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Research Article

Assessing Food Consumption Trends in Indonesia: Patterns and Challenges for Adoption of the Desirable Dietary Pattern

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ABSTRACT

This study aims to assess historical food consumption trends in Indonesia in relation to income and evaluate their implications for future food demand and the transition toward the Desirable Dietary Pattern (*Pola Pangan Harapan* (PPH)). Using the national socioeconomic surveys of food expenditure and macroeconomic data, consumption trends in relation to income for 15 food groups were analyzed. Food consumption was positively affected by income, except for consumption of staple rice, tubers, sugarcane, and nuts. Positive trends with income changes, known as positive income elasticity, were identified, and ranged from 0.19 (animal and vegetable oils) to 1.27 (restaurant and catering). Major adjustments to the current diet to comply with PPH criteria would include diversifying carbohydrate sources, increasing consumption of vegetables and fruits, increasing plant-based foods as a protein source, and reducing consumption of cooking oil and purchased foods. The income elasticity was positive in almost all food groups, which suggests that future consumption levels will rapidly increase beyond the PPH energy sufficiency standard. Therefore, there is an urgent need to focus on policy directions for the PPH agenda and alignment with the national climate policy, to ensure that future consumption is maintained at sustainable and healthy levels.

INTRODUCTION

Indonesia reached the status of an upper-middle-income country in 2023 and anticipates becoming a high-income nation before the middle of the century (Suyitno 2023). Studies have indicated the role of human capital and industrialization in supporting the country's long-term economic growth (Elfaki *et al.* 2021; Widarni & Bawono 2021). Following the Paris Climate Agreement ratification and the declaration of Indonesia's Net Zero Emissions (NZE) vision in 2060 or sooner, there is a need to couple economic growth with the sustainable development agenda (Government of Indonesia 2021).

A trend of increasing food consumption has been observed in developing regions, including Southeast Asia, which will affect the global sustainable pathway (FAO 2018; OECD & FAO 2023). Retaining a conventional diet pattern, with excessive energy intake and consumption of processed food, leads to a negative impact on health and non-communicable diseases (Popkin & Ng 2022; Barrera & Hertel 2023), and also contributes to higher Greenhouse Gas (GHG) emissions levels (Willett *et al.* 2019; De Pee *et al.* 2021).

The responses of food demand to changes in price and income are significantly different (Cornelsen *et al.* 2015; Femenia 2019), and they also differ between urban and rural regions (Faharuddin *et al.* 2017). Although food consumption behavior is inelastic to price, income level strongly affects the food demand trajectory in developing countries (Cornelsen *et al.* 2015; Bouyssou *et al.* 2024). Changes in food consumption relative to income (referred to as food income elasticity) have been widely used as a tool to capture shifting food consumption

preferences (Latka *et al.* 2021). Previous studies showed consistently increasing food consumption as income rises, with a sharper trend for animal-based products and fruits (Faharuddin *et al.* 2017; Femenia 2019; Aulia & Yuliana 2024).

Globally, countries including Indonesia, have developed dietary guidelines to maintain food consumption within a nutritional sufficiency. The Indonesian National Food Agency Law 11/2023 stipulates a Desirable Dietary Pattern (*Pola Pangan Harapan* (PPH)) as the ideal reference for healthy food consumption, at 2,100 kcal/cap/day. The PPH set a benchmark energy intake shares for each of several food types, which include staple carbohydrates for energy, plant-based and animal-based foods for protein, and for various regulating substances from fruits and vegetables. Recently, global studies and initiatives have also attempted to raise awareness of connecting a healthy diet to a sustainable food system, for instance, the so-called planetary health diet (Willett *et al.* 2019; Semba *et al.* 2020).

To assess the likelihood that future food demand patterns will correspond with the desirable dietary guidelines, it is important to analyze the historical trends of food consumption. In this study, these trends under income change were assessed by using multiple linear regression analysis. Such information is valuable to ensure the alignment of nutritional sufficiency, economic growth, and the sustainability agenda.

METHODS

Design, location, and time

This research is a quantitative study that employs secondary data analysis with a panel multiple linear regression approach. The focus of the study is national-level food consumption trends in Indonesia, using time series datasets covering the period 2005−2023. Data collection and processing commenced from January 2024 to July 2025 at the National Institute for Environmental Studies (NIES), Tsukuba, Japan.

Materials and tools

The analysis was performed at the national level using datasets published by official government agencies, including the Indonesia Statistics Bureau (BPS), the Ministry of Health, and the National Food Agency. Microsoft Excel was used for data cleaning, organizing, and visualization, while Minitab Statistical Software 22.2.0 was used specifically for statistical analysis.

