DIETARY INTAKE AND GREENHOUSE GAS EMISSION IMPACT IN INDONESIA : A LITERATURE REVIEW

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ABSTRAK

Meningkatnya suhu global akibat degradasi lingkungan menjadi perhatian utama. Emisi gas rumah kaca (GRK), sebagian berasal dari konsumsi makanan manusia, memberikan kontribusi yang signifikan. Tinjauan ini secara sistematis mengidentifikasi studi di Indonesia yang meneliti hubungan antara konsumsi makanan dan dampak lingkungan, terutama GRK. Penelitian dari Science Direct dan Pubmed antara tahun 2002 dan 2022 dianalisis. Hasil penelitian menunjukkan peningkatan konsumsi makanan berbasis hewani dan olahan, dengan asupan makanan berserat tinggi yang rendah. Tingkat konsumsi saat ini sedikit melebihi target global, kemungkinan karena peningkatan konsumsi kelompok makanan dengan emisi GRK yang lebih tinggi. Transformasi pola makan, termasuk pilihan makanan dan jumlahnya, memainkan peran penting. Pergeseran ke arah makanan berbasis hewani dan olahan, ditambah dengan asupan makanan berserat tinggi yang terus-menerus rendah, berdampak pada lingkungan. Mengonsumsi makanan beragam dalam porsi yang dianjurkan sangat penting untuk meminimalkan GRK dari konsumsi makanan.

Kata kunci : asupan makanan, kelompok makanan, dampak lingkungan, emisi gas rumah kaca, GRK

ABSTRACT

Rising global temperatures due to environmental degradation are a major concern. Greenhouse gas emissions (GHGE), partly from human food consumption, contribute significantly. This review systematically identified studies in Indonesia examining the relationship between dietary consumption and environmental outcomes, particularly GHGE. Research from Science Direct and Pubmed between 2002 and 2022 was analyzed. Results indicate increased consumption of animal-based and processed foods, with low intake of high-fiber foods. Current consumption levels slightly exceed global targets, likely due to increased consumption of food groups with higher GHGE emissions. Dietary pattern transformation, including food choices and quantities, plays a crucial role. The shift towards animal-based and processed foods, coupled with consistently low high-fiber food intake, impacts the environment. Consuming a diverse diet in recommended portions is crucial for minimizing GHGE from food consumption.

Keywords ***:*** *dietary intake, food groups, environment impact, greenhouse gas emissions, GHGE*

INTRODUCTION

Increasing global temperature as part of environmental degradation becomes a global concern responded by an international conference in agreement to prevent the increment of temperature (*Ministry of Environment and Forestry,2021*). South East Asia level of environmental degradation reaches a linear increase indicating concerned stages to determine adaptation act and mitigation towards conditions (*ASEAN Secretariat, 2021*). The contribution of several sectors to an increased degree including greenhouse gas emission (GHGE) is also derived from human food consumption (Willits-Smith et al., 2020). Agriculture contributes to greenhouse gas emission as much as 10-12 percent globally, while Tukker et al. in 2016 stated food alone drives 20%-30% life-cycle environmental impact of final household consumption

(Tukker et al., 2011). Naturally, GHGE was emitted from human everyday life, but since the 1950s GHGE has increased drastically due to the advancement of an industry that is directly proportional to energy consumption. Greenhouse gas emissions are among the important contributor of climate change and environmental degradation by increasing the earth's degrees from accumulated gas components (*Ministry of Environment and Forestry,2021*), (Friel et al., 2009), (Gustafson et al., 2016).

Carbon dioxide is produced during land clearing and fossil combustion (*Ministry of Environment and Forestry,2021*). Nitric oxide is a main component of fertilizer for all kinds of plants. Animal food source and manure management produced a bulk of methane during its production process. The way of food intake contributes to GHGE was throughout production process, from hatchery or seeding, harvesting, packaging, and distribution, table and waste. In some developed countries, the significant contributor of GHGE from food sector is animal source food where the estimation contributes 18% of the total emission, where ruminants meat found to be 250 times higher than legumes (Tilman & Clark, 2014). It is proven by research conducted from data 2015 that broiler chicken only contribute around 3% of GHGE as opposed to beef cattle contributed 66.99% from total GHG emissions from livestock sector (Nugrahaeningtyas et al., 2018). The most contributors from animal source food lie in the production process, where they required more land and natural source to grow than plant source food (Friel et al., 2009).

