

## **PROJECTED SCENARIO OF BIOFORTIFIED RICE NEEDS IN FIVE PRIORITY PROVINCES TO REDUCE STUNTING**

**Dian Amalina<sup>1</sup>, M. Yazid <sup>1</sup>, Utan Sahiro Ritonga<sup>1</sup>**

<sup>1</sup>Agricultural Socio-Economics Department of Sriwijaya University

dian.amalina@fp.unsri.ac.id

### **Abstract**

The problem of malnutrition and hidden hunger is still a challenge in Indonesia, with an uneven prevalence of stunting between regions. Nutrition interventions require a targeted approach. This study aims to analyze the market potential and project the demand for biofortified rice specifically in the five priority provinces with the highest stunting prevalence: Aceh, NTB, NTT, West Sulawesi, and Southwest Papua. This study uses a descriptive quantitative method with projection and scenario analysis. Secondary data from BPS, SUSENAS, and SSGI were analyzed to map the potential for market uptake using pessimistic (5%), moderate (15%), and optimistic (30%) adoption scenarios. The results of the analysis show a very significant economic potential. In the moderate adoption scenario (15%), the total estimated market value of biofortified rice in the five provinces collectively has the potential to reach Rp 16.987 trillion per year. Volume demand in the same scenario is projected to grow consistently, reaching 241,970 tons by 2030. These findings confirm that biofortified rice has a strong economic justification as an investment opportunity and nutritional intervention. This research provides quantitative targets for stakeholders to design effective production and distribution strategies in these priority areas.

Keywords: Food Investment, Rice Needs, Biofortified Foods, Nutritional Problems, Food Demand.

## INTRODUCTION

The increase in global population and the impact of climate change is affecting the need to improve rice production and quality. The recent food crisis has also prompted a review of rice self-sufficiency goals. For the sake of agricultural sustainability, rice-producing countries have established rice policies that emphasize productivity and quality growth to ensure adequate food supply for the Community. (Mohidem et al., 2022). As one of the main cereal crops, rice (*Oryza sativa* L.) provides staple food for almost half of the world's population, especially in developing countries. Increasing rice yields has always been a priority in rice plant breeding. However, along with economic development and improved living standards, improving nutritional quality such as the micronutrient content in grains has become a new goal to tackle "hidden hunger" (Zhang et al., 2020)

Hidden hunger, a form of malnutrition caused by micronutrient deficiencies, is still a critical global challenge affecting billions of people around the world. Biofortification of staple crops, such as rice, offers a promising solution to address this problem (Oswalt, 2024). Biofortification, which is an increase in vitamin and mineral content through plant breeding (biotechnology), which is applied to food crops with micronutrient elements has the potential to overcome widespread micronutrient deficiencies in humans (Bashir et al., 2013).

As for nutrition problems in Indonesia, there is a phenomenon known as "double burden of malnutrition" or the double burden of malnutrition. The term refers to conditions in which malnutrition problems (such as stunting, wasting, and micronutrient deficiencies) occur simultaneously with overnutrition (such as overweight and obesity) in the same population, household, or even individual (Fitzgerald, 2025). Lack of zinc in the body is one of the serious problems of malnutrition in Indonesia because it reduces immunity, productivity and quality of life of humans, and is one of the factors that cause stunting. Stunting is worrying because it can cause impaired children's growth and development which is characterized by substandard child height (Sopiana, 2024). Stunting or short body is still a problem faced by Indonesia today. This is because many Indonesian people are not aware of the magnitude of this problem. Generally, Indonesia pays more attention to underweight to determine nutritional conditions. However, by using this measure alone, the nutritional problem will appear to have been solved because the weight level is very low at only 5.4% of all toddlers in Indonesia (World Bank Group, 2015).

The prevalence of stunting in Indonesia reached 37.6% in 2013, dropping to 19.8% in 2024 (Ministry of Health of the Republic of Indonesia, 2025). Acute malnutrition (such as underweight and wasting) and chronic malnutrition (stunting) contribute to an increase in the incidence of disease, death, and physical and cognitive developmental disorders. The impact is not only on individuals but also on national economic policies in terms of increasing health service costs and decreasing future productivity.

