CIPS
Center for Indonesian
Policy Studies

Policy Paper No. 37

Food and Horticulture Crop Productivity in Indonesia

by Kadir Ruslan

www.cips-indonesia.org

Policy Paper No. 37

Food and Horticulture Crop Productivity in Indonesia

Author:
Kadir Ruslan

Acknowledgement:
The author would like to thank Octavia Rizky Prasetyo, Ratna Rizki Amalia, Isnaeni Nur Khasanah, Karina Astuti, Malik Faisal Aziz, and Amelia Derta Irjayanti who have assisted in the publication of this paper.

Jakarta, Indonesia
July, 2021

Editorial Notes:
In the previous version of this article, there were some errors found in the writing on pages 29-34. The corrections to the errors can be found in the editorial notes written at the bottom of the page where errors were found.

CONTENT

List of Tables

List of Figures

EXECUTIVE SUMMARY

Indonesia is faced with the challenge of ever-increasing domestic food demands as a consequence of population growth and improvements in people's purchasing power. To anticipate this, the national food production capacity should be increased through the expansion of agricultural lands and/or improvements in productivity, without which overreliance on food imports would be inevitable. Amidst the massive rate of agricultural land conversion to non-agricultural uses in recent years, increasing productivity must be pursued as the main strategy to boost the national food production capacity.

Statistics show that productivity trends of rice, soybean, and shallot tend to have sloped in the past few years. The national rice productivity seems to be persistent at 5 tonnes per hectare of dried unmilled rice (*Gabah Kering Giling* or GKG), whereas the shallot and soybean productivity rates tend to be stagnant at 10 and 1.5 tonnes per hectare, respectively, in recent years. These conditions undermine the viability of self-sufficiency in the three commodities. A more positive outlook comes from maize, which has seen a trend of significant increase in national productivity in the past few years. In 2019, the national maize productivity reached 5.4 tonnes per hectare. The use of hybrid maize seeds by Indonesian farmers that amounted to 75.13% was the key driver to the increasing trend. This increasing productivity can also be seen in chili and cayenne pepper.

There is a huge opportunity to increase productivity, both for food crops and horticultural commodities. Bolstering productivity, in general, can be pursued by enhancing land and human resource productivity. In concrete terms, these two can be accomplished by using high-quality seeds, especially those from government assistance; improving farmers' access to fertilizers; managing pest/plant-disturbing organism infestations; utilizing agricultural equipment and machinery (mechanization) both in pre-harvest and post-harvest processes to minimize production losses; refining cultivation techniques, such as by promoting the implementation of the *Jajar Legowo* planting system in the lowland rice cultivation at a more massive scale; repairing and expanding irrigation network accesses; using weather modification to mitigate the impacts of climate change; developing the capacity of human resources in agriculture; focusing on the young farmers; strengthening farmer institutions through the farmer group membership; and improving farmers' access to information technology.

For rice and maize, closing the productivity gap between Java and regions outside Java is key to spurring national productivity. The productivity rates of rice and maize outside Java are 23% and 13% lower, respectively, compared to the productivity in Java. Hence, increasing the productivity of land and farmers in regions outside Java must be the main strategy in stimulating the national rice and maize productivity.

INTRODUCTION

Population growth, especially the middle class, accompanied by an increase in purchasing power, consequently leads to the increasing demands on food commodities. If not accompanied by an increase in domestic production capacity, Indonesia will continue to be dependent on food imports to fulfill the domestic needs. Thus far, a number of food commodities, such as maize and soybean, are still imported due to the insufficient domestic production. Statistics Indonesia (*Badan Pusat Statistik* or BPS) recorded that, throughout 2020, maize and soybean imports reached 1.02 million tonnes and 2.67 million tonnes, respectively. Technically, the increase of food crop and horticulture production can be achieved in two ways, which are improving productivity (yields per hectare) and expanding the planting areas. Amidst the decreasing trend of agricultural land areas, specifically the rice fields[1] as a result of development that rapidly drives the conversion of agricultural lands to non-agricultural uses, increasing productivity becomes the right solution to increase the production capacity of food and horticulture crops.

This paper explores the level of plant crops and horticulture's productivity in Indonesia, focusing on several commodities, namely rice, maize, soybean, chili, and shallot. These five commodities were chosen as the focus because of their significant roles in fulfilling Indonesian's food demands and their contribution to the inflation of food items. Several issues related to the productivity of food and horticulture crops are reviewed comprehensively, which include technical notes on productivity measurement, trends on productivity development in the last few years, productivity rates of rice and secondary crops (*palawija*) based on the agriculture cultivation profile, productivity disparity or gap between the regions, and the impacts of technology through mechanization on enhancing rice productivity in Indonesia. This paper's analysis elaborates on the results of the 2019 Crop-Cutting Survey (*Survei Ubinan*) and the 2018 Inter-Census Agricultural Survey (*Survei Pertanian Antar Sensus* or SUTAS) conducted by Statistics Indonesia. To conclude, several policy recommendations to increase the productivity rate and improve the data collection of productivity of food and horticulture crops in Indonesia are presented.

[1] The Ministry of Agrarian and Spatial Planning (MOASP) recorded that the standard area of rice fields declined from 7.75 million hectares in 2013 to 7.46 million hectares in 2019. This decline has caused the production capacity of food and horticultural crops in rice fields to decrease.

TECHNICAL NOTES ON THE PRODUCTIVITY MEASUREMENT

Analysis on the productivity rates of agricultural commodities in Indonesia must face issues of different data and accuracy of the data collection methods. For instance, data on the productivity of rice and maize released periodically by the United States Department of Agriculture (USDA) significantly differ from those collected by Statistics Indonesia.[2] This section reviews the data collection methods of rice, maize, soybean, chili, cayenne pepper, and shallot productivity that have been used as a reference by Statistics Indonesia and the Ministry of Agriculture (MOA).

"Analysis on the productivity rates of agricultural commodities in Indonesia must face issues of different data and accuracy of the data collection methods."

In general, the approach to measure productivity can be categorized into objective measurement and subjective measurement. The objective measurement uses statistical approaches (sampling survey) and measurement experiments, whereas subjective measurement relies only on the subjective estimation from the data collection officers based on the on-field conditions. In terms of accuracy, objective measurement results in more accurate estimates. Statistics Indonesia's method of estimating the productivity of rice and secondary crops (*palawija*)[3] (including maize and soybean) through the Crop-Cutting Survey[4] is an example of objective measurement in collecting data on productivity. This method combines statistical techniques to choose household samples and land plots using experiments on the yields' weight measurement on the selected plots. Meanwhile, to date, data collection on the productivity of chili and shallot is still based on subjective measurement.

[2] A substantial difference can be seen in maize productivity. According to the USDA, maize productivity in Indonesia is approximately only 3.3 tonnes per hectare, whereas the result of Statistics Indonesia's Crop-Cutting Survey shows that the national maize productivity is more than 5 tonnes per hectare. One of the issues is in the water content of dried maize kernels. The USDA stated that the productivity of dried maize kernels has a water content of about 14%. However, the results of the Maize Conversion Survey conducted by Statistics Indonesia in September 2020 and January-April 2021 in more than 1,000 points across Indonesia show that, with a water content of 13-14%, the national maize productivity had reached more than 5 tonnes per hectare. Such a significant difference might have been caused by the difference in approaches used to measure productivity. Unlike Statistics Indonesia, the USDA does not conduct crop-cutting or field surveys to determine maize productivity in Indonesia. Instead, they use a balance sheet approach to analyze the stability of maize supply and demands in Indonesia. In this case, according to the author, the productivity rate measured by Statistics Indonesia illustrates a more accurate description of the actual conditions compared to the productivity rate as reported by the USDA.

[3] Secondary crop commodities are maize, soybean, groundnut, mung bean, cassava, and sweet potato.

[4] The Crop-Cutting Survey is annually conducted by Statistics Indonesia to estimate the productivity of rice and secondary crops. In addition to information related to productivity, this survey also provides information regarding factors affecting productivity, such as the type of soil, cultivation technique, use of fertilization, government assistance, and farmer institution. The Crop-Cutting Survey provides information down to the regency/municipality level.

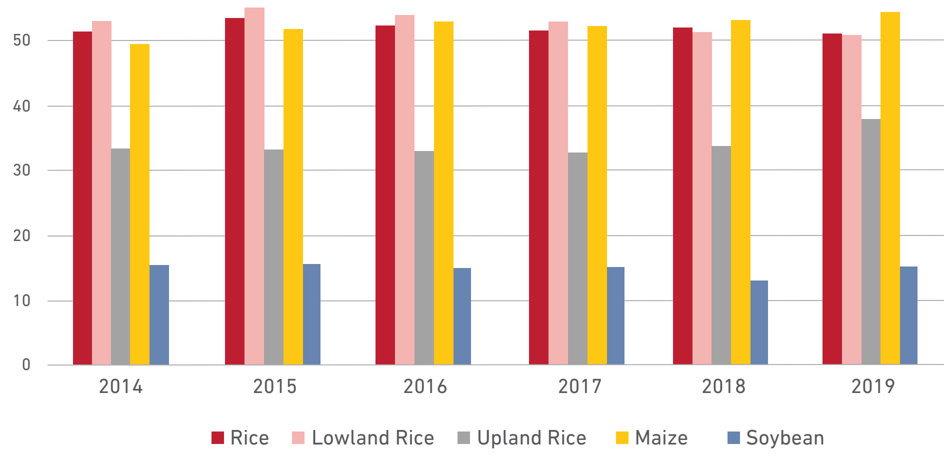
In practice, the productivity of chili and shallot is the result of dividing the production quantity by the harvest area, which are obtained not through measurement but from the estimation from the data collection officers based on the on-field conditions.[5] Therefore, the productivity data of chili and shallot presented in this paper are not free from inaccuracy issues.[6] A similar issue also exists in other agricultural commodities other than rice and secondary crops.

[5] Data on harvest area and production of horticultural commodities are collected monthly by the Agricultural officer at the district level, also known as the Head of Branch Office (*Kepala Cabang Dinas* or KCD), through the Horticulture Agricultural Statistics (*Statistik Pertanian Hortikultura* or SPH) activity. The resulting data is essentially the administrative data that are not based on statistical methods and objective measurement, but rather from the information obtained from the farmers in interviews and subjective estimation from the officer according to the on-field conditions.

[6] Since 2015, Statistics Indonesia has been developing an objective measurement method for several strategic horticultural commodities (chili, cayenne pepper, and shallot) by administering the Potential Horticulture Survey (*Survei Hortikultura Potensi* or SHOPI). However, the scale of this survey is still very limited, producing estimation only in a few regencies/municipalities.

TRENDS OF PRODUCTIVITY DEVELOPMENT FOR FOOD AND HORTICULTURE CROPS (RICE, MAIZE, SOYBEAN, SHALLOT, CHILI, AND CAYENNE PEPPER)

Figure 1.
Development of the Productivity of Rice, Maize, and Soybeans, 2014-2019
(in quintals per hectare)



Source: Statistics Indonesia

Over the last few years, the development of the productivity of strategic food crop commodities, which are rice, maize, and soybean, has generally remained stagnant.

Over the last few years, the development of the productivity of strategic food crop commodities, which are rice, maize, and soybean, has generally remained stagnant. From 2014 to 2019, maize was the only commodity that saw an increase in productivity. Within this period, the national maize productivity soared from 49.54 quintals of dried kernels per hectare to 54.52 quintals of dried kernels per hectare. In other words, it increased by approximately 5 quintals per hectare in total, or on average 1 quintal per hectare every year. Such an increase was partly due to the success of the introduction of hybrid seeds in recent years. Currently, the majority of maize cultivated by the farmers are those of the hybrid variety. The 2019 Crop-Cutting Survey revealed that approximately 75% of maize farmers cultivated the hybrid maize variety. Within the same period, however, rice productivity declined from 51.35 quintals of dried unmilled rice (GKG) per hectare to 51.14 quintals of dried unmilled rice per hectare. This decline was also seen in soybean, which fell from 15.51 quintals of dried grains per hectare to 15.11 quintals of dried grains per hectare.[7]

[7] Agriculture economist Bustanul Arifin (Kompas, 3 July 2020) gave an analysis on the declining rice productivity in the period of 2018-2019. According to him, the productivity decline was caused by several probabilities: (a) the national rice production started to decline and rice productivity started to level off; (b) the productivity measurement in the Crop-Cutting Survey is methodologically biased; and (c) the effectiveness of the government programs that aim to increase productivity is not optimal and needs to be improved.

