumption, particularly rice, through local food production. The first problem is the conversion of agricultural land due to rapid urbanization. Pressures from development, tourism facilities, and urban infrastructure have significantly reduced productive agricultural land. This has direct implications for reduced harvested area and reduced local food production capacity.

Another equally important issue is the limited irrigation infrastructure, which also poses a challenge. The Subak system, a cultural heritage and primary water distribution system, faces degradation and lack of maintenance. This reduces the effectiveness of water distribution, particularly during the dry season, ultimately impacting productivity.

Furthermore, the low adoption of appropriate technology remains a serious obstacle. Most farmers still rely on traditional cultivation methods. Lack of access to training, modern equipment, and precision farming technology prevents the potential for increased productivity from being optimally utilized.

Another problem is the weak regeneration of farmers. According to data from the Denpasar City Statistics Agency (BPS) (2023), only around 3.41% of the workforce is involved in the agricultural sector. This figure indicates the low interest of the younger generation in pursuing agricultural endeavors, as this sector is considered less promising than the service and tourism sectors. If this situation is allowed to persist, the sustainability of the agricultural sector in Denpasar will be increasingly threatened. The aforementioned issues demonstrate that the agricultural sector in Denpasar City faces complex challenges encompassing ecological, technological, social, and economic aspects.

Based on the Avoid, Shift, and Improve approach to agricultural production, alternative policies were formulated, taking into account the effectiveness and technical feasibility (Bardach, 2012).

The first policy alternative is the Sustainable Food Agriculture Protection Program (PLP2B), which aims to prevent the massive conversion of agricultural land into residential areas, tourism facilities, or urban infrastructure.

This program is integrated into the Denpasar City Spatial Plan (RTRW), thus ensuring the sustainability of rice fields.

The second policy alternative is increasing agricultural productivity through technology. This program is implemented through the implementation of smart farming and agricultural digitalization, with the provision of agricultural tools and machinery (alsintan) aimed at increasing production efficiency and reducing reliance on manual labor. Agricultural machinery assistance in the form of tractors, water pumps, and rice threshers is provided to farmer groups. This program has the potential to increase productivity and accelerate the cultivation process. This program can also be implemented through subsidies and training in the use of agricultural machinery, as well as the development of climate-adaptive superior seeds.

The third policy alternative involves agricultural diversification and the development of urban farming based on hydroponic and vertical farming technologies. This innovation is an adaptive strategy to address land limitations in urban areas. Urban farming is expected to provide a supply of fresh horticultural crops, improve household food security, and strengthen urban community involvement in agricultural activities.

The fourth policy alternative is institutional strengthening and agricultural regeneration. This program can be implemented through the establishment of modern farmer cooperatives, agricultural internships for the younger generation, and providing support for market access and value chains for farmer groups.

To ensure successful implementation, public outreach and education regarding the benefits of this policy, along with strict supervision and administration, are essential. The four policy alternatives will be scored to determine the policies to be implemented to address existing problems. The scoring process is described in Chapter III of this paper.

B. Policy Alternatives

The policy to increase agricultural production in Denpasar City is based on three main rationales: 1) limited and shrinking agricultural land due to the pressures of urbanization; 2) stagnant productivity, indicating low technology adoption and cultivation efficiency; and 3) dependence on food supplies from outside the region, which poses a risk of vulnerability when distribution disruptions occur. Accordingly, the policy direction is set to protect strategic agricultural land and maintain the function of the subak (land-based agricultural system); increase productivity through technological innovation, improved cultivation practices, and input efficiency; strengthen irrigation infrastructure and water management; encourage commodity diversification and urban farming; and strengthen institutions, financing, and farmer regeneration.

The policy direction is set to: (i) curb the rate of land conversion and ensure certainty of production space; (ii) increase the productivity of production factors through technological innovation and good cultivation practices; (iii) strengthen climate-adaptive Subak-based irrigation infrastructure; (iv) differentiate production sources through horticulture and urban farming; and (v) revitalize institutions and farmer regeneration to make the sector economically attractive and socio-ecologically sustainable.

Referring to the existing conditions outlined in Chapter II, the policy objectives are formulated as follows:

1. Land protection: stabilizing—and, in priority locations, increasing—harvest area through the establishment/enforcement of LP2B (Land Use Management) in high-potential areas and strategic Subak corridors.
2. Productivity: increasing rice productivity from approximately 7 tons/ha to >7.5 tons/ha through technology packages (adaptive superior seeds, precision fertilization, IPM) and appropriate-scale mechanization.
3. Diversification and urban farming: increasing the contribution of fresh urban horticulture through the development of hydroponics/vertical farming and the use of measurable yards.
4. Institutionalization and regeneration: increasing the participation of the younger generation (millennial farmers) and strengthening cooperatives/farmer groups based on value chains and digital platforms.