To deal with these nutritional problems, efforts are needed to change food consumption patterns in Indonesia so that the consumption of nutrients is in accordance with the needs (Laswati, 2017). Efforts to increase nutritional intake through changes in food consumption patterns often face quite complex challenges. This is not only related to taste preferences and eating habits that have been firmly rooted in people's cultures but also influenced by economic conditions and social life. For most households, food

choices are largely determined by purchasing power, so relatively more expensive nutritious foods are consistently difficult to reach. In addition, the existence of staple foods such as rice as staple food Indonesian people make efforts to replace or reduce their consumption is not an easy step. Rice has become an integral part of food identity, so a change in consumption patterns to other sources of carbohydrates or proteins is often perceived as "uneaten" or less filling. A more realistic and effective strategy is to improve the quality of nutrition in commodities that have been widely accepted by the public. The development of food that has better nutritional content needs to be considered as one of the relevant solutions. This approach not only supports the improvement of community nutrition but is also in line with the socio-economic conditions and culture of food consumption in Indonesia.

The average per capita rice consumption per week of the Indonesian people in 2024 will be 1,521 Kg. Although it has decreased in the last ten years, namely 1,626 Kg in 2014 (BPS, 2024), this data shows that compared to other types of staple foods, rice is still the main staple food of the Indonesian people, although it is known that the micronutrient content in rice is still not enough to meet the nutritional needs of the community. However, the large volume of national rice consumption shows its extraordinary potential. This means that any efforts to improve nutrition integrated into rice will have a large-scale impact, effectively transforming a major food commodity into a public health solution.

Table 1  
 Average Consumption per Capita Week Some Kinds of Important Food Ingredients

Types of Foodstuffs	Consumption/ Week (Kg)
Local rice/glutinous rice	1,521
Wet corn with skin	0,044
Pocelan/pipilan corn	0,011
Cassava	0,090
Pumpkin Spice	0,057
Cassava	0,001

Source: Badan Pusat Statistik, 2024

The nutritional content of food can be improved and even improved through plant breeding activities known as biofortification or biological fortification. Biofortification in Indonesia is very important and strategically associated with the high prevalence of stunting due to the lack of zinc nutritional consumption that occurs in the community, especially in children (Hartoyo, 2022). Biofortification is an intervention effort (including nutrients) to increase the nutrients available to plants. Biofortification technology is considered by the Indonesian government as an effective process to increase micronutrients in rice plants, as a step to strengthen food security in vulnerable food-insecure communities. Based on that, in 2019 through the Decree of the Minister of Agriculture No. 168/HK.540/C/01/2019, the government officially launched Inpari IR Nutri Zinc which is the first paddy rice variety in Indonesia that has a higher Zn content (25%) than other varieties (Center for the Implementation of Agricultural Instrument Standards, 2023).

The availability of technology such as Inpari IR Nutri Zinc is a fundamental breakthrough on the upstream side, its success at the population level does not only depend on its agronomic and nutritional advantages alone. A crucial gap emerges in the

downstream aspect, namely a deep understanding of the potential for market uptake, consumer acceptance, and realistic demand scales as demonstrated by Birol et al., (2015). Without this mapping, no matter how great innovation is at risk of failing to be widely adopted and will only stop as achievements at the research level. According to Bouis & Saltzman, (2017) Once released, the biofortified variety entered the national agricultural and food system. Research proves that farmers are willing to grow biofortified crops and consumers are willing to consume them. The evidence base has been developed in eight target countries (Bangladesh, Democratic Republic of Congo, India, Nigeria, Pakistan, Rwanda, Uganda, and Zambia) where HarvestPlus and national partners are leading the way in its provision. By the end of 2016, HarvestPlus estimates that about 20 million people from four million farmer households in HarvestPlus' target countries were now growing and consuming biofortified crops.