In 2019, rice productivity hit 51.14 quintals of dried unmilled rice per hectare. Rice cultivation in Indonesia is dominated by lowland rice with a productivity of about 51 quintals per hectare. On the other hand, the productivity of upland rice in Indonesia was only 38 quintals per hectare. Despite this, the productivity of upland rice increased significantly in 2019 compared to the period between 2014 and 2018.[8] Unfortunately, the limited scale of upland rice cultivation also means its contribution towards the overall rice productivity is minimal. The results of the Area Sampling Frame Survey (*Kerangka Sampel Area* or KSA) show that the proportion of upland rice area is less than 5% of the total national rice area. Nevertheless, increasing the productivity of upland rice through refining the cultivation technologies is one of the pivotal strategies that can be pursued to bolster the national rice productivity. If the average productivity of national upland rice can be increased to more than 40 quintals per hectare, it can have a significant impact on the national rice productivity increase. The development of upland rice can be intensified in a number of provinces outside Java. The Area Sampling Frame Survey also shows that the national cultivation centers of upland rice are in the Special Region of Yogyakarta, North Kalimantan, Central Kalimantan, East Kalimantan, and East Nusa Tenggara.

Learning from the success of maize productivity increase, one of the efforts to stimulate rice productivity is to enhance the scale of utilizing the improved variety, especially hybrid rice[9] (Krishnamurti et al., 2019). To date, farmers' acceptance of hybrid rice seeds is still considered low. The 2019 Crop-Cutting Survey revealed that only 9.06% of the lowland rice farming households used hybrid seeds. This low acceptance rate has become another challenge in introducing hybrid seeds massively. Albeit having higher productivity, hybrid seeds are not attractive for farmers, possibly due to several factors, such as the relatively higher cultivation cost due to a more intensive treatment, and the rice quality does not suit the consumers' preference.[10]

In 2019, maize had an average productivity of 54.52 quintals per hectare. This relatively high productivity was a long-term effect of the massive introduction of hybrid maize seeds[11] over the past few years, especially since 2015.[12] In contrast, the average productivity of soybean was relatively low, recording only 15.11 tonnes per hectare in 2019. With such low productivity, improving the national soybean production to reduce dependency on soybean imports becomes a herculean challenge. Data from the Food and Agriculture Organization (FAO) suggest that, on average, Indonesian people's demand for soybean is 3.2 million tonnes per year, 2.67 million tonnes of which are fulfilled by imports.

[8] Since 2019, Statistics Indonesia has implemented methodological changes in the sampling of the Crop-Cutting Survey. Before that, plot sampling to measure productivity used a household approach (list frame). With the existence of the Area Sampling Frame Survey, the plot sampling since 2019 has been based on its results (area frame). Hence, the movement of the productivity rate after 2019 compared to the previous periods might have been affected by the said methodological change. More details on this methodological change are discussed by Amalia and Kadir (2019).

[9] The varieties of seeds used in lowland rice cultivation are categorized into two types, namely the hybrid and inbred varieties. When cultivated properly, hybrid lowland rice can yield a higher rate of productivity. The yield potential of hybrid rice is 10% to 25% higher than the inbred varieties, such as IR64, Ciherang, and Way Apo Buru (Satoto & Suprihatno, 2008).

[10] The prospects and challenges of hybrid rice seeds in Indonesia are reviewed in-depth by Krishnamurti et al. (2019).

[11] Hybrid maize results from a cross of two different maize varieties, each with their own characteristics, and promoted to have a yield potential of between 8 to 13 tonnes per hectare, while the maximum yield potential of traditional seeds is only 7 tonnes per hectare.

[12] In 2015, the Ministry of Agriculture promulgated a policy named the Special Efforts in Agriculture (*Upaya Khusus* or UPSUS). One of its focuses is to increase maize productivity by distributing free hybrid maize seeds to farmers, aiming to encourage maize farmers to switch from using traditional seeds to pest-resistant hybrid seeds with higher productivity. This program proved to have succeeded in significantly increasing maize productivity (Freddy et al., 2018).

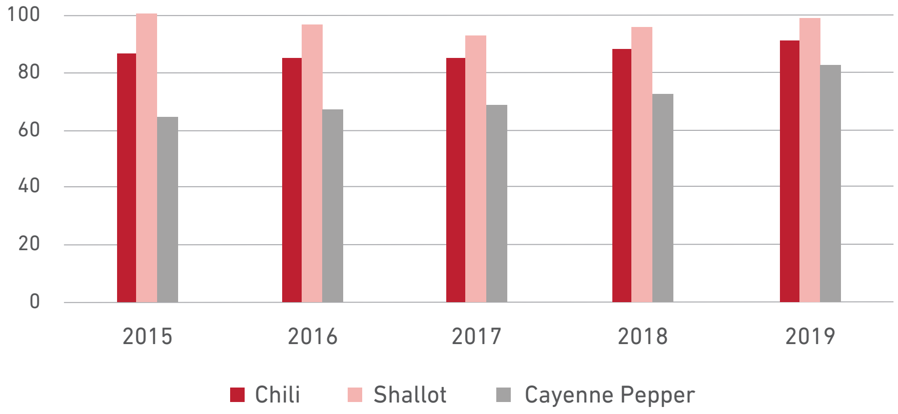
In 2019, the productivity rates of chili, cayenne pepper, and shallot in Indonesia were 91.01 quintals per hectare, 82.32 quintals per hectare, and 99.26 quintals per hectare, respectively. In general, from 2015 to 2019, the development of shallots' productivity tended to remain stagnant, whereas chili and cayenne pepper saw an increasing trend. The productivity of cayenne pepper increased the most during this period compared to the other two horticultural commodities.

The productivity of shallot tended to be stagnant from 2015 to 2019, reaching its lowest point in 2017. The national shallot productivity plummeted from 100.65 quintals per hectare in 2015 to 92.95 quintals per hectare in 2017. However, since 2018, the average productivity of shallot has increased to 99.26 quintals per hectare in 2019.

From 2015 to 2019, chili productivity increased by 4.52 quintals per hectare or approximately 1.31% annually. Albeit seeing a drop in 2016 and 2017, its productivity rose since 2018 to 91.01 quintals per hectare in 2019.

[11] Hybrid maize results from a cross of two different maize varieties, each with their own characteristics, and promoted to have a yield potential of between 8 to 13 tonnes per hectare, while the maximum yield potential of traditional seeds is only 7 tonnes per hectare.
[12] In 2015, the Ministry of Agriculture promulgated a policy named the Special Efforts in Agriculture (*Upaya Khusus* or UPSUS). One of its focuses is to increase maize productivity by distributing free hybrid maize seeds to farmers, aiming to encourage maize farmers to switch from using traditional seeds to pest-resistant hybrid seeds with higher productivity. This program proved to have succeeded in significantly increasing maize productivity (Freddy et al., 2018).

Figure 2.
Development of the Productivity of Chili, Cayenne Pepper, and Shallot, 2015-2019
(in quintals per hectare)



Source: Statistics Indonesia and Ministry of Agriculture

From 2015 to 2019, the national productivity of cayenne pepper experienced an increase of 6.90% per year, with the highest productivity increase in 2018, which was 8.47 quintals per hectare (12.31%) compared to in 2017. By 2019, it had reached 82.32 quintals per hectare, or an increase of 5.05 quintals per hectare (6.53%) from 2018.

FACTORS AFFECTING PRODUCTIVITY

The productivity of food crops is highly affected by the cultivation profiles implemented by the farmers, such as type of soil, planting technique, production facility and infrastructure utilization, as well as other factors, including government assistance, farmer group membership (farmers' institution), and climate change impacts. The results of the Crop-Cutting Survey enable the analysis to examine how those aforementioned factors affect productivity rate.

Rice Cultivation

Irrigated lowland rice generally has a higher rate of productivity compared to non-irrigated one. The 2019 Crop-Cutting Survey shows that 67.12% of lowland farmers cultivated their rice in irrigated areas. Amongst the non-irrigated lowland areas, rainfed areas made up the largest proportion of 29.53%. It should be noted that the performance of the national irrigation network is not yet optimal. In 2014, 46.11% of the irrigation network was found damaged, either as heavily damaged (15.97%), moderately damaged (16.84%), or lightly damaged (13.3%) (MOPH, 2017).

The average productivity of irrigated lowland rice was 54.10 quintals per hectare, much higher than that of the non-irrigated lowland rice. The productivity of rice cultivated in rainfed areas was only 44.97 quintals per hectare, whereas rice cultivated in tidal swamps and non-tidal swamps recorded a productivity rate of only 34.97 quintals per hectare and 45.34 quintals per hectare, respectively. This indicates that the role of the irrigation network is vital in maintaining rice productivity. Water sufficiency is a key to improving lowland rice productivity. The Crop-Cutting Survey also suggests that lowland productivity can be optimal, which is above 50 quintals per hectare, only if there is a sufficient amount of water for irrigation purposes. Hence, broadening the irrigation network, in addition to maintaining and revitalizing the existing network, is crucial to increasing the lowland rice productivity.

Table 1.
Productivity and Household Distribution of Rice based on Factors Affecting Productivity, 2019

No.	Factors Affecting Productivity	Productivity (in quintals per hectare)		Household Proportion (%)	
		Lowland Rice (Dried Unmilled Rice or GKG)	Upland Rice (Dried Unmilled Rice or GKG)	Lowland Rice	Upland Rice
1.	Type of Field				
	- Irrigated	54.1	-	67.12	-
	- Rainfed	44.97	-	29.53	-
	- Tidal swamp	34.97	-	2.36	-
	- Non-tidal swamp	45.34	-	0.99	-
2.	Water Sufficiency				
	- Poor	45.05	35.45	-	-
	- Sufficient	52.88	39.33	-	-
	- Excessive	48.58	34.59	-	-
3.	Planting Technique				
	- 2:1 Jarwo	50.45	-	3.02	-
	- 4:1 Jarwo	50.64	-	5.24	-
	- 6:1 Jarwo	52.52	-	4.47	-
	- Other Jarwo patterns	52.38	-	6.23	-
	- Non-Jarwo patterns	51.63	-	81.04	-
4.	Fertilizer and Seed Assistance				
	- Receiving fertilizer assistance	52.96	42.42	65.24	54.19
	- Not receiving fertilizer assistance	46.90	32.85	34.76	45.81
	- Receiving seed assistance	50.91	34.34	13.24	13.21
	- Not receiving seed assistance	50.85	38.61	86.76	86.79
	- Receiving agricultural equipment and machinery assistance	-	-	57.53	48.48
	- Not receiving agricultural equipment and machinery assistance	-	-	42.47	51.52
5.	Farmer Group Membership				
	- Member	51.25	38.53	65.66	55.57
	- Non-member	50.10	37.49	34.34	44.43
6.	Pest/Plant-Disturbing Infestations				
	- Infested	46.69	37.14	16.03	17.74
	- Not infested	56.94	42.42	83.97	82.26
7.	Climate Change Impacts				
	- Affected	44.11	33.27	22.43	24.71
	- Unaffected	52.81	39.65	77.57	75.29

Source: Processed from the results of the 2019 Crop-Cutting Survey

One of the cultivation techniques that is being intensively promoted to enhance lowland rice productivity is the *Jajar Legowo* technique. The *Jajar Legowo* planting system is a lowland planting method in which rice is planted in a pattern of alternating rows with an empty row in-between. The plants that are supposed to be placed in the empty rows are moved as inserted plants within the rows. Generally, this method can be employed in different types, such as the 2:1 *Jajar Legowo*[13] and 4:1 *Jajar Legowo* (IAARD, 2013). In practice, farmers also implement the 6:1 *Jajar Legowo* and other *Jajar Legowo* patterns.