A marked transition of dietary consumption to high animal source food burdening the food system as per explanation from Tilman & Clark argued GHG emission would increase 32% in 2050 if global diets change to more high meat protein, high demand of empty calories, and increase caloric per capita (Tilman & Clark, 2014). Indonesia is currently experiencing a dietary shift into the western diet as per level income increased. The changes in consumption patterns across Indonesia are shifting towards high consumption of energy, fat, animal products, and processed foods (Lowe et al., 2021a). In order to suppress environmental degradation, one of the remarkable efforts by each individual is put attention to their food consumption (Willett et al., 2019). Move towards more sustainable food consumption characterized by more plant based food and moderately consuming animal food sources are considered as more diet-related environmental conscious.

But currently, reduction of animal food consumption for purpose of environmental health can be jeopardizing health function among individuals especially Indonesia which acknowledged had a high prevalence of nutritional problems in all forms mostly caused by lack of nutritious food consumption (Ministry of Health, 2018). Increasing diet quality consumption by implement the suggested diet principle may offer the promising result in keeping health and environmental in lower negative impact. Suggested diet principle from Indonesia dietary guidelines was predicted for having lower gas emissions compared to dietary pattern of higher-income countries (Willett et al., 2019),(Behrens et al., 2017). The perceptible discrepancies are determined mainly by the different amount of food group consumption appear on each dietary pattern.

There are increase numbers of global commitment in reducing GHGE and Indonesia selves commits by 2030 cuts as much 29% by business-as-usual scheme (*Ministry of Environment and Forestry*, 2021). Food consumer has power to pushed ourselves by more aware in the food consumption and this may help the way forwarding of this action. Depicting our current consumption helps to gather additional information on where consumer consumption can be directed. The explanation of current food consumption and its impact to environment especially greenhouse gas emission, however, is needed. Despite the availability of reported evidence linking diet to adverse environmental health impacts dominated by non-asian countries (Temme et al., 2015),(Sjörs et al., 2017), the number of review and summary reports in Indonesia to date is limited. This may delay the inclusion of food consumption effect to

environmental impact awareness. Most dietary principles rely on systematic reviews and meta-analyses to curate scientific evidence, so a comprehensive review can help strengthen the evidence-based and advance this field. This literature review aims to identify and assess the findings of studies on environmental impact in Indonesia that have assessed the relationship between dietary consumption levels with environmental outcomes, especially greenhouse gas emissions.

METHOD

The literature search process was carried out on research articles including cross-sectional, case-control, cohort and experimental studies design within the last twenty years (2002-2022) using the electronic database available. The databases used in the literature search were Science Direct and Pubmed. The relevant research published before the period was also included and can be justified. Inclusion criteria were scientific articles that have gone through peer review, articles were in English.

Literature was excluded if it contained similar content to other articles or without a clear source of reference and if the study was also literature, systematic review, or meta-analysis. Literature was obtained with the several keywords “diet”, “intake”, “food consumption”, “environment impact”, “greenhouse gas emission”, “gas emission”, “carbon footprint”, “climate change”, and “Indonesia”. Article search technique by entering the words: diet AND greenhouse gas emission OR gas emission OR carbon footprint* AND Indonesia. The literature was used to answer several questions, namely “How was the food groups consumption in Indonesia?”, “What was diet-related greenhouse gas emission of Indonesia?”.

RESULT AND DISCUSSION

Literature Search

A total of 12 research articles results were included and further explained in tables below. Ten articles were analyzed according to dietary intake of Indonesia in table 1, while 2 articles were analyzed regarding diet-related greenhouse gas emission in table 2.

Dietary Intake Trend in Indonesia

Recently, lower-income countries rapidly changed their dietary consumption to expectedly more unhealthy directions. The changes are occurring in the structure of diet, physical activity, and obesity. Among modern societies in lower-income countries tend shifting their diet into more in sugar and refined foods, saturated fat, and low in fiber, recognized as the “western diet” (Popkin, 1994). According to Popkin's theory change in dietary patterns, people nowadays are on the 4th pattern called degenerative disease. This pattern introduces the conditions where more fat, sugar, processed food, and less fiber consumption. It also explains several characteristics such as obesity among elderly with many disabling conditions; typically work less active; growth in income and growing disparities; increased life expectancy; lower fertility rate; elderly proportion increase; infectious disease declining; and increased morbidity caused by diet pollution (Popkin, 1994).