Although there has been rapid progress in rice biofortification, the commercialization of biofortified crops has not been achieved. Need a brief review of the progress in rice biofortification according to future prospects (Bashir et al., 2013). In Indonesia, the distribution of nutrition problems and stunting is very uneven between provinces, so the need for highly nutritious food, including biofortified rice, also varies between regions. That reason then underlies that this research needs to be focused on purposive (deliberately) in five provinces with a high prevalence of stunting in Indonesia (Aceh, NTB, NTT, West Sulawesi, and Southwest Papua). Information on the projection and potential demand for biofortified rice in priority areas for stunting is crucial. The importance of the study of the projections and potential of biofortified rice is not only because it can provide an empirical basis for more effective and efficient food and nutrition policy planning but also can provide an overview of market opportunities for producers. Although each region has different purchasing power, rice consumption patterns, and perceptions of nutritious food, a case-based approach in priority areas of stunting problems is expected to assist governments and business actors in determining realistic regulatory scales, intervention models, and adoption targets. Thus, the results of this study are expected to reflect the real need for biofortified rice that needs to be developed for the community which is also important information about the existence of economic potential as a positive impact on overcoming stunting problems in Indonesia.

## **RESEARCH METHODS**

This study uses a descriptive quantitative research method with a mathematical projection approach and scenario analysis. The method used combines secondary statistical analysis, mathematical calculations (market potential and population projections), and scenario approaches to anticipate variations in market adoption so that they are in accordance with the data structure and research objectives that are predictive analytics. The determination of the area to be projected in this study is determined purposively based on the highest stunting prevalence rate in Indonesia according to the Indonesian Nutrition Status Survey (SSGI) from the Ministry of Health of the Republic of Indonesia, which then determines the five selected provinces as can be seen in the following Table 2:

Table 2  
 Stunting Prevalence Rate in 5 Provinces with the Highest Prevalence in Indonesia

No.	Province	Population	Stunting Prevalence Rate (%)	Category
1.	Aceh	5.626.000	28,6	Tall
2.	NTB	5.731.100	29,8	Tall
3.	NTT	5.742.600	37	Very High
4.	Sulawesi Barat	1.525.300	35,4	Very High
5.	Southwest Papua	636.400	30,5	Very High
<b>Average</b>			<b>32,26</b>	<b>Very High</b>

Source: BPS & Indonesia's Nutrition Status Survey, 2024

The determination of the five provinces in table 2 is the result of consideration that according to the World Health Organization (WHO) limits, the stunting rate is said to be very high if the prevalence is  $\geq 30\%$  and the high category if the prevalence is 20% - 30%. In the last five years, it is known that the decline in stunting prevalence in Indonesia is quite good, where in 2024 the average stunting will be at 19.8% (Ministry of Health of the Republic of Indonesia, 2025), but there are in the provinces of Aceh, NTB, NTT, West Sulawesi and West Papua which are on average in the very high category.

Furthermore, the analysis is carried out by looking at market potential based on the needs of the number of consumption per capita. The calculation of the total market value of rice in the selected province is carried out by estimating the total market potential. Refers to Kotler, (2018), the total potential market is calculated by multiplying the total population by the average consumption per capita and the average price per unit assuming that:

1. The price of rice is assumed to be the same, both between regions and between types
2. The amount of per capita consumption is assumed to be the same/constant and applies in all locations regardless of whether there is a substitution of rice with local food

Based on these assumptions, the total market potential is calculated using the following mathematical equations:

$$Q = n \cdot q \cdot P \dots\dots\dots (1)$$

Where:

- Q = Total Market Value of rice
- n = Number of populations per province
- q = per capita rice consumption (tons/year)
- p = Average price of rice at the wholesale trade level (Rp/kg)

To analyze the potential of the biofortified rice market amid uncertainty of consumer adoption, this study uses Scenario Analysis Schoemaker (1995) With three scenarios, namely pessimistic (5%), moderate (15%), and optimistic (30%) which were developed to map the range of potential market absorption. The use of the numbers 5% (Pessimistic), 15% (Moderate), and 30% (Optimistic) is not a rigid number, but a justified assumption (justified assumptions) set out in the interest of this study to model adoption uncertainty as a standard practice in Scenario Analysis as each scenario

includes risk mitigation strategies to address market uncertainty in accepting new innovations from the private sector (Shobari et al., 2025).