Two main data inputs were employed in this study: macroeconomic data and food-related data. The macroeconomic data from BPS includes Gross Domestic Product (GDP) and Consumer Price Index (CPI) information for food products and general items related to food and services for the period 2005–2023. The food-related data includes food consumption information from expenditure-based approaches from BPS within the period 2005–2023, a food composition table from the Ministry of Health, food waste assumption from a global source (FAO 2011), and ideal food consumption information based on the PPH from the National Food Agency Law 11/2023.

Data collection

The data used in this study were compiled from officially published documents and international references. The macroeconomic (in IDR) and historical food consumption data for the period 2005–2023 were downloaded from the BPS official website. Each year, the BPS administers a household Socio-Economic Survey (SUSENAS) to measure household welfare, involving over 300,000 households. The earliest data publicly available are from 2005. The data collection comprises weekly household expenditure at the national level for food and non-food, which includes housing and its facilities, goods and services, durable goods, etc. Since the food consumption data were derived from household expenditures, they include food waste.

The historical food consumption data were pre-processed by converting the physical volume of food purchase into the physical value of food demand (kcal/cap/day) using a food composition table. Further, the data were divided into 15 food groups, with 13 groups representing raw products, and the remaining two groups representing processed foods and restaurants and catering (Table 1) (Monterio *et al.* 2019). These latter two were intended to identify food that is purchased indirectly through the food services sector.

Data analysis

A statistical approach was used to assess the trend of food consumption to income. The analysis employed a panel multiple linear

regression approach between historical food demand (kcal/cap/day) with income level (GDP per capita), and price-effect adjustment (CPI for food commodities relative to the general CPI; Equation 1).

$$\ln FD_{(i,t)} = a \times \ln GDP_{(t)} + b \times \ln \frac{PRI_{(i,t)}}{PRItot_{(t)}} + c + error \quad \text{(Equation 1)}$$

where FD is food demand (kcal/cap/day) for i and t; i is the food group being considered; t is the year; GDP is income per capita in Indonesian rupiah (IDR/cap); PRI is consumer price index for food (dimensionless); PRItot is general consumer price index for all goods and services (dimensionless), and a and b are the slope values for income and price, and c is the intercept.

From Equation 1, a was considered the true value for food income elasticity and $PRI_{(i,t)}$/ $PRItot_{(t)}$ the price-effect adjustment. Usually, food elasticity is measured using the demand system model (Faharuddin *et al.* 2017; Arifin *et al.* 2019; Forgenie *et al.* 2023; Khoiriyah *et al.* 2023). However, for long-term datasets of the type used in this study, a statistical approach was considered more appropriate to capture the food consumption trend.

Prior to the regression analysis, data cleaning process was conducted to eliminate outliers due to unpredictable events, for instance, food inflation and the global food crisis in 2007–2009 (Faharuddin *et al.* 2017; Arifin *et al.* 2019). It was assumed that the residual value of food demand followed a normal distribution and set a 95% confidence level for residual values, to exclude the outlier data. The multiple linear regression was generated repeatedly until all residual values were within the 95% confidence level, and only the final equation with the outliers excluded was considered.

Table 1. Food group classifications and included SUSENAS food items

Food groups	SUSENAS* food items
Paddy rice	Rice, glutinous rice
Grains	Fresh corn, dry shelled corn, wheat flour, and others
Tubers	Cassava, dried cassava, sweet potato, sago flour, taro, potatoes, and others
Sugarcane	Sugarcane, brown sugar
Nuts	Peanuts, soybeans, tofu, fermented soybean cake, soya cake, and others
Vegetables	Spinach, cabbage, mustard greens, string beans, tomato, carrot, cucumber, cassava leaves, eggplant, bean sprouts, squash, young jackfruit, unripe papaya, stink beans, onion, garlic, chilies, green chili, cayenne pepper, and others
Fruits	Orange, mango, apple, rambutan, langsat, durian, snake fruit, banana, papaya, watermelon, and others
Coffee, cacao, and tea	Tea, coffee beans, and others
Poultry (meat and egg)	Broiler egg, local chicken egg, duck egg, other eggs, broiler meat, and local chicken meat
Livestock (meat and dairy)	Beef, lamb, pork, other meat, and milk
Fish	Yellow tail, tuna, mackerel, anchovies, milk fish, snake head, catfish, rabbit fish, silver catfish, carp, preserved fish, and others
Marine products, excluding fish	Shrimp, squid, crab, snails, and others
Animal and vegetable oil	Coconut oil and other cooking oils
Processed food	Sausage, nuggets, canned milk, powdered milk, salt, spices, soya sauce, MSG, chili sauce, instant noodles, crisps, packaged porridge, bread, cookies and biscuits, cake, and beverages
Restaurant and catering	Fritters, porridge, salads, mixed rice, fried rice, cooked rice, steamed rice, cooked soup, cooked vegetables, roasted meat, noodles with meatballs, cooked noodles, snacks, roasted fish, processed meat, and other prepared foods