Even though life expectancy increases and diet is transitioning to recent dietary patterns, it affects the quality of diet as a product of economic growth. In some cases, “westernization” of eating habits and environment exploration responsible for obesity and associated with chronic disease (Drewnowski & Popkin, 1997). Recent statistics of Indonesia showing positive trends in food security and malnutrition in Indonesia, in fact stunting resulting from severe malnutrition, remains high. The projections of food consumption demand in Indonesia picturing the increased consumption of rice and animal product but only in the highest income

group experienced declining rice consumption (Arifin et al., 2019). Health consequences of nutrition transition of high-risk food on chronic disease have long been known, especially among non-communicable diseases but the effect on environmental impact has been controversial and debatable (Fresán et al., 2019). The environmental impact of appearing dietary patterns transition depends on the magnitude of changes.

Table 1. Food Consumption in Indonesia

No	Title and Author	Year	Subjects	Method	Result
1	Associations of meal patterning, dietary quality, and diversity with anemia and overweight-obesity among Indonesian schoolgoing adolescent girls in West Java(Agustina et al., 2020a)	2020	School-going adolescent girls aged 12–19 years from three districts in West Java	Design: Cross-sectional Analysis: Dietary assessment was done by two days of non-consecutive day 24-hour food recall. Dietary Quality Index (DQI) for adolescent was used to assess dietary quality, and Dietary Diversity score (DDS) for diet diversity.	Anemic adolescent girls found lower animal-based food consumption compared to non-anemic girls significantly. They also tend to have lower dietary quality and diversity scores rather than another group.
2	The dietary diversity of rural Indonesian households declines over time with agricultural production diversity even as incomes rise(Mehraban & Ickowitz, 2021a)	2021	2785 households of rural farmers	Design: a longitudinal study from a comparison of 2000 and 2014/2015 consumption and production data Analysis: 7-day household food record to estimate household dietary diversity (HDDS)	Dominantly consumption of plant-based foods and fish declined over the period, the production also decrease except for fish. In contrast, consumption of meat, eggs, and dairy all increased as well as the production. The increment also found in consumption of processed foods consume inside and outside the house over the period.
3	Family eating habits among overweight adolescents in SMAN 16 Makassar(Nurhaedar et al., 2020a)	2021	64 senior high school children in Makassar	Design: Descriptive study Analysis: Family eating habits questionnaire was used to assess family eating habit	Nuts is the most common food type available at home, while wafer/biscuits is sweet food most prominent available at home.
4	Food Consumption Pattern and the Intake of Sugar, Salt, and Fat in the South Jakarta City—Indonesia(Andarwulan et al., 2021b)	2021	323 subjects from 100 households consist of school-age children (6-12 years), adolescents (13-18 years), and adults (>= 19 years) in South Jakarta	Design: cross-sectional study analysis: Two days weighed food records (weekday and weekend). There are two types of categorizations. Thirteen food categories, and there is classification according source food into processed, homemade, and street/restaurant/fast	Eggs and poultry products have been identified as the major sources of animal protein for all respondents. Adult respondents consumed more legumes and fruits.