The use of percentages in the three scenarios is carried out by considering socioeconomic aspects. Considering that rice is the most basic need of the Indonesian people, even at a pessimistic level, it is still possible to absorb adoption at 5%. This is supported by research Birol et al., (2015), which specifically synthesizes various studies and shows that consumer acceptance of biofortified foods in developing countries is not automatic, but is strongly influenced by price, availability of information, and perception. The optimistic scenario is based on empirical evidence that large-scale adoption is possible if the ideal conditions that have been mentioned are met. As stated Bouis & Saltzman, (2017) in its study that reviewed evidence from HarvestPlus showing that millions of people from millions of farming households in eight target countries (such as Bangladesh, India, and Nigeria) have successfully grown and consumed biofortified crops. The 30% scenario projects a similar success rate in Indonesia, where the product manages to penetrate the market significantly and move towards full commercialization.

As for calculating the projected demand for biofortified rice, the data used is population growth projection data. Remembering the data presented BPS Indonesia (2023) is 5-year interval projection data, then population data per year of research, namely 2026-2029, which is not available, is directly interpolated with five-year interval data using the Geometric Projection Method. The method used assumes a constant annual growth rate over the period 2025-2030 (Swanson et al., 2004), using the following mathematical equations:

$$P_{t+1} = P_t \times (1 + r) \dots\dots\dots (2)$$

Where:

- P<sub>t+1</sub> = Projected Population next year (e.g. 2026)
- P<sub>t</sub> = Projected Population this year (e.g. 2025)
- r = Annual Population Growth Rate (from the table below)

**RESULTS AND DISCUSSION**

In this study, the stunting prevalence figures were taken from 5 provinces with the highest stunting prevalence rates, namely Aceh, NTB, NTT, West Sulawesi, Southwest Papua which ranged from 28-32%. From the stunting prevalence data in the 5 selected provinces, the average stunting prevalence rate is or reaches 32.26%, which according to WHO standards is categorized as very high. If the government takes special steps to reduce this number in these five priority areas through the procurement of biofortified rice, of course, from an economic and agribusiness point of view, it will give rise to market potential.

Understanding market potential is not just about knowing the magnitude of demand, but also a strategic step to connect the goals of national nutrition development with strengthening the competitiveness of local agribusiness, so that stunting alleviation interventions can go hand in hand with the economic growth of communities in priority areas. In terms of policy, understanding the market potential helps the government in developing programs that are not only subsidies or short-term interventions, but also

able to create a productive and independent agribusiness ecosystem in areas with a high prevalence of stunting. The government can direct food policies, production incentives, and distribution to be more targeted, as well as ensure that biofortified rice is truly acceptable to the public in terms of price and access. Based on areas with high stunting rates as potential markets, business actors can develop efficient value chains, adjust production scales, and design market strategies that suit the social and cultural characteristics of the target area, so that later biofortified rice will not only be seen as a healthy commodity, but also as an economic opportunity that supports regional development.

### *Analysis of the Potential of the Biofortified Rice Market*

Market potential analysis was carried out to map the market opportunities for biofortified rice. An analysis of the potential market for biofortified rice was carried out by calculating the total market value of rice (all types) in the target province to get an overview baseline. Based on BPS (Susenas) per capita consumption data and average rice prices at the major trade level in September 2025, the estimated total market value is presented in table 3.