Despite the fact that the *Jajar Legowo* planting technique has a significant potential to increase rice productivity (Prasetyo & Kadir, 2019), the 2019 Crop-Cutting Survey indicates that the proportion of Indonesian lowland rice farmers that employed the *Jajar Legowo* patterns was only 18.96%, while the other 81.04% used non-*Jajar Legowo* patterns. From the total lowland rice farmers, 5.24% of them used the 4:1 *Jajar Legowo* pattern, while 4.47% used the 6:1 *Jajar Legowo* pattern, and the other 3.02% used the 2:1 *Jajar Legowo* pattern. This suggests that the 4:1 *Jajar Legowo* pattern is a popular technique used by Indonesian lowland rice farmers, mainly because it is easier to implement than other patterns.

Lowland rice cultivated using the *Jajar Legowo* planting pattern, especially the 6:1 pattern, generally has a higher productivity rate than those planted with non-*Jajar Legowo* system. Lowland rice cultivation that implements the 6:1 *Jajar Legowo* pattern yields average productivity of 52.52 quintals per hectare. In contrast, the average productivity of lowland rice planted using non-*Jajar Legowo* system is 51.63 quintals per hectare.

Government assistance in seeds and fertilizers also plays a vital role in improving national rice productivity. The use of improved seeds certainly will elevate rice productivity. The 2019 Crop-Cutting Survey shows that the majority of lowland rice farmers (86.76%) and upland rice farmers (86.7%) stated that they never received any seed assistance, and only 13% of them did. This assistance comes from various sources, including the central government, regional governments, state-owned enterprises or private enterprises, and individuals.

The results of the Crop-Cutting Survey further revealed that there is no significant difference between the productivity of lowland rice planted using the seeds from the assistance program and non-assistance seeds. The productivity rates of lowland rice produced by farmers who received seed assistance and those who did not reached approximately 50.91 quintals per hectare and 50.85 quintals per hectare, respectively. Meanwhile, the productivity rate of upland rice produced by farmers who did not receive seed assistance was higher than that of the recipients. Farmers under the seed assistance program yielded 34.34 quintals per hectare, whereas those who cultivated non-assistance seeds yielded 38.61 quintals per hectare. This might be due to the fact that the quality of the upland rice seeds from the assistance program was not of significantly higher quality than the seeds used by most upland rice farmers. Moreover, the seeds from the government might have been unsuitable with the soil condition, and they required a special treatment which was not implemented by the farmers optimally.

[13] Every two rows are separated with one empty row

This insignificant difference might indicate two things. First, the effectiveness of seed assistance is not optimal in terms of its relation to the farmers' preference or the suitability of the seeds to their actual needs. Second, most farmers have access to improved seeds despite not receiving seed assistance from the government. Hence, the quality of the seeds does not differ significantly or is even better than those from the government.[14]

In addition to seeds, another production input assistance that is also vital in raising productivity is fertilizers. In 2019, approximately 65% of Indonesian lowland rice farmers received fertilizer assistance, of which 63% of them received subsidies, and 2.24% received free fertilizers. Meanwhile, the other 34.76% did not receive any fertilizer assistance. On the other hand, 45.81% of upland rice farmers stated that they did not receive the fertilizer assistance, and the other 54.19% did, whether it is in the form of subsidies or free fertilizers. This shows that the fertilizer assistance program has covered most of the rice farmers.

The Crop-Cutting Survey further revealed that farmers under the fertilizer assistance program yielded a higher average of productivity than those who did not receive it. The fertilizer assistance was given in the forms of subsidies or free fertilizers. The productivity rates of lowland and upland rice cultivated using the fertilizers from the government were 52.96 quintals per hectare, and 42.42 quintals per hectare, respectively, while the lowland and upland rice farmers who did not receive the fertilizer assistance produced 46.90 quintals per hectare, and 32.85 quintals per hectare, respectively. These statistics confirm the integral role of fertilizers in maintaining rice productivity.

Farmers' access to government assistance depends heavily on their farmer group memberships. In practice, the distributions of assistance programs are always administered through the farmer groups. For instance, the distribution of fertilizer subsidies uses the Definitive Plan of Farmer Group's Need (*Rencana Definitif Kebutuhan Kelompok Tani* or RDKK) as a reference in its allocation. Therefore, non-members of farmer groups have comparatively limited access to government assistance to increase their productivity. Unfortunately, the 2019 Crop-Cutting Survey indicates a high proportion of lowland and upland rice farming households who were not part of farmer groups, which were 34.34% and 44.43%, respectively. Regional Agricultural Offices ought to put serious attention to this issue to ensure that farmers under their administrative areas are members of a farmer group. This is because farmer group institutions are of utmost importance in increasing the economic scale and easing the coordination in implementing cultivation technologies to increase productivity.

Based on the 2019 Crop-Cutting Survey results, the average productivity rates of both lowland and upland rice produced by the members of farmer groups were higher than those of the non-members. The lowland rice productivity of farmer group members hit 51.25 quintals per hectare, and the rice productivity of non-members reached 50.10 quintals per hectare. Similarly, the upland rice productivity rates of the members and non-members of farmer groups saw a considerable difference, which were 38.53 quintals per hectare and 37.49 quintals per hectare. This condition indicates that farmer group membership plays an essential role in increasing rice productivity in Indonesia.

[14] The author's in-person interviews with some farmers support this statement. The distribution of seed assistance is often delayed because it does not match the farmers' planting calendar, hence the unused seeds. Additionally, the types of seeds are usually unsuitable with the condition of their lands, resulting in less optimal yields. Based on their experience, farmers tend to know more about the types of seeds suitable for the conditions of their fields.

Furthermore, pests/plant-disturbing organisms (*Organisme Pengganggu Tanaman* or OPT) also affect rice productivity. In 2019, rice that was not infested with pests/plant-disturbing organisms tended to yield higher productivity. The average productivity of lowland rice with no pest/plant-disturbing organism infestations hit 56.94 quintals per hectare, while the productivity of pest-infested rice was only about 49.69 quintals per hectare. This is also in line with upland rice, in which the productivity of pest/plant-disturbing organism-infested upland rice was only 37.14 quintals per hectare, and the areas without pests/plant-disturbing organisms produced 42.42 quintals per hectare. This significant difference in productivity indicates how important it is for the farmers to manage pest/plant-disturbing organism infestations in an effective and timely manner to prevent them from affecting the yields. Regarding this issue, the government can participate by giving agricultural extensions to the farmers routinely. However, it should be noted that the significant difference does not exist solely because there are no pest/plant-disturbing organism infestations, but because there are other factors that contribute towards productivity, such as water sufficiency and the use of fertilizers. This difference at least indicates that pest/plant-disturbing organism infestations affect rice productivity.

The Crop Cutting Survey also examines the impacts of climate change on lowland and upland rice productivity. In 2019, most of the lowland rice farmers (77.57%) and upland rice farmers (75.29%) said they were unaffected by climate change. However, about one-fourth of them stated that the productivity of their rice was affected by the impacts of climate change, such as flood and drought.

A favorable climate is undoubtedly necessary in rice cultivation. Climate change can be caused by several factors, such as the uncertain changes of air temperature and rainfall. When these conditions occur continuously, the production of rice yields may not be optimal. The 2019 Crop-Cutting Survey shows that both lowland and upland rice affected by the climate change had lower productivity rates of 44.11 quintals per hectare and 33.27 quintals per hectare, respectively. Meanwhile, lowland and upland rice that are unaffected by climate change had higher rates of productivity, which were 52.81 quintals per hectare and 39.65 quintals per hectare. These facts confirm that guiding the farmers to prepare them for the potential climate change impacts is important.

Maize and Soybean Cultivations

Similar to rice, maize that is cultivated in irrigated fields have higher productivity compared to maize cultivated in non-irrigated fields or areas other than fields. The productivity of irrigated maize reaches 69.33 quintals per hectare. It seems that the high productivity of maize cultivated in fields is due to reliable water sufficiency (irrigation). Unfortunately, the proportion of maize cultivated in irrigated fields is only about 14.76%. Most maize is cultivated in areas other than fields (72.05%), with average productivity of 53.97 quintals per hectare. Thus, efforts to expand the national maize planting area should be focused on areas other than fields to avoid trade-off with lowland rice.

Maize cultivated in rice fields is generally planted between October and December after the rice has been grown on the field twice between January and September (intercrop plant). Therefore, increasing the productivity of maize grown in areas other than rice fields is a key to bolstering the national maize productivity and production. This also applies to soybean. The productivity rate of soybean grown in areas other than rice fields is only 13.18 quintals per hectare, much lower than the productivity of irrigated soybean, which recorded 17.14 quintals per hectare. Soybean grown on rice fields is also a form of intercrop plant. This means that expanding the planting areas of soybean on areas other than rice fields should be accompanied by efforts to increase productivity.

The Crop-Cutting Survey results confirm that water sufficiency is crucial in maize and soybean cultivation. Maize and soybean grown with adequate water supply yield a higher productivity than those in a condition in which the water supply is inadequate or excessive. This is in line with the tendency that maize and soybean grown on rice fields, with an adequate water supply, have higher productivity than those grown on areas other than rice fields.

The expansion of hybrid seeds in maize cultivation is the key to increasing the national maize productivity over the last few years. Currently, 75% of maize cultivated by the farmers use hybrid seeds with average productivity of more than 60 quintals per hectare. It suggests that efforts to increase the national maize productivity can be further pursued by enhancing the application of hybrid seeds. The results of the Crop-Cutting Survey revealed that the proportion of farmers that still use local seeds remained high at 18.56%, while its productivity rate was only 35 quintals per hectare.

Similar to rice cultivation, fertilizer assistance is also pivotal to improve maize productivity. In soybean cultivation, however, fertilizer assistance does not contribute significantly towards its productivity. This is because the scale of soybean cultivation is not as extensive as rice and maize cultivation. Thus, the need for fertilizers to cultivate soybean can be fulfilled by the farmers themselves without having to rely on government assistance.

Farmer group membership significantly determines the farmers' access to assistance and coaching provided by the government. The Crop-Cutting Survey also shows that the productivity rates of maize and soybean grown by the members of farmer groups were higher than those grown by the non-members. However, the proportion of non-member maize and soybean farmers remained high, which were 36.42% and 18.98%, respectively.

The survey further confirms the importance of the efforts to manage pest/plant-disturbing organism infestations to mitigate the impacts of climate change on maize and soybean productivity, namely drought and heavy rainfall. Like in rice cultivation, the impacts of climate change significantly decrease the productivity of maize and soybean.