*SUSENAS (National household socio-economic survey)

To compare the current diet pattern with the PPH, the two datasets were harmonized to ensure consistency. As the PPH score represents the actual food intake for each food item, food waste was incorporated into the PPH energy structure, based on the value for food waste in developing countries in Asia (FAO 2011). Since food waste per capita can vary significantly depending on income group (Barrera & Hertel 2021), the share of food waste was adjusted to the current year by executing a linear interpolation of food waste that followed income growth. The final values of the PPH energy structure with adjustment for food waste are provided in Table 2.

To ensure classification consistency, the ideal energy patterns of the 9 PPH food groups (Table 2) were used to re-calculate the 15 more detailed categories of food consumption data considered in this study (Table 1). These calculations also reflected the share of each item in a group according to the historical SUSENAS food consumption data.

RESULTS AND DISCUSSION

The results of the data analysis showed that income level mainly affected food demand in a positive pattern (Table 3). The food commodities most sensitive to income were restaurant and catering, coffee, cacao, and tea, animal-based foods (livestock, poultry, and marine products excluding fish), processed food, and fruits. A negative response to income was identified only for sugarcane, staple rice, nuts, and tubers (Table 3). These findings reflect Indonesia's dietary shifts in consumption of staple rice and foods rich in plant-based protein, which are similarly found in other developing regions (Miller *et al.* 2022).

The high income elasticity for processed foods and restaurant and catering services suggests a dietary shift from whole food products to purchased food (Table 3). Considered together with a negative income elasticity for rice, this suggests that direct rice consumption may have shifted to ready-to-eat rice-based products in processed foods or restaurants and catering items. Similarly, regarding the negative trend of sugarcane consumption, this may indicate that consumption shifted to sugary beverage products in processed foods or restaurants and catering items. Such shifts in the pattern of consumption to purchased food has been found in global studies and other studies of Asian regions (Baker *et al.* 2020; Popkin & Ng 2022). It is important to note that although processed foods are capable of satisfying macronutrient sufficiency, research has shown that they carry a risk of micronutrient deficiency and food hygiene issues (Baker & Friel 2016; Hess *et al.* 2023).

Among protein-rich foods, the present study found a positive trend in consumption of animal-based foods in relation to income changes, especially meat products, whilst the trend was negative for nuts (Table 3). These patterns suggest risks of a negative health impact, including cardiovascular and other non-communicable diseases (Pan *et al.* 2022). A negative impact on the environment was also expected, because livestock enteric fermentation and manure management contribute almost 40% of agricultural GHG emissions in Indonesia (Republic of Indonesia 2024).

Table 2. PPH energy sufficiency values adjusted for food wastage

PPH* food groups	Sufficiency (kcal/cap/day)	Food waste (%)**	Total (kcal/cap/day)
Grains	1,050	4.4	1,097
Tubers	126	4.4	132
Animal-source food	252	4.0	262
Fats and oil	210	4.0	218
Seeds oil	63	1.6	64
Nuts	105	1.6	107
Sugar	105	1.6	107
Vegetables and fruits	126	8.6	137
Spices and beverages	63	1.6	64
Total	2,100		2,187

*Desirable Dietary Pattern (*Pola Pangan Harapan* (PPH)); **(FAO 2011), adjusted for income growth

Table 3. Income elasticities of food consumption by food group

Food categories	a*	b	c	n (R^2)**
Paddy rice	- 0.258	0.038	7.725	18 (88.25)
Grains	0.219	- 1.543	2.661	15 (80.77)
Tubers	- 0.158	-0.686	4.359	18 (20.89)
Sugarcane	- 0.681	0.746	6.952	15 (95.17)
Nuts	- 0.168	- 0.403	4.631	18 (77.99)
Vegetables	0.267	- 0.568	2.764	18 (27.47)
Fruits	0.712	- 0.986	1.191	18 (60.82)
Coffee, cacao, and tea	1.100	- 0.834	-1.292	15 (96.26)
Poultry (meat and egg)	0.887	- 0.775	0.916	17 (93.94)
Livestock (meat and dairy)	0.974	- 1.165	-1.635	14 (80.85)
Fish	0.248	- 0.324	2.898	17 (59.15)
Marine products excluding fish	0.934	- 0.615	-2.357	17 (83.11)
Animal and vegetable oil	0.186	- 0.163	4.802	18 (63.07)
Processed food	0.772	- 0.113	2.296	16 (85.29)
Restaurant and catering	1.267	- 1.822	0.925	19 (87.04)