Table 3  
Projected Total Rice Market Value in Five Priority Provinces (2025)

No.	Province	Population	Total Consumption (Tons/Yrs)	Average price of rice/Kg	Market Value (Rp/Trillion/Year)
1	Aceh	5.626.000	444.989	14290	IDR 35,775
2	NTB	5.731.100	453.301	14290	IDR 37,124
3	NTT	5.742.600	454.211	14290	IDR 37,273
4	Sulawesi Barat	1.525.300	120.644	14290	IDR 2,630
5	Southwest Papua	636.400	50.336	14290	IDR 458

From Table 3. The total market value of rice in East Nusa Tenggara Province, which has a higher population compared to the other four provinces, is estimated to reach Rp 37,273 trillion per year. The magnitude of this figure shows the economic significance of rice commodities in each of these provinces and confirms its potential as a vehicle for nutrition intervention. Furthermore, based on the baseline market value, the absorption potential for biofortified rice is estimated using three adoption scenarios as seen in Table 4.

Table 4  
Market Potential based on Three Biofortified Rice Adoption Scenarios

No.	Province	Market Value (Rp/Trillion/Year)	Market Penetration Assumptions		
			Pessimistic (5%)	Moderate (15%)	Optimistic (30%)
1	Aceh	IDR 35,775	IDR 1,788	IDR 5,366	IDR 10,733
2	NTB	IDR 37,124	IDR 1,856	IDR 5,567	IDR 11,137
3	NTT	IDR 37,273	IDR 1,864	IDR 5,591	IDR 11,182
4	Sulawesi Barat	IDR 2,630	IDR 131	IDR 394	IDR 789
5	Southwest Papua	IDR 458	IDR 23	IDR 69	IDR 137

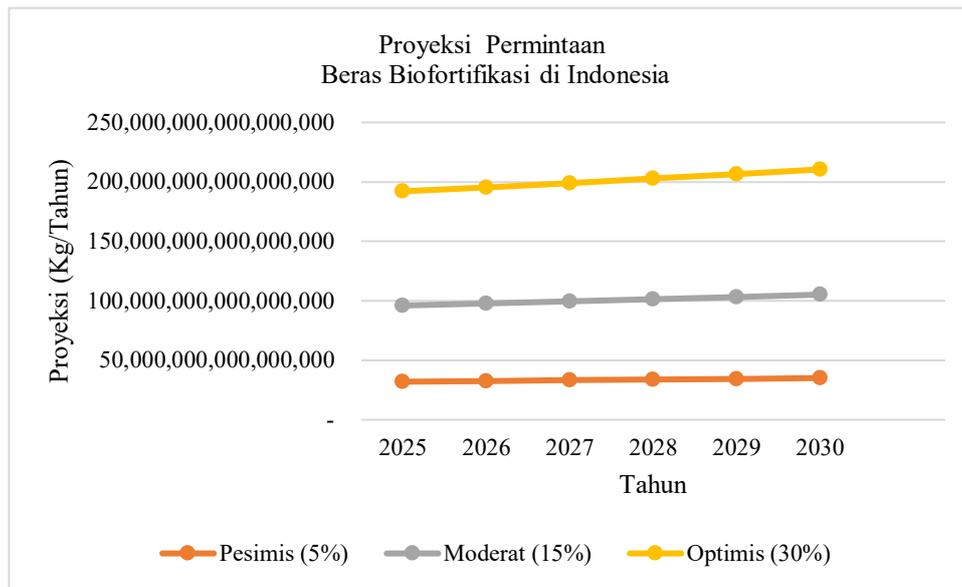
Source: BPS data processed

Based on data, the total market value of biofortified rice in five priority provinces—Aceh, NTB, NTT, West Sulawesi, and Southwest Papua—is estimated to reach Rp113.26 trillion per year. If it is assumed that market penetration is only 5% (pessimistic scenario), then the economic value that can be mobilized reaches around Rp5.66 trillion per year. In a moderate scenario with a penetration of 15%, the potential increases to around IDR 16.99 trillion, and in an optimistic scenario (30%), the value can reach more than IDR 33.86 trillion per year. These figures show that despite small market penetration, the resulting economic impact remains significant, especially when it is associated with social goals in the form of stunting alleviation.