Table 2.
Productivity and Household Distribution of Maize and Soybean based on Factors Affecting Productivity, 2019

No.	Factors affecting productivity	Productivity (in quintals per hectare)		Household Proportion (%)	
		Maize (dried kernels)	Soybean (dried grains)	Maize	Soybean
1.	Type of Field				
	- Irrigated	69.33	17.14	14.76	35.75
	- Rainfed	56.39	15.30	12.50	29.60
	- Tidal swamp	54.44	18.05	0.57	0.41
	- Non-tidal swamp	62.62	13.22	0.12	0.04
	- Non-rice field	53.97	13.18	72.05	34.20
2.	Water Sufficiency				
	- Poor	53.26	13.77	-	-
	- Sufficient	58.08	16.52	-	-
	- Excessive	52.70	11.59	-	-
3.	Seed Variety				
	- Hybrid	62.46	-	75.13	-
	- Composite	49.35	-	6.31	-
	- Local	35.06	-	18.56	-
4.	Planting Method				
	- Monoculture	58.82	15.87	82.18	80.72
	- Intercropping	46.06	12.58	17.82	19.28
5.	Fertilizer and Seed Assistance				
	- Receiving fertilizer assistance	59.64	15.00	60.41	56.54
	- Not receiving fertilizer assistance	51.80	15.56	39.59	43.46
	- Receiving seed assistance	59.16	15.02	25.96	32.72
	- Not receiving seed assistance	55.63	15.35	74.04	67.28
	- Receiving agricultural equipment and machinery assistance	-	-	35.88	52.53
	- Not receiving agricultural equipment and machinery assistance	-	-	64.12	47.47
6.	Farmer Group Membership				
	- Member	58.95	15.33	63.58	81.02
	- Non-member	52.35	14,86	36.42	18.98
7.	Pest/Plant-Disturbing Organism Infestations				
	- Infested	56.36	14,83	64.99	71.03
	- Not infested	56.64	15.41	35.01	28.97
8.	Climate Change Impacts				
	- Affected	51.70	13.85	24.89	27.83
	- Unaffected	58.15	15.78	75.11	72.17

Source: Processed from the results of the 2019 Crop-Cutting Survey

PRODUCTIVITY DISPARITY BETWEEN REGIONS

Productivity Gaps of Rice, Maize, and Soybean

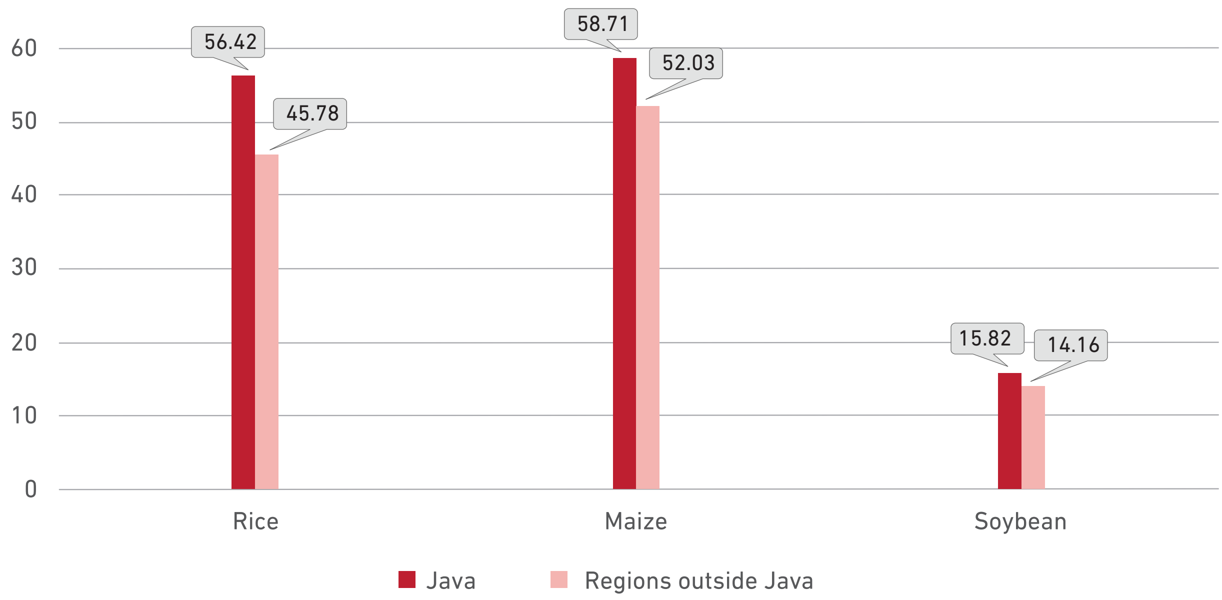
The stagnant trend of rice productivity in recent years can actually be overcome by spurring productivity growth in regions outside Java, which is very feasible considering the fact that rice cultivation in other regions is still underdeveloped compared to in Java. This is reflected by the low rice productivity in other regions. The 2019 Crop-Cutting Survey conducted by Statistics Indonesia identified that one of the important issues in stimulating national rice productivity is the productivity disparity between the farmers in Java and those in regions outside Java. The productivity of farmers in Java was 23% higher than that of the farmers from other regions.

In 2019, the average productivity of farmers in regions outside Java was only about 45.78 quintals of dried unmilled rice per hectare, lower than the farmers in Java who recorded a productivity rate of about 56.42 quintals of dried unmilled rice per hectare. Consequently, even though the rice harvest area in regions outside Java accounts for 50% of the total 10.68 million hectares of the national rice harvest area in 2019, farmers in other regions only contributed 44% towards the national rice production.

Statistics show that the productivity disparity between Java and other regions tends to have been persistent in the last two decades. If this gap is narrowed down, it can have a remarkable effect on increasing national rice production. As an illustration, rice production is the result of multiplying productivity by the harvest area. With the current rice harvest area of approximately 11 million hectares, an increase of rice productivity of 0.5 million tonnes per hectare can contribute towards increasing the national rice productivity by as much as 5.5 million tonnes. These 0.5 million tonnes of increase in rice productivity can be achieved if the productivity gap between Java and regions outside Java is narrowed down by around 12%.

"Statistics show that the productivity disparity between Java and other regions tends to have been persistent in the last two decades. If this gap is narrowed down, it can have a remarkable effect on increasing national rice production."

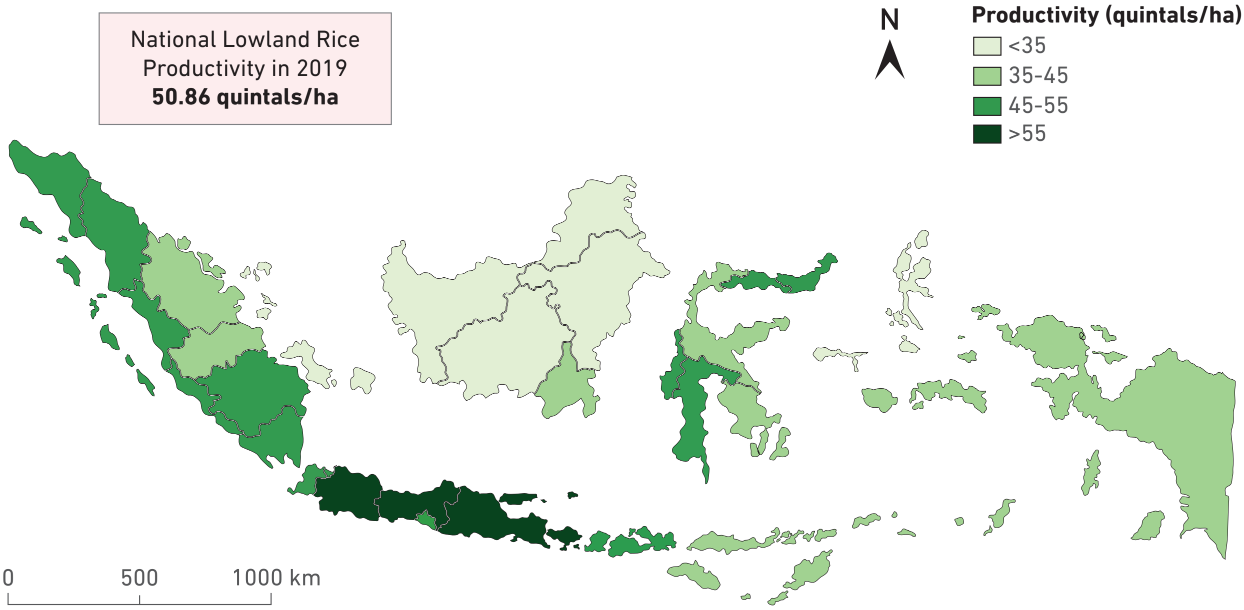
Figure 3.
Productivity Rates of Rice, Maize and Soybean based on the Regions, 2019
(in quintals per hectare)



Source: Statistics Indonesia

Almost all provinces in Java recorded an average lowland rice productivity of more than 55 quintals of dried unmilled rice per hectare in 2019 (Figure 4). Only two provinces outside Java had average productivity of more than 55 quintals per hectare, namely Aceh and Bali. Efforts to increase lowland rice productivity should be focused on provinces whose productivity rates are below 45 quintals per hectare by means of mechanization and the use of improved seeds. Some of those provinces are chosen as the locations of the Food Estate program, which the government initiated to increase national food production, including Central Kalimantan.

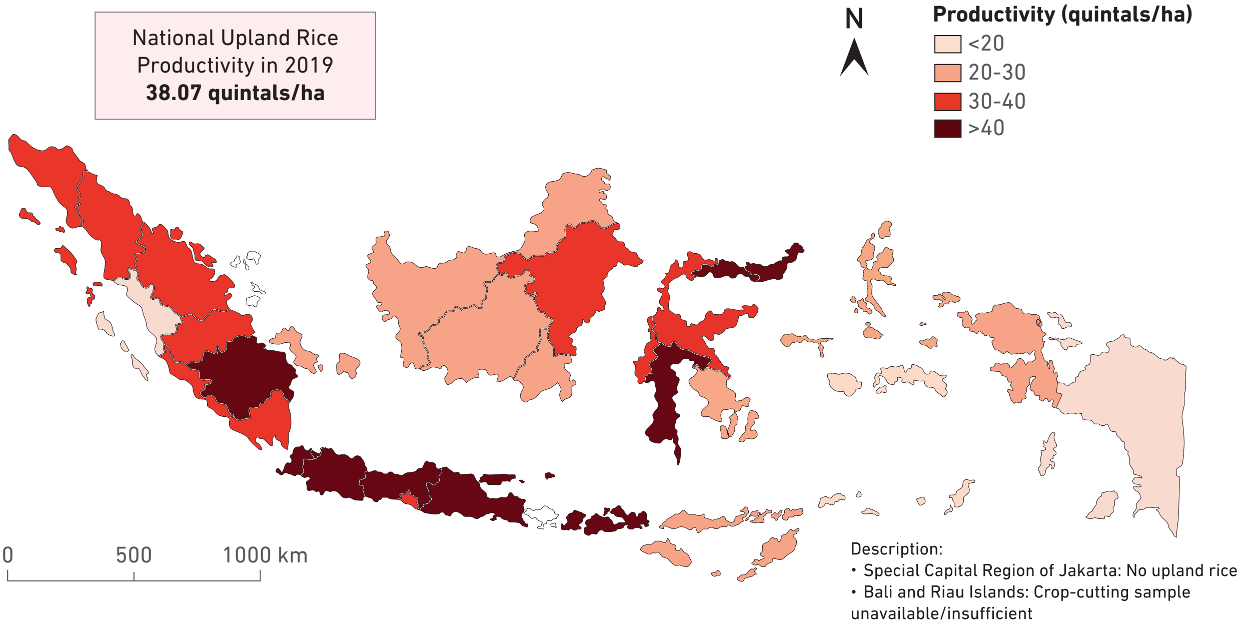
Figure 4.
Distribution Map of Average Lowland Rice Productivity Rates in Indonesia, 2019



Source: Processed from the results of the Crop-Cutting Survey

Productivity gaps between the regions are also apparent in upland rice. In general, almost all provinces in Java had an upland rice productivity rate of above 40 quintals per hectare, while the majority of provinces outside Java recorded less than that.