*Food income elasticity based on calculation from Equation; **: R^2 in percentage; a: The food income elasticity estimated from Equation 1; b: The slope coefficient associated with price; c: The intercept term

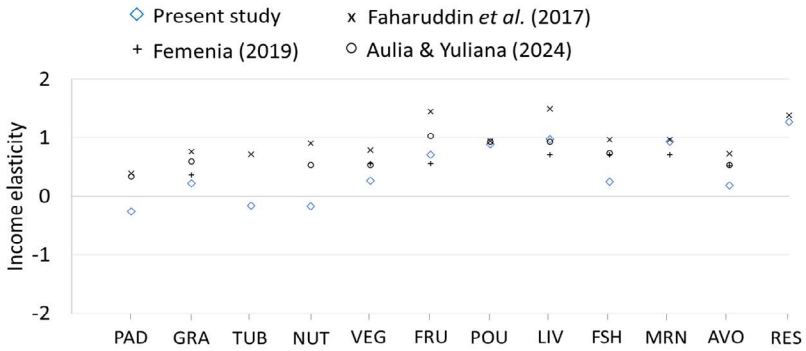
The present study also found positive income elasticity for fruits and to a lesser degree for vegetables (Table 3). Global projections suggest a higher demand for fruits and vegetables in the future, to accompany increasing incomes (USDA 2024). However, the lower income elasticity for vegetables and fruits compared with animal products suggests a continuing minor energy intake from these food groups in diet structures of the future.

To evaluate the findings, the results of the present study were compared with existing studies that measure the response of consumption patterns to income using food elasticities (Figure 1). The food income elasticities are mainly positive, which reflects increased consumption with increased income. Among the food groups with high income elasticity, our results were similar to the findings in other reports, particularly for livestock products, fruits, and ready-to-eat food from restaurants (Faharuddin *et al.* 2017; Femenia 2019; Aulia & Yuliana 2024).

Although there were differences in dataset periods and food categories that may have affected the variance among studies, all studies similarly found that food demand tends to react positively to income changes (Figure 1). This confirmed that rapid economic growth is likely to be the driver for the increasing future food consumption. Nonetheless, following the Engel-Bennet Laws, food elasticity is likely to become less sensitive to income, especially after a nation enters a high-income status (Femenia 2019).

The average dietary energy intake in Indonesia in 2023 was 2,116 kcal/cap/day. Various global projections suggest that food consumption in 2030 for developing regions and middle-lower income countries will range from 2,859 to 2,900 kcal/cap/day (Bodirsky *et al.* 2015; FAO 2018; OECD & FAO 2023). Using an estimated 5% annual increase in food consumption from these sources, the future projection for business-as-usual food consumption exceeds both the 2,100 kcal/cap/day National PPH level and the 2,500 kcal/cap/day planetary health diet (Figure 2a).

These expected increases in food consumption potentially risk national food security and the sustainable development agenda. After ratifying the Paris Agreement in 2016, the Government of Indonesia is endeavoring to become a net-zero emission country by 2060 (Government of Indonesia 2021). Under the



PAD: Paddy Rice; GRA: Other Grains; TUB: Tubers; NUS: Nuts; VEG: Vegetables; FRU: Fruits; POU: Poultry; LIV: Livestock; FSH: Fish; MRN: Marine; AVO: Animal and Vegetable Oils; RES: Restaurant; Note that sugar cane, coffee, cacao and tea, and processed foods are not included in this figure

Figure 1. Income elasticity for various food types, data from the present study and others (Faharuddin *et al.* 2017; Femenia 2019; Aulia & Yuliana 2024)

baseline conditions, it is anticipated that GHG emissions from agriculture will increase by 8% in 2030 compared to 2010, while the implementation of climate change mitigation policies is projected to reduce GHG emissions by 9% compared to the baseline (Republic of Indonesia 2022). Many studies have shown potential environmental benefits from implementing a healthy diet level (De Pee *et al.* 2021; Barrera & Hertel 2023). Similar studies for assessing climate mitigation policies and diet patterns together are needed for developing nations with large populations, like Indonesia.