In a pessimistic scenario, the relevant strategy is to strengthen nutrition education programs and socialize the benefits of biofortified rice, because the market is still limited and consumer awareness has not yet been formed. The government can play a role in providing seed subsidies, incentives for millers, and integrating programs with stunting interventions across sectors such as health and education. In the moderate scenario, governments and business actors can start developing a more self-sustaining agribusiness ecosystem, by encouraging the participation of local farmers and cooperatives in the production and distribution value chain. Policy support is directed at strengthening production capacity, improving post-harvest quality, and providing logistics facilities. This is in line with efforts to expand market reach to rural areas that have limited access to nutritious food. Meanwhile, in the optimistic scenario, when the level of public acceptance of biofortified rice is high, the policy focus shifts to strengthening market competitiveness and sustainability. The government can provide support for the local agribusiness system development model by strengthening partnerships between stakeholders in the private sector and financial institutions whose needs are relevant to the production process both technically and non-technically.

#### ***Biofortified Rice Demand Projections (2025-2030)***

The projected demand for biofortified rice is carried out to see the level of demand that will grow in the future, which is essential for production capacity planning and logistics. Given that the data presented by BPS Indonesia (2023) is a five-year interval projection data, the annual population data for the period 2026-2029 that is not available is directly interpolated using the Geometric Projection Method. The available population growth data is data based on age categories (0-14), (15-64), (65+), from the three population increases at that age and then added up to get the total population. This is done because each age group has a different growth rate. This study uses the growth rate of the BPS Moderate Scenario, which is 0.07% for 0-14 years old, 0.70% for 15-64 years old, and 5.12% in the 65+ year age group. The main assumption used is that per capita consumption remains constant. Thus, demand growth is purely driven by population growth. The total demand for rice is then multiplied by three adoption scenarios (pessimistic 5%, moderate 15%, and optimistic 30%) to produce the projected data on biofortified rice demand presented in the following figure.



Graph1  
 Projected Demand for Biofortified Rice in Five Priority Provinces (2025-2030)

Chart 1 visually shows consistently increasing trends for all three scenarios over the projection period. This is in line with BPS data which projects a total population increase of 5.89% in all three age groups in Indonesia. In the Moderate Scenario (15%), demand is projected to grow from around 228,522 tons in 2025 to 241,970 tons in 2030. This figure represents the estimated volume of biofortified rice that needs to be prepared by stakeholders (local governments, Bulog, or the private sector) to meet market demand and stunting intervention targets in the five priority provinces. These findings have important operational implications, as the projected demand figure of 241,970 tons by 2030 (for a moderate scenario) can serve as a quantitative target for logistics planning, seed distribution to farmers, and program budget allocation. The availability of supply in accordance with this projected demand will be key to the successful adoption of biofortified rice in the long term.

The high rate of population growth, when analyzed the population growth in Indonesia from year to year is increasing, meaning that the growth is very extraordinary which has implications for the level of consumption that demands food needs and consumption that increases very significantly (Chaireni et al., 2020). According to the law of the market, if demand increases, while other factors remain, there will be an increase in prices. As in the short term, the effect of increasing population on rice demand and prices in the long term is higher than the effect of increasing per capita income (Nuryanti, 2016). The increase in domestic rice prices will encourage rice import activities (Wibawa et al., 2023). To prevent price increases that can reduce the consumption level of biofortified rice, the government needs to establish an integrated price stabilization policy. The increase in demand for biofortified rice must be balanced by supply availability and good market arrangements, so that prices remain stable and public consumption is not disrupted.

The quantitative analysis in this study, which projects the potential of the trillions of rupiah biofortified rice market even in a moderate scenario, provides a strong economic