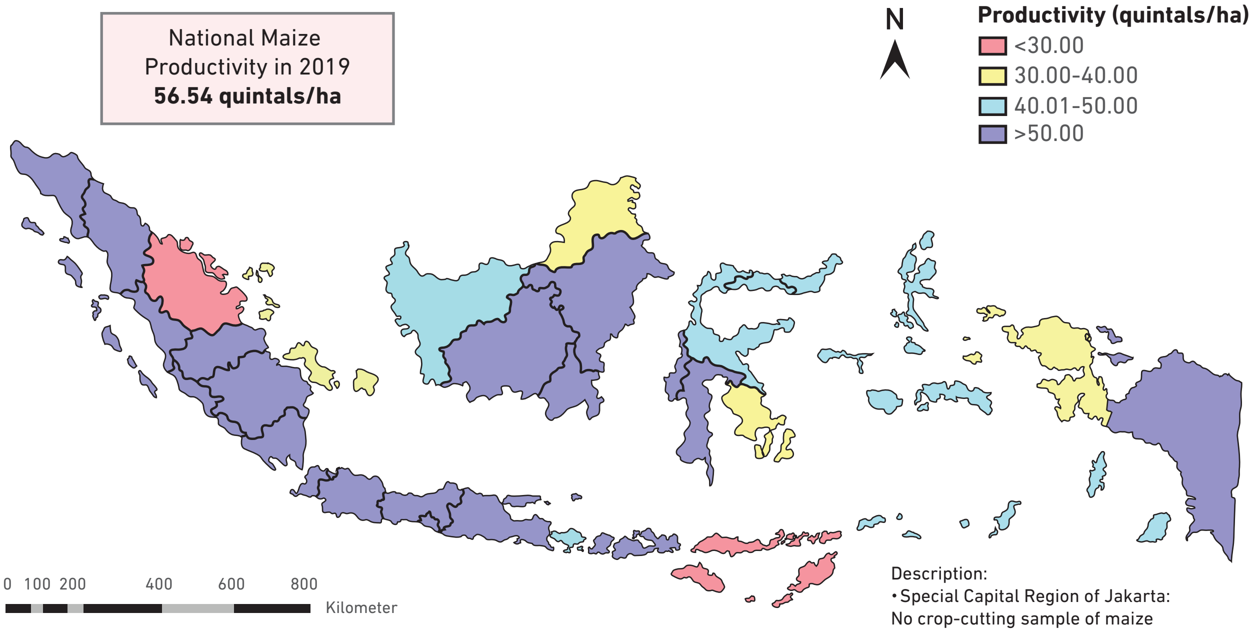
Figure 5.
Distribution Map of Average Upland Rice Productivity Rates in Indonesia, 2019



Source: Processed from the results of the Crop-Cutting Survey

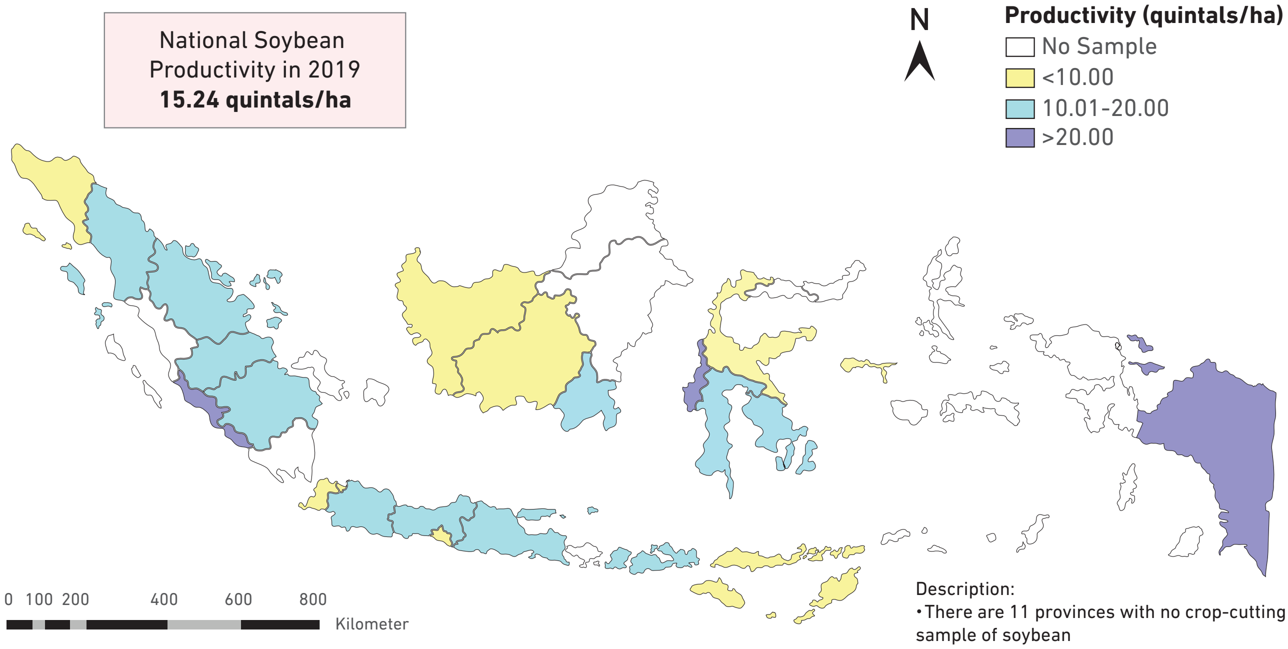
The massive introduction of hybrid maize seeds results in maize productivity rates that are relatively more homogeneous than rice when analyzed based on the regions. At present, most of the main producing provinces of maize have an average productivity of above 50 quintals per hectare. Only a few provinces have a productivity of less than 40 quintals per hectare. For soybean, productivity gaps between the regions can also be considered relatively low. The productivity rates in most of the soybean-producing provinces are below 20 quintals per hectare. In 2019, only three provinces produced more than 20 quintals per hectare, which were Bengkulu, West Sumatra, and Papua. These facts indicate the enormous potentials of regions outside Java in developing their soybean productions.

Figure 6.
Distribution Map of Average Maize Productivity Rates in Indonesia, 2019



Source: Processed from the results of the Crop-Cutting Survey

Figure 7.
Distribution Map of Average Soybean Productivity Rates in Indonesia, 2019



Source: Processed from the results of the Crop-Cutting Survey

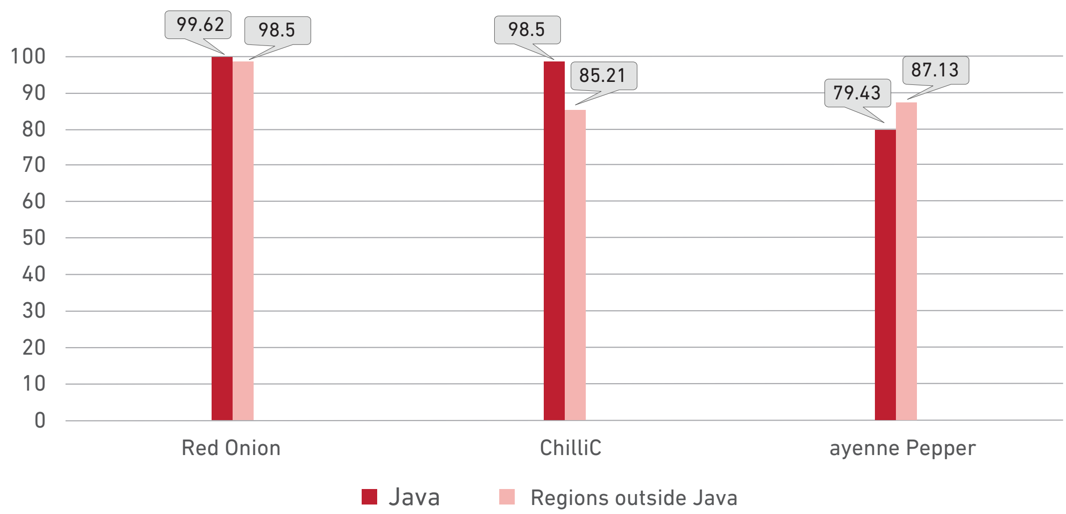
Hence, narrowing down the productivity gaps between the regions can be accomplished by fostering the farmers' capacity, knowledge, and skills in regions outside Java, such as through coaching, comparative studies, intensive agricultural extensions, and institutional development through farmer groups. The agricultural infrastructures and cultivation technologies in those regions must be improved.

The productivity gap exists as a result of multiple factors, such as the difference in the levels of soil fertility and climate conditions that are favorable for the cultivation process, human resource (farmers' profile), development of the agricultural infrastructures (irrigation), and cultivation technologies implemented in the respective region. In general, farmers in regions outside Java lagged behind the Javanese farmers in terms of their capacity as well as the agricultural cultivation technologies that they implement. Hence, narrowing down the productivity gaps between the regions can be accomplished by fostering the farmers' capacity, knowledge, and skills in regions outside Java, such as through coaching, comparative studies, intensive agricultural extensions, and institutional development through farmer groups. The agricultural infrastructures and cultivation technologies in those regions must be improved, which can be pursued by establishing irrigation networks and promoting mechanization at a larger scale in the cultivation activities, starting from the land preparation to the harvesting process.

Productivity Gap between Chili and Shallot

Shallot productivity in Java is generally higher than in regions outside Java. In 2019, provinces whose shallot productivity rate was high (more than 90 quintals per hectare) are mostly from Java, Bali, and Nusa Tenggara Islands. Outside Java, other than Bali and Nusa Tenggara, only West Sumatra and South Sulawesi recorded more than 90 quintals per hectare, which confirms that there is a spatial productivity gap of shallot. Narrowing down this productivity gap is the key to increasing national shallot productivity.

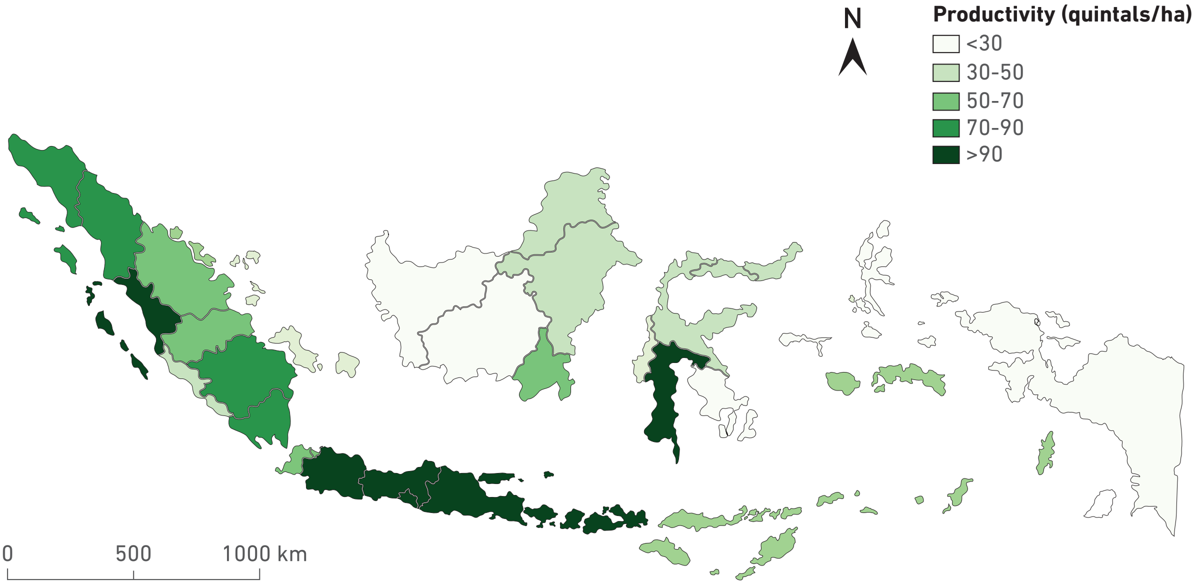
Figure 8.
Productivity Rates of Shallot, Chili, and Cayenne Pepper by Region, 2019
(in quintals per hectare)



Source: Statistics Indonesia and Ministry of Agriculture

Bali recorded the highest shallot productivity in 2019, reaching 149.71 quintals per hectare. This number is significantly higher than the national average, indicating that Bali has the potential to support the national need of shallot, especially for Eastern Indonesia other than South Sulawesi and West Nusa Tenggara.