				foods	
5	Micronutrient Intake and Perceived Barriers among Anaemic Pregnant Women in Aceh, Indonesia(Nahrisah et al., 2019a)	2019	158 pregnant women with mean age 28.5 years	Design: cross-sectional study analysis: the three days of 24 hours-food recall in non-consecutive of 2 weekdays and 1 weekend. Food consumed then classified into protein-animal-food, protein plant-food, vegetables, and fruits	All food groups (protein-animal-food, protein plant-food, vegetables, and fruits) reported consumed <3-4 portions/day. Fish and chicken eggs were the most frequent animal food, tofu and tempeh the most frequent from protein plant-food. Kale, spinach, cassava leaves, mustard greens are the most vegetables consume. Bananas, papaya, guava, snake fruit, orange, and mango were most dominant fruits item.
6	Poor dietary diversity and low adequacy of micronutrient intakes among rural Indonesian lactating women from Sumedang district, West Java(Rahmannia et al., 2019)	2019	118 lactating women with mean age 25 years old	Design: cross-sectional study analysis: Dietary assessment covered seasonal and culture differences along six months period of time. Dietary assessment used three nonconsecutive days using 12-hour home weighed food records and maternal 12-hour recall report 6 pm-6 am prior of time	Starchy staples especially rice were the most consumed food groups by lactating women. It followed by flesh foods/other meats and legumes, and nuts. while dairy and organ meats consumption was low
7	Processed and ultra processed food consumption pattern in the Jakarta Individual Food Consumption Survey 2014(Setyowati et al., 2018)	2018	1605 individuals classified into the following age groups: 0–4, 5–12, 13–18, 19–55, and >55 years	Design: cross-sectional study analysis: dietary data were collected using 24-hour food recall. Foods were categorized using the NOVA system as nonprocessed foods, processed ingredients, processed foods, and ultra processed foods.	Nonprocessed foods, processed ingredients, ultra processed foods and processed foods position accordingly the rank of most consumed. Inverse trend found, as age increase the consumption of ultra processed foods were decreased.
8	Relationship between dietary intakes and the double burden of malnutrition in adults of Malang, Indonesia: An exploratory study(Lee & Ryu, 2018)	2018	140 adults in Malang	Design: cross-sectional analysis: dietary data assessed using 24-hours food recall. The food groups consumed by the subjects fall into staple food, animal foods, milks, legumes, vegetables, and fruits.	Staple food and legumes were two food groups frequently consumed by the respondents, while rarely consume dairy and fruits food groups.

9	Rural-Urban Differences in Dietary Behavior and Obesity: Results of the Riskesdas Study in 10–18-Year-Old Indonesian Children and Adolescents(Nurwanti et al., 2019)	2019	155,645 adolescents aged 10 to 18 years	Design: cross-sectional study analysis: A simple questionnaire and food cards were used to assess the frequency and portions of food consumption of 10 food groups, including vegetables and fruits, sugar-sweetened beverages and foods, coffee consumption, caffeinated soft drinks and energy drinks, fatty and fried foods, refined carbohydrates, salty foods, instant noodles, preserved meats, and grilled foods.	The rural-urban living location is associated with discretionary foods consumption example sugar-sweetened beverages, coffee, caffeinated soft drink and energy drink, fatty fried foods, refined carbohydrate, preserved meat, and grilled foods whereas urban tend to have higher consumption than rural society. In agreement, vegetables and fruits consumption showed slightly higher percentage than rural adolescent.
10	The double burden of malnutrition and dietary patterns in rural Central Java, Indonesia(Lowe et al., 2021b)	2021	1521 respondents 3-94 years old from 4 villages	Design: cross-sectional study Analysis: Dietary assessment conducted using 24-hour food recall to capture recent dietary intake included amount, processing method, ingredients, and time consumption. While food frequency questionnaire was used to record variety of food group consumption.	There were three identified dietary patterns, and a indication of the dietary transition is arising. Characteristics of these diet were correlated with animal source food, confectionery, snack consumption and fat, protein, and externally purchased foods.

Diets themselves explain the effect of food consumption on health and importantly environmental impact. Table 1 explains there is a dietary transition that is apparent in urban and rural societies in Indonesia. The shifting typically had higher intake of animal-based foods and rose in prepared foods since the nutrition transition correlated with animal foods.(Lowe et al., 2021a) Some food groups that indicate declining were vegetables, fruits, legumes, cereals, tubers, and fish, while consumption of eggs, meat, and dairy all increased as did their production in rural communities (Mehraban & Ickowitz, 2021b). There is a difference in protein consumption between rural and urban societies, where in urban communities eggs, chicken, and poultry products have been identified as the major sources of animal protein (Mehraban & Ickowitz, 2021b),(Andarwulan et al., 2021a),(Nahrisah et al., 2019b). The higher-level protein intake is found in urban areas. Factors identified may trigger differentiation in both areas was migration of rural-to-urban indicate transform consumption from staple-food such as legumes and grains into more consuming energy-dense and high animal source food. Massive food advertisement contains fast foods, processed foods, and beverages consumption that are high in carbohydrates, sugar, fat, and salt is more extensive in urban societies. Consumption of packaged foods increased mainly ultra-processed food group along with the reduction of minimally processed foods and it also decreased as the older age (Andarwulan et al., 2021a). Among the adolescents group, wafer/biscuits were prominently found in most households both in and outside the home, and animal-based food was found lower in anemic adolescent girls as the anemic percentage is high in Indonesia (Agustina et al., 2020b),(Nurhaedar et al., 2020b). Total amount of added sugar was estimated at 9-10 teaspoons

and salt intake was 5.46-7.42 g/capita/day were the two of them identified as very typical to packaged food products. Among the age group, adults were more consume legumes and its products, fruits and fruit products (Andarwulan et al., 2021a). In pregnant women, animal protein, plant protein, vegetables, and fruits are consumed less than 3-4 portions/day (Nahrisah et al., 2019b).