justification for large-scale business development as an interesting finding in this study. The opportunities that have been measured are a clear signal of market incentives for the private sector and SOEs to not only invest in the upstream side (seed production), but also build efficient downstream supply chains, including milling, packaging, and distribution. However, this business potential cannot be realized optimally without targeted policy intervention from the government. Given that the ever-increasing demand projections are consistent with population growth, the main risk identified is price instability due to increased demand. Therefore, the role of the government is crucial in designing integrated price stabilization policies, for example by ensuring the absorption of farmers' production (Off-take) and integrate biofortified rice into the government's food assistance program as an anchor market to create stable initial demand (Thorpe & Reed, 2016). This is where the role stakeholder The key, namely farmers, is vital. As a first step to ensure supply availability according to the quantitative projection target, farmers need real support in the form of easy access to certified Inpari IR Nutri Zinc seeds, definite market guarantees, and decent price incentives. On the other hand, stakeholder the community as the final consumer needs to be encouraged through massive educational campaigns about the importance of zinc nutrition to prevent stunting (Meenakshi et al., 2010), so that projected demand can shift from mere latent need to a sustained effective demand. Thus, the findings of this study confirm the need for policy orchestration that synchronizes business potential with the government's role as a stabilizer and the active participation of farmers and communities.

## **RESEARCH LIMITATIONS**

Specifically, the study did not measure farmers' preferences for growing biofortified rice varieties such as Inpari IR Nutri Zinc nor did it analyze the level of acceptance and willingness of consumers to purchase biofortified rice, which may have different prices or sensory characteristics. Even though as Birol et al., (2015) states that consumer acceptance in developing countries is a determining factor for the success of the biofortification program. For this reason, as a step to develop further information, it is still necessary to study aspects of consumer behavior through primary surveys, both at the level of farmer households and consumers, in stunting priority areas.

## **CONCLUSION**

The potential of the biofortified rice market in the five priority stunting provinces (Aceh, NTB, NTT, West Sulawesi, and Southwest Papua) is very economically significant. This study identified a large market potential in areas that are the main targets of nutrition interventions. Based on the analysis of the moderate adoption scenario (15%), the total estimated market value of biofortified rice in the five provinces collectively has the potential to reach Rp 16.987 trillion per year. This figure provides a strong signal that there is a clear market incentive for manufacturers, the private sector, and state-owned enterprises to invest in production and down streaming. The demand volume (tonnage) of biofortified rice in the target region shows a consistent growth trend, driven by the rate of population growth. The projected demand volume for the moderate scenario (15%) in these five provinces is expected to grow from 228,522 tons in 2025 to 241,970 tons in 2030. These findings provide clear quantitative targets for stakeholders in planning production capacity, provision of superior seeds, and supply chain strategies to meet the needs in these priority areas in the future.

## REFERENCES

- Center for the Implementation of Agricultural Instrument Standards. (2023). Inpari IR Nutri Zinc. Center for the Implementation of Agricultural Instrument Standards. <https://repository.pertanian.go.id/handle/123456789/22422>
- Bashir, K., Takahashi, R., Nakanishi, H., & Nishizawa, N. K. (2013). The road to micronutrient biofortification of rice: progress and prospects. *Frontiers in Plant Science*, 4, 15.
- Birol, E., Meenakshi, J. V., Oparinde, A., Perez, S., & Tomlins, K. (2015). Developing country consumers' acceptance of biofortified foods: a synthesis. *Food Security*, 7(3), 555–568.
- Bouis, H. E., & Saltzman, A. (2017). Improving nutrition through biofortification: a review of evidence from HarvestPlus, 2003 through 2016. *Global Food Security*, 12, 49–58.
- BPS. (2024). Average Per Capita Consumption of Several Kinds of Essential Foodstuffs, 2007-2024. <https://www.bps.go.id/id/statistics-table/1/OTUwIzE=/rata-rata-konsumsi-per-kapita-seminggu-beberapa-macam-bahan-makanan-penting--2007-2022.html>
- BPS Indonesia. (2023). Indonesia Population Projection Based on Census 2020. In Badan Pusat Statistik. <https://webapi.bps.go.id/download.php?f=D/qqDyqOikWjGBHgQ+e2asZYx83/z3N4GXHPtfhAc7AMoBc/bw/UHfQDg3gSYVfYmQ9gQ5ID5cAwe0D84TkG+/O7tRJbsZDV/DDfqpqDKRh7zrtLis0RCa/wymwvxDdTVWY4HhzWYyuXiTLR0mMt7VUX9HTEZ0IjXtCP49BxBxpIs7SNBYbPqSi2Ns66mXJMLLVk9qHJErBnzwEejZA0EX>
- Chaireni, R., Agustanto, D., Wahyu, R. A., & Nainggolan, P. (2020). Sustainable food security. *Journal of Population and Environmental Development*, 1(2), 70–79.
- FitriYani, S. (2025). Analysis of Factors and Strategies for Countering the Double Burden of Malnutrition in Indonesia. Bookchapter of Public Health, State University of Semarang, 6, 27–49.
- Hartoyo, B. (2022). Perbaikan Mutu Gizi Bahan Pangan Melalui Biofortifikasi Kandungan Mineral Improving the Nutritional Quality of Food Ingredients Through Biofortification of Mineral Content. *Journal of Agrifoodtech*, 1(1), 12–20.
- Ministry of Health of the Republic of Indonesia. (2025). Survey of Indonesia's Nutritional Status in Numbers. <https://www.badankebijakan.kemkes.go.id/survei-status-gizi-indonesia-ssgi-2024/>
- Kotler, P. (2018). *Kotler & Armstrong-Principles of Marketing 17th GLOBAL*. Pearson. [https://www.pearson.com/nl/en\\_NL/higher-education/subject....](https://www.pearson.com/nl/en_NL/higher-education/subject...)
- Laswati, D. T. (2017). Nutritional problems and the role of balanced nutrition. *Agrotech: Scientific Journal of Agricultural Technology*, 2(1), 69–73.