Figure 9.
Distribution Map of Average Shallot Productivity Rates in Indonesia, 2019

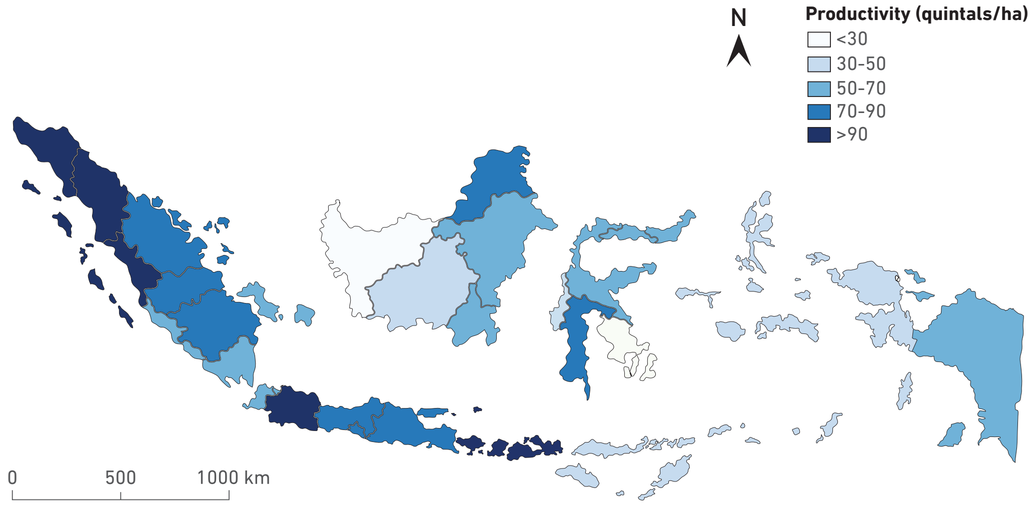


Source: Statistics Indonesia and Ministry of Agriculture

Spatially, the productivity gap can also be seen in chili. Chili productivity in regions outside Java tends to be lower than that of Java. Consequently, the national chili productivity only 91.01 quintals per hectare in 2019, even though the contribution of regions outside Java towards the national chili productivity is more than 50%. This might be due to the underdeveloped cultivation of chili in those regions when compared to in Java.

Although the productivity of regions outside Java is relatively lower than Java, most of the provinces in Sumatra had higher productivity rates than other provinces with an average of 70 quintals per hectare. Aceh, North Sumatra, and West Sumatra, for example, have productivity rates of above 90 quintals per hectare. Bali and Nusa Tenggara Barat also prove to have relatively higher productivity rates of more than 90 quintals per hectare.

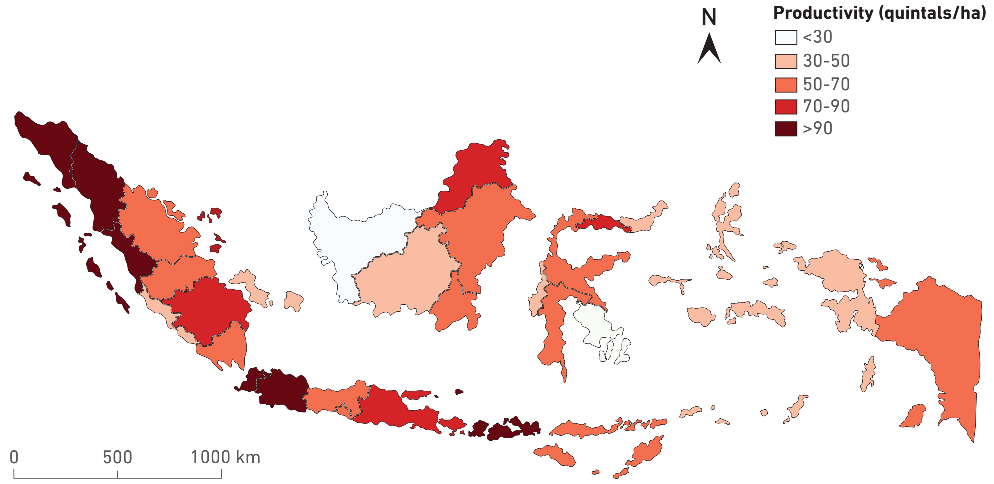
Figure 10.
Distribution Map of Average Chili Productivity Rates in Indonesia, 2019



Source: Statistics Indonesia and Ministry of Agriculture

The cayenne pepper productivity rates of regions outside Java, in general, tend to be higher than in Java. West Nusa Tenggara had the highest productivity, with a rate of more than 200 quintals per hectare in 2019.

Figure 11.
Distribution Map of Average Cayenne Pepper Productivity Rates in Indonesia, 2019



Source: Statistics Indonesia and Ministry of Agriculture

Upon further analysis, the high productivity of cayenne pepper in regions outside Java is due to the contributions of only Sumatra, Bali, and Nusa Tenggara. In Kalimantan, Maluku, and Papua, for instance, the productivity rates are mostly less than 70 quintals per hectare. It seems that the limited access to cultivation technologies and techniques are amongst the causes of the low productivity in the said regions.

Lowland Rice Productivity Determinants

To further examine the factors affecting lowland rice productivity rates in Java and regions outside Java, an analysis was conducted using an econometric model. A detailed explanation of the estimated model is presented in Appendix A1. The results of the model estimation are presented in Table 3.

The estimation results show that access to irrigation can increase rice productivity by approximately 13%. In regions outside Java, access to irrigation can increase productivity by approximately 18%, whereas in Java, the impact is only 5%. The 2018 Crop-Cutting Survey revealed that access to irrigation in regions outside Java was only 52%, which is much lower compared to the 70% in Java (Table A1b). This means that improving access to irrigation in regions outside Java is the key to narrowing down the productivity gap between the regions and increasing the national lowland rice productivity.

Meanwhile, the use of hybrid seeds has yet to increase the national rice productivity significantly. This can be attributed to the low proportion of lowland rice farming households cultivating this type of rice, which was less than 10%. In contrast, fertilizer use has the largest and most significant magnitude in increasing lowland rice productivity, which was 45%. In relation to this, Table 3 shows that the relatively high magnitude of fertilizer use is more of a phenomenon in regions outside Java, because the proportion of lowland rice farming households that have not used fertilizers in those regions is quite high (6.38%). The use of fertilizers outside Java can increase productivity by approximately 48%, but in Java, it is statistically insignificant because almost all of the lowland rice farmers in Java already use fertilizers (99%).

As expected, the implementation of the *Jajar Legowo* planting system is statistically significant in boosting lowland rice productivity by 5% to 8%. The estimation results show that the positive impact of the *Jajar Legowo* implementation is consistent in both Java and regions outside Java. Similarly, government assistance and farmer group membership also have a significant and positive effect in increasing the productivity of lowland rice, which is also consistent in Java and regions outside Java. However, using pesticides in managing pests and plant-disturbing organism infestations is not very effective in increasing productivity. This suggests that other pest control methods, such as agronomic, mechanical, and biological methods are more effective in increasing the productivity of lowland rice. The estimation result further confirms that the productivity values vary between the sub-rounds, in which the first sub-round (January-April) tends to have a higher productivity than that of the second sub-round (May-August) and third sub-round (September-December).

Editorial Notes:

- Access to irrigation can increase rice productivity by approximately 13%, it was previously written as 12%.
- In regions outside Java, access to irrigation can increase productivity by approximately 18%, it was previously written as 16%.
- Fertilizer use can increase productivity by 45%, meanwhile in regions outside Java, fertilizer use can increase productivity by 48%, it was previously written as 37% and 39%, respectively.
- The implementation of the Jajar Legowo planting system is statistically significant in boosting lowland rice productivity by 5% to 8%, it was previously written as 5% to 7%.

Table 3.
Estimation Results of the Econometric Model of Lowland Rice Productivity in Indonesia

Independent Variable: log(productivity)	Regions outside Java	Java	Indonesia
Regions outside Java	-	-	-0.2421***
	-	-	(0.0073)
Irrigation	0.1684***	0.0509***	0.1201***
	(0.0107)	(0.0077)	(0.0066)
Monoculture	0.0448	0.0048	0.0352
	(0.0428)	(0.0122)	(0.0277)
Hybrid	-0.0316	-0.0048	-0.0221
	(0.0268)	(0.0111)	(0.0185)
Fertilizers	0.3919***	-0.0579*	0.3685***
	(0.0100)	(0.0330)	(0.0194)
Pesticides	-0.0241**	-0.0072	-0.0176**
	(0.0120)	(0.0065)	(0.0075)
2:1 Jarwo	0.0568**	0.0817***	0.0659***
	(0.0219)	(0.0116)	(0.0130)
4:1 Jarwo	0.0859***	0.0577***	0.0776***
	(0.0232)	(0.0132)	(0.0145)
6:1 Jarwo	0.0714***	0.0709***	0.0703***
	(0.0171)	(0.0121)	(0.0121)
Other Jarwo patterns	0.0632***	0.0327**	0.0510***
	(0.0163)	(0.0157)	(0.1118)
Assistance	0.0149	0.0198**	0.0168***
	(0.0093)	(0.0078)	(0.0062)
Farmer group (Poktan)	0.0266***	0.0757***	0.0494***
	(0.0081)	(0.0060)	(0.0045)
Subround II	-0.1030***	-0.0701***	-0.0876****
	(0.0114)	(0.0055)	(0.0062)
Subround III	-0.0135	-0.0066	-0.0146
	(0.0173)	(0.068)	(0.0099)
Constant	1.1577***	1.8965***	1.4283***
	(0.0290)	(0.0358)	(0.0249)
Adjusted-R2	0.1524	0.0600	0.2441
Number of Observations	33.740	29.331	63.071

Note: robust standard error is written in parentheses; *** significant at the significance level of 1%; ** significant at the significance level of 5%; * significant at the significance level of 10 %.

THE EFFECTS OF MECHANIZATION AND FARMERS' CAPACITY ON RICE PRODUCTIVITY

This section examines the impacts of using agricultural equipment and machinery (mechanization) and the farmers' capacities (education level, age, and access to the Internet) on rice productivity in Indonesia by using the 2018 Inter-Census Agricultural Survey results conducted by Statistics Indonesia. The impacts were estimated quantitatively using econometric models that are explained comprehensively in Appendix. The estimation results of the models are presented in Table 4.

Table 4.
Econometric Model Estimation of the Effects of Mechanization and Farmers' Capacity on Rice Productivity

Independent Variable: log (productivity)	OLS	Standard Error
Mechanization	0.1458*	0.0020
Sex (Male)	-0.0110*	0.0027
Education		
Elementary School	0.0645*	0.0023
Junior High School	0.1046*	0.0030
Senior High School	0.1103*	0.0032
D1/D2	0.0900*	0.0139
D3	0.1260*	0.0147
D4/S1	0.0983*	0.0069
S2/S3	0.1263*	0.0208
Age (In Years)		
30-34	0.0267*	0.0062
35-39	0.0499*	0.0057
40-44	0.0657*	0.0056
45-49	0.0745*	0.0056
50-54	0.0861*	0.0056
55+	0.1023*	0.0054
Internet Access	0.0393*	0.0030
Variety		
Hybrid lowland rice	0.4915*	0.0053
Inbred lowland rice	0.5508*	0.0034
Constant	2.7119	0.0094

Description:* significant at α = 1%. Weight was used in the estimation process. The number of observations = 1,349,716.

The estimation results of the econometric model show that mechanization in agricultural activities brings positive and significant impacts on the increase of upland and lowland rice productivity in Indonesia. On average, agricultural households that utilize mechanization in their activities yield 16% more rice productivity than those that do not. In other words, the role of agricultural equipment and machinery is integral in the efforts of increasing rice production. This finding is in line with a number of previous empirical studies (Saputra et al., 2018; Prayoga & Sutoyo, 2017; Muhammad, 2017; and Saliem et al., 2015). Thus, mechanization should further be encouraged to increase rice productivity.

"On average, agricultural households that utilize mechanization in their activities yield 16% more rice productivity than those that do not."