National Food Agency of Indonesia released their analysis on food consumption of Indonesia from 2018 to 2022. The publication reported there is a slightly lower energy consumption at national level compared to standard energy requirement, still there are 11 provinces that had more energy consumption than standard. The same report also showed a steadily increase of protein by contribution from fish, poultry and eggs consumption, while deeper analysis showed ruminants consumption only experienced a little increase from 2018. Overall, energy and protein consumption of population are still in normal range compared to standard requirement given increase and decrease intake. During 2018 to 2022, fruit and vegetables consumption is fluctuated and consistently still far from Indonesia National Long-Term Plan, as well as other plant food source where relatively low consumption compared to standard requirement. The opposite finding identified in cereal, oil and fat consumption that in 5 years these two food groups consistently attained more than standard requirement (*National Food Agency*, 2023). In addition to that, the sales per capita of ultra-processed food and beverages referred to "products with additives and industrially processed ingredients that have been technically broken down and modified" increased as a doubled in 2024 compared to 2016 projected using synthesis review methodology. Given increased concern on their nutritional impact to population health status, the industries majorly contribute to environmental degradation of plastic waste (Moodie et al., 2021). The abovementioned food groups examined had a big role on nutrition-environmental course.

Indonesia delivered its national target on emission curbing ranged 29% to 41% by 2030. The commitment stated by Presidential Decree in 2021 of Implementation of Carbon Economic Valuation for the Attainment of Nationally Designated Target Contributions and Control of Greenhouse Gas Emissions in National Development. The profile of national greenhouse gas emission in 2020 from the biggest to the lowest as follow: energy, forest and other land use and peat land, agriculture, waste, and industrial process and product use/IPPU. Food production dominated from agricultural process, where at least contribute 98 GTCO2e in 2020 (*Ministry of Environment and Forestry,2021*). In addition to the government's commitment, various entities must also attend to their roles. This includes producers engaging in sustainable processes, as well as distributors who consider environmental aspects. In this manner, consumers' efforts to conscientiously considers food consumption in terms of both quality and quantity, prioritizing variety and balanced intake, will also contribute to the overall of gas emissions.

Diet-Related Environmental Impact

Understanding the environmental burden of food production and consumption is broadly defined by the effect on water, land, air, and biological ecosystem. The indicator of the environment proposed by Chaudary et al. covers ecosystem status, greenhouse gas emission (GHGE) per capita, blue water consumption per capita, land use per capita, non-renewable energy use per capita, and biodiversity footprint per capita (Chaudhary et al., 2018). Many publications stated that dietary composition influences GHGE. According to United Nations on Environment Programme (UNEP) in 2008, in Asia 70-80% of gas emission is produced from combined sectors of food and beverages, transportation, and construction industry (*UNEP*, 2008). According to official release, agriculture sector in Indonesia contribute around 5% in 2019 alone from total GHGE nationally (*Ministry of Environment and Forestry,2021*). We found two scientific publications related to food consumption with environmental impact

especially greenhouse gas emissions in Indonesia provided in Table 2. The studies use national dietary data to picture a whole nation. Table 2 explains there was a notable difference in annual GHG emissions among BMI groups, with normal and overweight reaching higher levels of greenhouse gas emission. The study found animal sources contributed to around 62% of the total emission across all BMI groups, although it was consumed in less amount than plant-based foods. plant-based generated lower GHG emissions compared to animal-based foods (Rahmi et al., 2020a). It is in line with studies in high-income countries that mentioning in most developed and high-income countries, the compatibility of dietary quality to greenhouse gas emission profile is finding an inverse correlation (Masset et al., 2014). High-income nations are characterized by high consumption of animal products. Animal product consumption accounts for 70% in high-income nations' diets compared to 22% in different counterparts (Behrens et al., 2017).