In analyzing the priorities of policy alternatives, a scoring assessment of 1-5 was carried out by key persons within the Denpasar City Agriculture Service, namely Echelon II, III, IV and Jafung officials based on the Avoid, Shift, and Improve approach by considering the criteria of effectiveness, efficiency, and long-term impact.

TABLE VI
RICE HARVEST AREA (HECTARES) IN DENPASAR CITY IN 2020-2024

Policy Alternative	Effectivities	Efficiency	Long Term Impact	Total Skor
Sustainable Food Agriculture Protection Program (PLP2B)	4	3	4	11
Increasing agricultural productivity through technology	5	5	5	15
Agricultural diversification and urban farming development based on hydroponic and vertical farming technologies	5	4	5	14
Institutional strengthening and agricultural regeneration	4	3	3	10

Source: 2025 Analysis Results

The results of the scoring analysis of policy alternatives in the table above indicate that the policy alternative for increasing agricultural productivity through technology, based on effectiveness, impact efficiency, and long-term impact, has the highest score.

Agricultural productivity in Denpasar City, particularly for rice and horticultural commodities, continues to stagnate. Data shows that rice productivity is relatively

stable at around 7 tons/ha, while the potential for growth has not been optimally achieved. This condition is closely related to various factors, including limited land due to land conversion, low technology adoption rates, and limited agricultural infrastructure that supports cultivation efficiency. In this context, productivity improvement policies are aimed not only at improving production performance but also at strengthening the competitiveness and sustainability of urban agriculture.

The main substance of the policy focuses on the application of appropriate technology and modern cultivation practices tailored to Denpasar's agricultural characteristics. This city is characterized by relatively limited land and a Subak-based management system, which demands more efficient, measurable, and adaptive cultivation strategies to climate change and the pressures of urbanization. Therefore, the productivity improvement strategy is formulated through five instruments:

First, the use of Adaptive Seeds. Selecting superior varieties that are resistant to biotic (pests and diseases) and abiotic (drought, flooding, and extreme temperatures) stresses is a crucial prerequisite for maintaining production stability. Furthermore, varieties must be tailored to local market preferences and the tourism sector, a major consumer of food products in Denpasar. The implication of using climate-adaptive seeds is the achievement of stable harvest yields despite climate change. Furthermore, production is aligned with local market and tourism preferences.

Second, Precision Fertilization Based on Soil Testing. Fertilization practices have tended to be generic, often leading to inefficiency and degradation of soil fertility. With soil testing, fertilizer application can be balanced and appropriately dosed, thereby reducing input costs, maintaining land quality, and increasing yields.

Third, Integrated Pest Management (IPM). The IPM approach integrates the use of biological agents, crop rotation, and ecosystem management to reduce reliance on chemical pesticides. IPM not only reduces production costs, but also maintains environmental sustainability and the quality of agricultural products that are safer to consume.

Fourth, Appropriate-Scale Mechanization. The limited agricultural land in Denpasar demands the implementation of small-scale mechanization, such as mini tractors, power threshers, and energy-efficient pumps. This appropriate-scale mechanization increases labor efficiency, reduces the physical burden on farmers, and accelerates land preparation and harvesting. To ensure sustainability, agricultural machinery needs to be managed collectively through operation and maintenance (O&M) service centers at the farmer group or cooperative level.

Fifth, Participatory Learning through Farmer Field Schools (FFS). One of the main barriers to technology adoption is farmers' limited understanding. Therefore, FFS serves as a platform for hands-on, hands-on education through demonstration plots (demfarms). By comparing the results of new technology implementation with existing practices, farmers can make evidence-based decisions (evidence-based adoption), resulting in faster and more sustainable adoption.

Overall, this policy is expected to have several strategic implications, namely: (i) increasing rice productivity above 7.5 tons/ha, (ii) reducing production costs per unit of yield, (iii) improving the quality of grain and horticultural crops to meet modern market standards, and (iv) maintaining ecological and social sustainability through environmentally friendly cultivation practices. Therefore, this policy is not only a technical solution but also an instrument for structural transformation to strengthen urban food security amidst the dynamics of urbanization.

Implementing the strategy to increase agricultural productivity through technology in the short term (0–2 years) can be done through a series of practical and immediately operational instruments. Several key implementation steps can be outlined as follows.

First, technology socialization and education are crucial initial steps to introduce farmers to modern agricultural technology. This activity takes the form of short training sessions on the use of drip irrigation technology, soil moisture sensors, and the use of liquid organic fertilizers. The primary responsibility lies with the Department of Agriculture, with support from field agricultural extension workers (PPL). Within 3 to 6 months, it is hoped that at least 200 farmers will participate in the training, with a target technology adoption rate of 30%.

Second, agricultural technology pilot projects need to be implemented to provide farmers with empirical evidence of the technology's effectiveness. This program involves piloting land that implements light mechanization, such as transplanters, mini hand tractors, and drone sprayers, in one to two subak (land-based agricultural units). Implementation will be carried out by the Department of Agriculture in collaboration with farmer groups over a period of six to twelve months. The expected result is a 10–15% increase in productivity compared to land that does not use the technology.