Under the National Food Agency Law 11/2023, National PPH is considered as an ideal concept for balanced nutrition. Using the PPH scores, the proportions of energy substances, protein substances, and fiber/regulating substances were measured to represent diet quality. A national study showed that in 2019, none of the provinces in Indonesia achieved PPH energy adequacy standard and balanced nutrition (Randani *et al.* 2022). The necessary adjustments for each food group in the 2023 diet to comply with PPH recommendations were calculated (Figure 2a, Figure 2b). The changes included diversification of carbohydrate consumption from staple rice to tubers, increasing consumption of vegetables, fruits, and foods rich in plant-based protein, and reduction of cooking oil consumption and ready-to-eat foods from restaurants (Figure 2b).

Considering the positive income elasticity, a broader range of diet patterns compared to PPH is likely to be found in future consumption details. The positive income elasticity of cooking oil and ready-to-eat food suggests that in the future, it may even be necessary to reduce consumption closer to the PPH levels, compared to the current estimates (Figure 2b). Furthermore, the elastic behavior of the consumption of animal-based food groups and processed foods suggests potential increases in future consumption of these food groups beyond the PPH standards and the current diet levels.

It is likely that shifting the current diet pattern to conform to the PPH will require multi-actor policy intervention regarding food diversification and expansion of societal awareness of the PPH scores. For example, after the Mega Rice Project, the reliance on rice consumption intensified, fueled by the uniformity of food products due to industrialized farming (Mehraban & Ickowitz 2021). While food diversification initiatives have been accomplished in the past, for instance, replacing rice with local products like cassava, institutional challenges remained due to a mixed agenda for policy implementation and a lack of coordination among actors (Rozaki *et al.* 2023; Alwi *et al.* 2023).

To address the high income elasticity of red meat consumption, policies intended to diversify the source of protein are needed, especially to include more fish and marine products. While a major public movement to popularize fish consumption (*Gerakan Memasyarakatkan Makan Ikan* (GEMARIKAN)) has been implemented, the main challenge is ensuring the quantity and quality of fish and seafood production. A strategic plan from the Indonesia Ministry of Maritime and Fisheries, which

The current diet and the ideal Desirable Dietary Pattern (DDP) are based on the present study, while the projected energy intake for 2030 is derived from previous studies (Bodirsky *et al.* 2015; FAO 2018; OECD & FAO 2023); (b) Adjustments needed for the 2023 diet to achieve the ideal PPH energy structure

Figure 2. Changes in dietary consumption of various food types

optimizes aquaculture production and increases the value added to fish products, may represent a complementary intervention to achieve a healthy diet with appropriate protein intake.

Beyond nutrition, maintaining the amount of food consumption may be beneficial in reducing food waste. A relatively high share of food waste has been observed for animal-based food groups, vegetables, and fruits (Table 2). The likelihood of increasing future consumption patterns for these groups suggests a need to reduce food waste amounts both at the household level and in restaurants.

Lastly, additional health- and nutrition-related information is urgently needed to support policy making and to track the impact of altered food consumption patterns in the future. While the PPH score is suitable to assess the diversification of energy sources, it cannot fully capture overconsumption and the alarming share of processed food consumption. Studies of Indonesian food consumption have consistently found an unhealthy diet, which increases obesity (Oddo *et al.* 2019; Anyanwu *et al.* 2022; Pramono *et al.* 2023). Therefore, information about food elasticities and food consumption trends is needed for the development of suitable policy instruments, such as taxes and subsidies, to control healthy food distribution and consumption.

CONCLUSION

Income level positively affects consumption in most food groups. The highest food income elasticities were identified (in descending order) in food from restaurants and catering; coffee, cacao, and tea; animal-based foods, processed food; and fruits. Negative income food elasticity was found only in rice, tubers, sugarcane, and nuts. Suggested adjustments of the current diet to reach PPH criteria include diversification of carbohydrate sources from staple rice to tubers or starchy foods; increasing consumption of vegetables, fruits, and foods rich in plant-based protein; and reducing consumption of animal and vegetable oils and purchased foods. Increasing future consumption of most food groups based on current patterns and food income elasticity suggests an increasing deviation beyond the PPH standards. Mainstreaming the PPH agenda and strengthening food diversification policy are highly suggested to ensure that future food consumption is maintained at healthy levels. In addition, comprehensive studies covering climate mitigation policies and a dietary shift to an ideal PPH energy structure are needed to support the science-based policy toward a sustainable and healthy diet.

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DECLARATION OF CONFLICT OF INTEREST

The authors have no conflict of interest.

DECLARATION OF GENERATIVE AI IN SCIENTIFIC WRITING

The authors used Grammarly to assist with language editing and manuscript preparation, in addition to professional proofreading services. All suggested revisions were carefully reviewed and evaluated by the authors, who take full responsibility for the accuracy and final content of the manuscript.

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