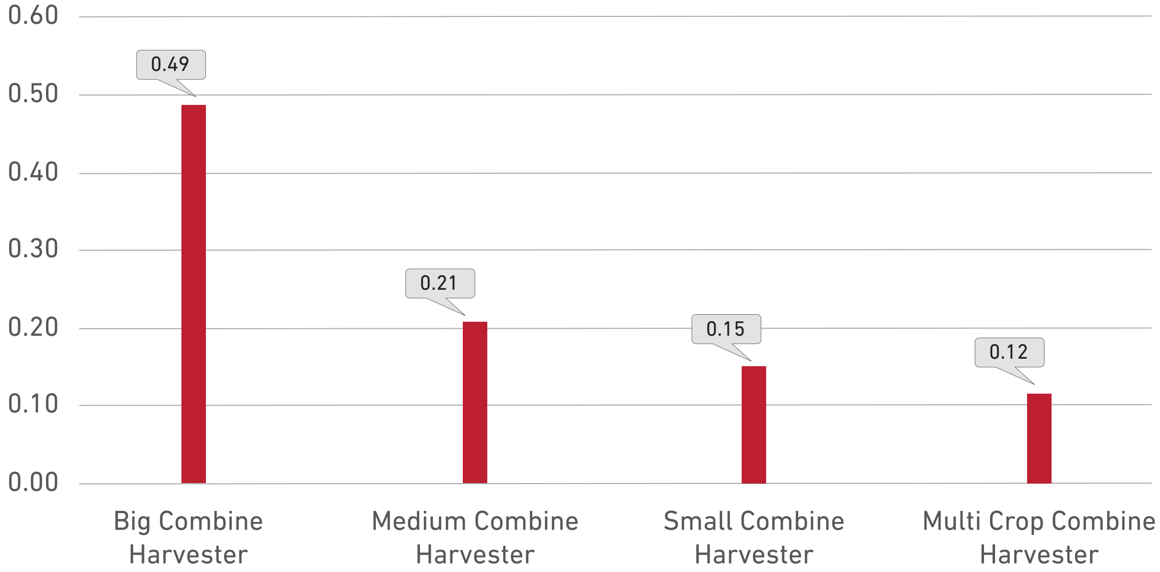
One of the important roles of mechanization in increasing rice productivity is to minimize losses during the harvesting process. Regarding this, utilizing combine harvesters massively on rice can be a game-changer in increasing productivity. Limited studies in several provinces[15] conducted by the Ministry of Agriculture and Statistics Indonesia found that combine harvester assistance significantly affects rice productivity. On average, combine harvester utilization can increase rice yields by 0.12 to 0.49 tonnes per hectare, depending on the machine's scale. The result of the study shows that big-scale harvesting equipment minimizes losses in the harvesting process most optimally.

[15] Study was conducted in 10 provinces, which were Aceh, North Sumatra, South Sumatra, Lampung, West Java, Central Java, East Java, West Nusa Tenggara, South Kalimantan, and South Sulawesi to evaluate the effectiveness of the agricultural equipment and machinery assistance distributed by the Ministry of Agriculture, including the multifunction harvesters.

Editorial Notes:

- On average, agricultural households that utilize mechanization in their activities yield 16% more rice productivity than those that do not, it was previously written as 14%.

Figure 12.
Average Increases of Yields After Using Combine Harvesters (CH) based on Its Types (in tonnes per hectare)



Source: Statistics Indonesia and Ministry of Agriculture

The estimation results further show that the rice productivity of female farmers is higher than that of male farmers, although the difference is diminutive, which is approximately 1%. This is an interesting finding since female farmers often face the problems of limited access to agricultural resources, such as credit access, land ownership, and other production inputs such as seeds and fertilizers. On the other hand, the estimation results also revealed that education affects productivity positively and significantly. In general, the higher the level of education, the higher the productivity rate. It seems that this might be because farmers with a higher level of education possess broader knowledge and find it easier to comprehend new information. This finding is in line with some previous studies (Paltasingh & Goyari, 2018; Osanyinlusi & Adenegan, 2016; and Oduro Ofori et al., 2014). Education plays a central role in opening the farmers' minds to adopt agricultural technologies. On top of that, the level of education also significantly affects farmers' decision in using modern varieties to yield a higher productivity (According to Odori et al., 2014; Paltasingh & Goyari, 2018).

The age of the farmers also positively and significantly affects productivity at the rate of 5%. As farmers grow older, they yield a higher rice productivity. This is due in part to the experience factor, in which older farmers have more agricultural experiences. Young farmers who tend to be the newcomers are assumed to have minimum experiences. Nonetheless, young farmers have enormous potential to increase rice production through agricultural intensification because they are essentially more innovative and not afraid of taking risks compared to the farmers in old groups (Musafiri, 2016). Therefore, coaching and agricultural extensions from the government must be continued to develop young farmers' capacity.

Farmers with access to the Internet are found to have a higher rate of rice productivity compared to those who do not, by approximately 4%. The Internet seems to be an alternative for the farmers to gather more information related to increasing production. The estimation result is in line with a study by Kaila and Tarp (2019), they found that Internet utilization can increase overall agricultural outputs by approximately 6% to 7% in Vietnam's case.

Using hybrid and inbred varieties also affect rice productivity positively and significantly. The estimation result shows that both hybrid and inbred lowland rice yields higher productivity rates of 63% and 73%, respectively, compared to upland rice. It is interesting to note that hybrid rice cultivation has lower productivity than inbred lowland rice. This is because the environmental conditions in several regions are less ideal, or the technology implementation is improper, resulting in nonoptimal yields of hybrid lowland rice.

Editorial Notes:

- The estimation result shows that both hybrid and inbred lowland rice yields higher productivity rates of 63% and 73%, it was previously written as 49% and 55%, respectively.

CONCLUSION AND POLICY RECOMMENDATIONS

From 2014 to 2019, the development of rice and soybean productivity levels tended to remain stagnant or experience minuscule changes. The effort to increase soybean productivity to more than 2 tonnes per hectare is still far from expected. Within this period, only maize showed a remarkable increase in productivity, which was due in part to the success of introducing hybrid maize seeds that have been massively used by most Indonesian farmers (75%). For horticultural commodities, productivity rates of chili and cayenne pepper increased from 2015 to 2019. Unfortunately, such an increasing productivity trend was not seen in shallot whose productivity rate tended to be stagnant during the same period.

The room for increasing productivity is wide open, both for food crops and horticultural commodities. Bolstering productivity, in general, can be pursued by improving land and manpower productivity. In concrete terms, these two can be accomplished by using improved seeds, especially those from the government assistance; improving the farmers' access to fertilizers; managing pest/plant-disturbing organism infestations; utilizing agricultural equipment and machinery (mechanization) both in pre-harvest and post-harvest process to minimize production losses; refining cultivation techniques, such as by promoting the implementation of the *Jajar Legowo* planting system in lowland rice cultivation at a more massive scale; repairing and expanding irrigation network accesses; using weather modification to mitigate the impacts of climate change; developing the capacity of agriculture human resources, focusing on the young farmers; strengthening farmer institutions through farmer group membership; and improving the farmers' access to information technology.

The productivity gaps of food crops (rice, maize, and soybean) between Java and regions outside Java is an issue of paramount importance that must be solved in order to increase national productivity. In general, the productivity level of food crops in regions outside Java is lower than that of Java. The productivity rates of rice and maize in regions outside Java are respectively 23% and 13% lower than in Java. Ergo, improving land and farmers' productivity in regions outside Java must become the government's focus in the effort of increasing national productivity. Efforts to increase productivity should be focused on regions whose productivity rates are relatively lower than other regions in Indonesia by improving cultivation techniques, such as using improved fertilizers and seeds. Moreover, improving access and repairing irrigation networks in regions outside Java can also be done as a part of the effort.

Productivity data collection that is based on objective measurement should be promoted continuously to improve the quality of data on productivity. This is an issue of high urgency since data collection on horticultural commodities still relies on subjective measurement.

REFERENCES

Amalia, R.R. & Kadir. (2019). Improving Paddy Statistics in Indonesia: Developing Crop Cutting Survey Using Area Sampling Frame. Unpublished manuscript.

Arifin, Bustanul. (2020). Misteri Penurunan Produktivitas Padi. *Harian Kompas*, 3 Juli 2020.

Balitbang Pertanian, Kementerian Pertanian Republik Indonesia. (2013). Sistem Tanam Legowo. Jakarta.

Freddy, Imelda M., et al. (2018). Reforming Trade Policy to Lower Maize Prices in Indonesia. *Center for Indonesian Policy Studies*. DOI: 10.35497/270483.

Hill, R. Charter, Griffiths, William, E., & Lim, Guay C. (2011). *Principles of Econometrics Fourth Edition*. John Wiley & Sons.

Kaila, Heidi & Tarp, Finn. (2019). Can the Internet improve agricultural production? Evidence from Viet Nam. *The Journal of the International Association of Agricultural Economics*, 50(6), 675-691

Kementerian PUPR. (2017). Modul Pemeliharaan Jaringan Irigasi: Pelatihan Operasi dan Pemeliharaan Irigasi Tingkat Juru. Kemen PUPR.

Krishnamurti, Indra, & Muhammad D. Biru. (2019). Expanding Hybrid Rice Production in Indonesia. *Center for Indonesian Policy Studies*, DOI: 10.35497/287925.

Muhammad, I. (2017). Analisis Pengaruh Penggunaan Alsintan Terhadap Produksi Padi di Sumatera Barat (Doctoral Dissertation). Universitas Andalas, Padang.

Musafiri, I. (2016). Effects of Population Growth on Smallholder Farmers' Productivity and Consumption in Rwanda: A Long-term Analysis. *Asian Journal of Agricultural Extension, Economics & Sociology*, 12(4), 1-11. DOI: 10.9734/AJAEES/2016/27693.

Paltasingh, K.R., & P. Goyari. (2018). Impact of Farmer Education on Farm Productivity under Varying Technologies: Case of Paddy Growers in India. *Agricultural and Food Economics* 6(7). Accessed from https://doi.org/10.1186/s40100-018-0101-9

Oduro-Ofori, E., Aboagye, A. P., & Acquaye, N. A. E. (2014). Effects of Education on the Agricultural Productivity of Farmers in the Offinso Municipality . *International Journal of Development Research*, 4(9), 1951-1960.

Osanyinlusi, O. I., & Adenegan, K. O. (2016). The Determinants of Rice Farmers' Productivity in Ekiti State, Nigeria. *Greener Journal of Agricultural Science*, 49-58. Accessed from http://doi.org/10.15580/GJAS.2016.2.122615174

Prasetyo, O.R., & Kadir. (2019). Teknik Penanaman Jajar Legowo untuk Meningkatkan Produktivitas Padi di Jawa Tengah. *Jurnal Litbang Sukowati*, 3(1), 28-40

Prayoga, A., & Sutoyo, S. (2017). Produktivitas dan Pendapatan Usaha Tani Padi Sawah: Dampak Program bantuan Alat Mesin Pertanian, Benih dan Pupuk di Kabupaten Malang, Provinsi Jawa Timur. *Jurnal Ilmu-Ilmu Pertanian*, 24(1).

Saliem, H.P., Kariyasa, K., Mayrowani, H., Agustian, A., Friyatno, S., & Sunarsih. (2015). Prospek Pengembangan Pertanian Modern Melalui Penggunaan Teknologi Mekanisasi Pertanian pada Lahan Padi Sawah. *Laporan Analisis Kebijakan*. Bogor: Pusat Sosial Ekonomi dan Kebijakan Pertanian.

Saputra, M. D., Antara, M., & Effendy, E. (2018). Dampak Program Pajale terhadap Produktivitas Padi Sawah di Desa Jono Oge, Kecamatan Sigi Biromaru, Kabupaten Sigi. *Agroland: Jurnal Ilmu-ilmu Pertanian*, 25(2), 96-105.