Third, in terms of information, agricultural digitalization is a crucial step in facilitating access to knowledge and coordination among farmers. One possible approach is the use of simple applications, such as WhatsApp groups or subak-based applications, to share information on market prices, weather forecasts, and planting schedules. This initiative can be initiated by the city government in collaboration with the local technology community, with an estimated implementation time of three to six months. The target achievement indicator is the formation of at least five active digital groups at the subak level.

Fourth, technology adoption incentives are needed to encourage farmers to more quickly transition to modern agricultural systems. A possible scheme would be a 30–40% subsidy for the procurement of agricultural equipment such as drip irrigation, drone sprayers, or soil moisture sensors. This program could be implemented by the local government with support from the private sector over one

to two years. The target outcome is for at least 50 farmers to receive technology assistance, allowing adoption to expand to the farming community level.

Fifth, to ensure implementation is on track, regular monitoring and rapid evaluation are necessary. This evaluation should include crop yields, input cost efficiency, and farmer satisfaction levels. This activity can be implemented by the Department of Agriculture, involving academics, over a period of one to two years. The primary expected indicator is the availability of an annual productivity evaluation report as a basis for formulating further policies.

C. Recommendation Policy

To promote the effectiveness of technology-based agricultural productivity improvement policies in Denpasar City, a regulatory framework is needed that provides both a legal basis and operational guidelines. This regulatory framework serves to clarify the division of duties and authorities between agencies, establish program implementation mechanisms, and ensure synergistic coordination among the involved institutions. With comprehensive regulations, every development actor—including local governments, extension workers, farmer groups, and the private sector—has a clear reference point in carrying out their roles. Furthermore, the existence of formal regulations can also reduce overlapping authority, strengthen accountability, and ensure the continuity of agricultural technology programs from the planning stage to evaluation.

Policy recommendations for increasing agricultural productivity through the use of technology in Denpasar City need to be formalized in a special regulation, namely a Mayoral Regulation (Perwali) concerning Agricultural Technology Implementation Procedures. This regulation serves not only as a legal instrument but also as a technical guideline governing the implementation, monitoring, and supervision mechanisms for technology-based programs in the agricultural sector. With this regulation, the process of technology adoption by farmers can be more focused, transparent, and measurable, in line with regional agricultural development goals. This Mayoral Regulation covers several important aspects, including establishing standard procedures for the use of agricultural technology (such as light mechanization, modern irrigation systems, and digital agricultural applications), mechanisms for providing technology assistance or subsidies, and structuring the roles of each Regional Apparatus in supporting program sustainability. Furthermore, this regulation establishes procedures for periodic monitoring and evaluation to ensure that the program is not only effective but also targeted to the needs of farmers and farmer groups at the subak level.

Furthermore, this Mayoral Regulation serves as a coordination instrument between agencies within the Denpasar City Government. For example, the Agriculture Service will act as the implementing coordinator, while the Communication and Informatics Service will support the digitalization of agricultural information, the Cooperatives and MSMEs Service will facilitate access to capital, and the Regional Planning Agency will ensure synchronization with regional development planning documents. This regulatory framework is expected to foster strong synergy between Regional Apparatus, so that policies to increase agricultural productivity through technology can be implemented consistently and sustainably, and have a tangible impact on food security and the welfare of farmers in Denpasar City.

As a follow-up to the enactment of the Denpasar Mayoral Regulation on Agricultural Technology Implementation Procedures, derivative documents are required at the regional government level to ensure program implementation aligns with policy directives. At the operational level, the Mayoral Regulation is elaborated through a Decree (SK) from the Head of the Denpasar City Agriculture Service, which serves as both a technical guideline and a coordinating instrument for implementing the agricultural technology utilization program.

III. CONCLUSION

This Decree details the formation of the Agricultural Technology Implementation Implementation Team within the Denpasar City Agriculture Office. It establishes the team's organizational structure, the duties and responsibilities of each division, and the coordination mechanism between units. The team is mandated to plan, implement, facilitate, and monitor the implementation of various agricultural technologies, ranging from light mechanization and modern irrigation systems to the digitization of agricultural information.

Furthermore, this Decree also regulates the technical procedures for program implementation, including the provision of technological assistance, training and mentoring mechanisms for farmers, and a monitoring and evaluation system for program achievements at the subak (village-level) and farmer group levels. With this Decree, policy implementation is not only normative but also operational and applicable in the field.

Ultimately, this Decree from the Head of the Agriculture Office is expected to strengthen synergy between units within the Regional Apparatus Organization (OPD), while also serving as a bridge for coordination with other regional agencies, such as the Communication and Informatics Office, the Cooperatives and MSMEs Office, and the Regional Development Planning Agency (Bappeda). With a clear operational framework, agricultural technology implementation in Denpasar City can be more effective, targeted, and contribute significantly to increasing regional agricultural productivity.

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