Table 2 also shows current Indonesian diet produced GHGE above the 2050 target as adapted from the EAT-Lancet commission report (de Pee et al., 2021). According to Behrens et al., the average Indonesian diet produces 1.6 KgCO2eq per day (Behrens et al., 2017). The multiplication in a year's consumption results in 152 Mt CO2eq per year or 10 percent of Indonesia's gas emissions (Vermeulen et al., n.d.). The most GHGE-intensive food group in the Indonesian current diet was rice because the consumption levels were high in agreement with a study by Rahmi e al. In 2000, Indonesia sector in agriculture contributed to 5% of national's GHGE, mainly from rice cultivation, direct N2O emissions, and enteric fermentation. The livestock in Indonesia is dominated by beef cattle, buffalo, and goats with enteric fermentation as an important emitter.

Table 2. Diet-Related Environmental Impact of Indonesian Consumption

No.	Title and Author	Year	Subjects	Method	Result
1	Environmental Impacts Related to Food Consumption of Indonesian Adults(Rahmi et al., 2020b)	2020	67159 adults aged 19-55 years old	design: cross-sectional Analysis: Data from the Total Diet Study assessed using 24-hour food recall, while data from National Basic Health Survey did not mention the method was used.	There was a prominent difference in annual greenhouse gas emissions between BMI groups, whereas normal and overweight reached higher levels of greenhouse gas emission. Animal sources contributed to around 62% of the total emission across all BMI groups, although it was consumed in less amount than plant-based foods. plant-based generated lower GHG emissions compared to animal-based foods.
2	Balancing a sustained pursuit of nutrition, health, affordability, and climate goals: exploring the case of Indonesia(de Pee et al., 2021)	2021	N/A	design: cross-sectional Analysis: Data from FAO Food Balance Sheet and Indonesia Household Income and Expenditure Survey household food expenditure. They modeled several diet scenarios and calculated the greenhouse gas emission of each scenario and current diet.	The current Indonesian diet had greenhouse gas emission above the 2050 target as adapted from the EAT-Lancet commission. According to GHGE production per kcal, bovine meat is the most intensive food groups, followed by sheep and goat meat, pig meat, eggs, and dairy. Rice content also contributed substantially to the GHGE of the diets, because the consumption levels were high

The identified dietary shift weighs on animal-based food consumption and processed food. The studies show our direction of consumption pattern probability will burden the future efforts on diminishing malnutrition and prevention of climate change at once. Staple food consumption dominated by wheat products is still at a high rate, animal-based foods rise while consumption of high fiber foods and plant protein foods were low as per explained by Rahmi et al and De Pee et al animal-based foods contribute to the highest GHGE per food items, but the studies also indicated the number of food groups consumed plays integral part determining GHGE production ("Nur Masripatin," n.d.). Therefore, the more diverse food consumption content of high fruits, vegetables, legumes, whole grains, high fiber, low meat, low refined sugar, low fat, and moderate dairy consumption was suggested to protect the environment (de Pee et al., 2021), and health by improving nutritional status.

The research articles used in this study applied standardized methods which could attribute to the accurate results, despite only a few studies linking food consumption and the environment. There were limitations from the research articles we reviewed, such as the studies mentioned did not provide the pattern of food group consumption as the main exploration; the secondary data on food intake used in the articles may not picture the actual consumption of respondents. It is required to carry out primary data collection and explore food groups' consumption linked with environmental impacts. Also, there were several limitations to this review. This review did not separate the age group and did not further identify the other environmental impact parameters of food consumption except the greenhouse gas emission.

CONCLUSION

The production of greenhouse gas emissions in Indonesia's food consumption is influenced by several factors, such as the increased consumption of food groups that emit relatively high greenhouse gasses than others. Second, the transformation of dietary pattern affected by the selection and amount food group being consumed as an indicator, and so with greenhouse gas emission impact. Indonesia's dietary consumption is indicating the direction of higher consumption of animal-based foods, prepared foods, and steadily low consumption high fiber foods. The typical dietary pattern explaining environmental impact assessed greenhouse gas emission was slightly higher than global targets, therefore consuming diverse food in recommended portions is suggested to strive at the least level of greenhouse gas emission from food consumption.

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