Satoto & Suprihatno. (2008). Pengembangan Padi Hibrida di Indonesia. *Jurnal Iptek Tanaman Pangan*, 3(1), 27-40.

APPENDIX

Appendix A1.
The Econometric Model of Rice Productivity Determinants

The econometric model that was used to analyze productivity determinants using the data from the 2018 Crop-Cutting Survey is as follows:

$$ln\ y_i = x_i'\beta_i + \delta Regions\ outside\ Java_i + \varepsilon_i$$

Where $\ln y_i$ is the natural logarithm of the lowland rice productivity of the household's rice crop business number-i and x_i is the matrix covariate from factors affecting the productivity of lowland rice household's number-i, consisting of the type of land, planting method, use of fertilizers, type of varieties, use of pesticides, application of the Jajar Legowo system, government assistance, farmer group membership, and harvest period. The in-depth explanation of each variable that is included in the model can be seen in Table A1a. The error component ε_i is assumed independent and identically distributed (i.i.d).To anticipate the violation of the assumption, robust standard errors are used to correct the effect of heteroscedasticity. To estimate the productivity gaps between regions, the model includes the *Regions outside Java*$_i$ variable, in which the value is 1 for the household in regions outside Java, and 0 for the opposite. Therefore, the estimation results of the coefficient δ explain the average inequality of rice productivity between the regions (Java and regions outside Java). This interpretation is possible because the functional form of the model used is semi-log. Ideally, the average gap calculation is corrected using the following formula $(e^{\delta}-1)\times 100\%$ (Hill et al., 2011).

Table A1a.
The Definitions of the Independent and Dependent Variables

Dependent Variable: the logarithm of lowland rice productivity; lowland rice productivity in tonnes per hectare	
Independent Variable:	
Regions outside Java	Code 1 for **regions outside Java**, and code 0 for **Java**
Type of field	Code 1 for **irrigated field**, and code 0 **for other types of field** (rainfed field, tidal swamp, non-tidal swamp, and non-paddy field
Planting method	Code 1 for **monoculture** system, and code 0 for **mixed methods/intercropping**
Use of seeds	Code 1 for hybrid seed, and code 0 for others
Fertilizers	Code 1 for cultivation using fertilizers, and code 0 for cultivation without using fertilizers.
Pesticides	Code 1 for using pesticides to control pests and plant-disturbing organisms, and code 0 for not using pesticides.
Jarwo system	The application of the Jajar Legowo planting pattern is divided into five categories, which are not using the **Jarwo system** (as the reference), **2:1 Jarwo, 4:1 Jarwo, 6:1 Jarwo**, and **other Jarwo patterns**.
Government assistance	Code 1 for receiving **government assistance**, and code 0 for not receiving government assistance.
Farmer groups	Code 1 for the members of farmer groups, and code 0 for non-members.
Harvest period	The harvest period is divided into three called the subround period (every 4 months), consisting of **sub-round 1** (January-April) as the reference, **sub-round 2** (May-August), and **sub-round 3** (September-December).

Table A1b.
Distribution of Econometric Model Variables (%)

Variable	Java	Regions outside Java	Indonesia
Irrigation	70.41	51.93	60.52
Non-irrigation	29.59	48.07	39.48
Monoculture	98.76	97.81	98.25
Mixed-crop	1.24	2.19	1.75
Using fertilizers	99.46	93.62	96.33
Not using fertilizers	0.54	6.38	3.67
Hybrid	4.48	7.85	6.28
Non-hybrid	95.52	92.15	93.72
Using pesticides	77.72	77.71	77.72
Not using pesticides	22.28	22.29	22.28
2:1 Jarwo	3.5	4.0	3.77
4:1 Jarwo	5.68	9.14	7.53
6:1 Jarwo	4.05	5.58	4.87
Other Jarwo patterns	4.09	5.98	5.10
Non-Jarwo patterns	82.68	75.30	78.73
Assistance	19.72	27.06	23.65
Non-assistance	80.28	72.94	76.35
Farmer group member	67.23	73.00	70.31
Non-member of the farmer group	32.77	27.00	29.69

Note: The official figure of this productivity calculation is calculated using a different method from the one used in this paper.

Appendix A2.
Econometric Model of the Effects of Mechanization on Rice Productivity

To analyze the effects of agricultural mechanization on rice productivity, the proposed specification for the research model is as follows:

$$\ln y_i = x'_i \beta + \delta\, Mechanization_i + \varepsilon_i;\ i = 1,2,\ldots,n$$

Where y_i is rice crops productivity in household number-i. $Mechanization_i$ is a vector containing dummy variables for the use of agricultural mechanization without using agricultural mechanization as the reference category. This regression analysis is focused on estimating the impacts of mechanization on rice productivity. Meanwhile, x'_i is a vector of variables that contains other variables that are assumed to be able to explain the productivity as shown in Table 3.1. Vector also contains dummy variables of provinces to capture the region-specific effects that are constant for each unit of observation. ε_i are regression errors that are assumed independent and identically distributed (i.i.d). The research model was estimated using the Ordinary Least Square (OLS). Standard error estimation used robust standard error to solve heteroskedasticity issues in the residual variance-covariance matrix. A weight survey was also used in estimating the regression coefficient. To estimate the effect of mechanization, the model includes a dummy variable of $Mechanization_i$, which has a value of 1 for households in regions outside Java and 0 for households in Java. Therefore, the estimation results of δ coefficient explains the average of the difference of productivity in percentage between those using mechanization and those who do not. This interpretation is possible because the functional form of the mode used is semi-log.

Table A2.
Research Variables

Dependent variable: logarithm of rice productivity; productivity in quintals per hectare	
Independent variable:	
Mechanization	Use of agricultural equipment and machinery (mechanization) where the reference category is not using agricultural equipment and machinery.
Sex	The sex of the farmers consists of two categories (male and female), in which the female group is the reference category. The farmers in this study are the main farmers (the largest production value) in each sample household.
Education	The level of education of farmers is based on the highest education completed. The reference category is not attending school/not completing elementary school.
Age	Age of the farmers in years. Divided into several groups, with the main farmers under 30 years old as the reference.
Internet Access	Accessing the Internet, where the reference category is not accessing the Internet.
Seed Variety	Seed varieties are divided into upland rice, hybrid lowland rice, and inbred rice. The reference category is the upland rice variety.

Table A3.
Food and Horticulture Crop Productivity, 2019 (in quintals per hectare)

Province	Rice	Maize	Soybean	Shallot	Chili	Cayenne pepper
Aceh	55.30	56.29	10.47	78.02	130.94	152.96
North Sumatra	50.32	61.36	17.51	80.45	95.80	97.17
West Sumatra	47.58	65.01	14.95	111.63	105.84	107.66
Riau	36.56	35.30	10.03	55.08	83.77	61.32
Jambi	44.57	66.06	15.02	64.30	78.57	68.51
South Sumatra	48.27	61.91	15.97	79.89	78.07	85.44
Bengkulu	46.03	57.74	14.87	49.85	58.27	45.18
Lampung	46.63	55.61	13.20	77.16	62.33	63.66
Bangka Belitung Islands	28.56	30.80	16.73	43.59	67.24	44.19
Riau Islands	32.30	39.00	15.94	39.42	117.92	79.22
Special Capital Region of Jakarta	53.96	-	-	-	-	-
West Java	57.54	74.79	17.63	110.43	136.65	121.74
Central Java	57.53	61.18	16.95	100.51	75.11	62.26
Special Region of Yogyakarta	47.86	55.13	9.44	97.72	84.07	65.19
East Java	56.28	55.70	14.89	94.94	85.87	79.11
Banten	48.41	51.84	15.45	64.90	83.47	92.27
Bali	60.78	35.53	13.64	149.71	117.24	77.36
West Nusa Tenggara	49.78	67.18	13.70	112.81	104.55	206.33
East Nusa Tenggara	40.82	26.33	7.78	47.49	43.32	51.50
West Kalimantan	29.23	47.78	10.28	6.35	22.79	27.59
Central Kalimantan	30.35	50.54	15.06	29.23	39.16	48.40
South Kalimantan	37.69	58.83	12.60	61.46	69.55	56.71
East Kalimantan	36.41	66.84	15.00	43.13	59.77	68.22
North Kalimantan	32.40	34.94	15.48	31.59	78.80	71.29
North Sulawesi	44.79	45.37	15.05	47.07	62.71	43.73
Central Sulawesi	45.40	43.49	9.54	47.82	62.55	61.77
South Sulawesi	50.03	56.49	13.77	98.20	80.76	50.75
Southeast Sulawesi	39.27	42.54	16.41	29.77	26.13	27.79
Gorontalo	47.18	47.37	13.89	49.50	60.95	78.85
West Sulawesi	47.96	50.89	17.09	39.27	45.79	44.38
Maluku	37.82	32.29	6.55	40.87	33.18	36.87
North Maluku	32.43	34.20	15.55	20.86	43.65	41.55
West Papua	41.63	41.56	14.92	20.66	35.83	37.02
Papua	43.48	46.40	16.32	21.26	59.47	53.44
INDONESIA	51.14	54.52	15.11	99.26	91.01	82.32

Source: Statistics Indonesia and Ministry of Agriculture

ABOUT AUTHOR

Kadir Ruslan is a Research Fellow at Centre for Indonesian Policy Studies and has been working in official statistics, particularly food and agricultural statistics, for more than a decade. During his career as a statistician, he has been involved in many food and agricultural surveys and their analysis. Kadir is also an active writer focusing on the socio-economic issues in the food and agricultural sector. A number of his writings related to socio-economic issues, especially in the agricultural sector, have been published in national newspapers, such as The Jakarta Post. He obtained his master's degree in Applied Econometrics from Monash University, Australia.

JOIN OUR SUPPORTERS CIRCLES

Through our Supporters Circles, you, alongside hundreds of others, enable us to conduct our policy research and advocacy work to bring greater prosperity to millions in Indonesia.

Those in our Supporters Circles get the opportunity to engage in the work of CIPS on a deeper level. Supporters enjoy:

- Invitation to CIPS' annual Gala Dinner
- Exclusive Supporters-only briefings by CIPS leadership
- Priority booking at CIPS-hosted events
- Personal (Monthly/Quarterly) Supporters-only update emails and videos
- Free hard copy of any CIPS publication upon request

Dharma Club

Dewi Sri Circle

Wijaya Circle

For more info, please contact anthea.haryoko@cips-indonesia.org.

Scan to join

ABOUT THE CENTER FOR INDONESIAN POLICY STUDIES

Center for Indonesian Policy Studies (CIPS) is a strictly non-partisan and non-profit think tank providing policy analysis and practical policy recommendations to decision-makers within Indonesia's legislative and executive branches of government.

CIPS promotes social and economic reforms that are based on the belief that only civil, political, and economic freedom allows Indonesia to prosper. We are financially supported by donors and philanthropists who appreciate the independence of our analysis.

KEY FOCUS AREAS:

Food Security & Agriculture: To enable low-income Indonesian consumers to access more affordable and quality staple food items, CIPS advocates for policies that break down the barriers for the private sector to openly operate in the food and agriculture sector.

Education Policy: The future of Indonesia's human capital need to be prepared with skills and knowledge relevant to the 21st century. CIPS advocates for policies that drive a climate of healthy competition amongst education providers. Such competition will drive providers to constantly strive to innovate and improve education quality for the children and parents they serve. In particular, CIPS focuses on the improvement of operational and financial sustainability of low-cost private schools who serve the poor.

Community Livelihood: CIPS believes that strong communities provide a nurturing environment for individuals and their families. They must have the rights and capacities to own and manage their local resources and to ensure healthy and sound living conditions for the development and prosperity of the community.

www.cips-indonesia.org

facebook.com/cips.indonesia
@cips_id
@cips_id
Center for Indonesian Policy Studies
Center for Indonesian Policy Studies

Jalan Terogong Raya No. 6B
Cilandak, Jakarta Selatan 12430
Indonesia