- Meenakshi, J. V, Johnson, N. L., Manyong, V. M., DeGroot, H., Javelosa, J., Yanggen, D. R., Naher, F., Gonzalez, C., Garcia, J., & Meng, E. (2010). How cost-effective is biofortification in combating micronutrient malnutrition? An ex ante assessment. *World Development*, 38(1), 64–75.
- Mohidem, N. A., Hashim, N., Shamsudin, R., & Che Man, H. (2022). Rice for food security: Revisiting its production, diversity, rice milling process and nutrient content. *Agriculture*, 12(6), 741.
- Nuryanti, S. (2016). Analysis of the balance of the rice supply and demand system in Indonesia. *Journal of Agroecconomics*, 23(1), 71–81.
- Oswalt, S. A. (2024). Assessing Consumer Willingness to Pay for Zinc-Biofortified Rice—the Case of Colombia. University of Arkansas.
- Schoemaker, P. J. H. (1995). Scenario planning: a tool for strategic thinking. MIT Sloan Management Review.
- Shobari, M. N., Junaid, M. T., SE, M. A., Malik, A. D., SE, M. A., Ahmatang, S. E., & Dodi Apriadi, S. E. (2025). MSME Financial Management: Improving Efficiency & Transparency. Hosted by Innovatix Labs.
- Sopiana, R. (2024). Development of biofortified rice for reduce stunting rates in South Sumatra Province. *Jurnal Lahan Suboptimal: Journal of Suboptimal Lands*, 13(2), 94–100.
- Swanson, D., Siegel, J. S., & Shryock, H. S. (2004). The methods and materials of demography. Elsevier Academic Press California, USA.
- Thorpe, J., & Reed, P. (2016). Addressing market constraints to providing nutrient-rich foods: an exploration of market systems approaches.
- Wibawa, N. C., Ardini, H., Hermawati, G., Firdaus, R. N., Anggoro, K. B., & Wikansari, R. (2023). Analysis of rice imports in Indonesia and factors affecting rice imports. *Journal of Economics*, 2(2), 574–585.
- World Bank Group. (2015). The Double Burden of Malnutrition for Indonesia. <https://www.worldbank.org/in/news/feature/2015/04/23/the-double-burden-of-malnutrition-in-indonesia#:~:text=Stunting can reduce a person's productivity, this is the double burden of malnutrition.>
- Zhang, Z., Gao, S., & Chu, C. (2020). Improvement of nutrient use efficiency in rice: current toolbox and future perspectives. *Theoretical and Applied Genetics*, 133(5), 1365–1384.