

National food development policies in Indonesia: An analysis of food sustainability and security

Saktyanu K. Dermoredjo^{1*}, Umi Mu'awanah¹, Agus S. Hidayat¹, Restu P. Hidayat², Woro Estiningtyas³, and Sahat M. Pasaribu¹

¹Research Center for Economics of Industry, Services, and Trade, National Research and Innovation Agency, Jakarta, Indonesia

²Indonesian Center for Agricultural Socio-Economic and Policy Studies, Ministry of Agriculture, Bogor, Indonesia

³Research Center for Climate and Atmosphere, National Research and Innovation Agency, Bandung, Indonesia

Abstract. Enhance the food development policy's effectiveness by preventing stakeholder overlap in Indonesia, covering grains, legumes, and tubers. The Food Sustainability Index (FSI) and the Global Food Security Index (GFSI) reveal the challenges of food development. FSI assesses food sustainability and nutrition, while GFSI analyses the causes of food vulnerability. The objective of this paper is to examine the achievement of indicators that can support future reference points for relevant ministries/agencies. This study employs descriptive analysis (through indicator analysis and ranking process), connected to the results of both FSI and GFSI analyses. Certain indicators within both systems have already aligned with the Food Development Policy. Indonesia's FSI index is 59, ranked 51 out of 78 countries; the GFSI index is 60.2, ranked 63 out of 113 countries. To improve FSI and GFSI targets, there is a need for better consolidation among ministries/agencies across various indicators. The Ministry of Agriculture, in partnership with other ministries, works towards sustainable agriculture, climate resilience, and women's empowerment. Collaboration, infrastructure development, and technology integration are vital for increasing competitiveness and achieving better socio-economic progress in both food sustainability and food security.

1 Introduction

Many international institutions develop indices measuring a country's progress in various aspects of development. These include the Global Competitiveness Index (GCI) by the World Economic Forum, Global Hunger Index (GHI) by IFPRI, Ease of Doing Business Index by the World Bank, Food Sustainability Index (FSI) by EIU and Barilla Center for Food & Nutrition, Food Price Index (FPI) by FAO, Food Security and Vulnerability Atlas (FSVA) by WFP, and Global Food Security Index (GFSI) by EIU. Notably, FSI and GFSI are relevant to food system development.

* Corresponding author: saktyanuadi@gmail.com

FSI and GFSI assess food system sustainability and food security. FSI gauges food system sustainability, including hunger and nutrition. GFSI investigates global food system dynamics, helping countries pinpoint food security policy priorities. Both indices involve government and society sectors. Pertaining to Indonesia's rice-centric context [1,2]: a) rice supply is vital for national food security, b) stable, affordable rice prices enhance food affordability, c) sustainable, eco-friendly rice farming is crucial, and d) as a primary carbohydrate source, rice significantly affects Indonesia's nutrition.

In 2021, Indonesia was ranked 51st out of 78 countries in the FSI, while in 2022, Indonesia's rank in the GFSI was 63rd out of 113 countries [3,4]. These indicate that Indonesia needs to improve its FSI and GFSI. This requires a deep understanding and reconsideration of policies aligned with the indicators in these indices to enhance Indonesia's food security and sustainability. Therefore, the objective of this paper is to evaluate the achievement of indicators that can provide future reference points for relevant ministries/agencies.

2 Methodology

The government has adopted a policy of enhancing the agriculture sector for sustainable food production and encouraging cooperation in the national food system to ensure high-quality and safe food. This includes creating good policies, providing stable food access, efficient distribution, and food assistance to vulnerable households. Evaluating the use of the Food Security Index (FSI) and Global Food Security Index (GFSI) in shaping Indonesian agricultural policies is crucial (see Fig. 1). Harmonizing policies from different sectors is necessary to prevent conflicts or redundancies. Additionally, supporting policies should be practical and easily implemented by stakeholders to enhance agricultural development in Indonesia.

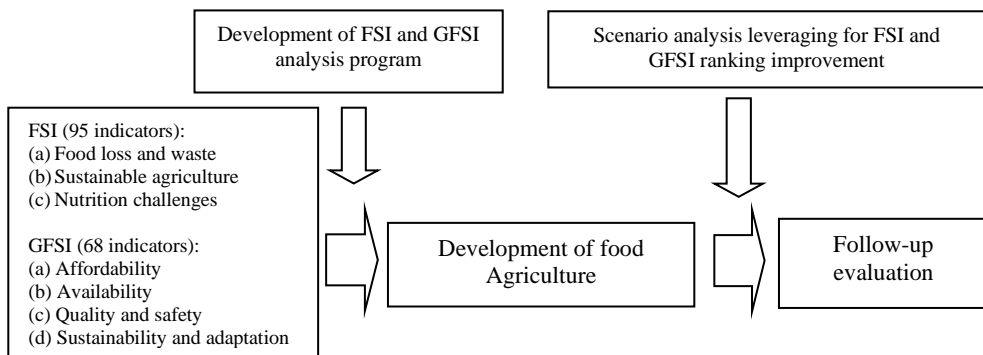


Fig. 1. Framework for utilising FSI and GFSI in Indonesian food agriculture development policy.

According to the specifications of FSI and GFSI, FSI data is supported by 95 indicators, while 68 indicators support GFSI data. A different number of countries use each of these indicators. FSI uses a sample of 78 countries, whereas GFSI uses 113 countries, representing global conditions. FSI consists of three main pillars: (a) food loss and waste, (b) sustainable agriculture, and (c) nutritional challenges, while GFSI also consists of four main pillars: (a) affordability, (b) availability, (c) quality and safety, and (d) sustainability and adaptation [3,4].

In assessing indicators for country rankings, a sequential process is followed: (a) Indicators are evaluated and ranked, (b) highest gets 100, lowest gets 0, (c) weights determine indicator scores, (d) graded scores yield a composite score for ranking. FSI and GFSI analysis involves (1) using data from their respective websites and (2) altering variables based on indicators. Microsoft Excel with macros is the tool. Both FSI and GFSI assign 0-100 scores

to indicators, either sequentially from lowest to highest or vice versa, based on their significance. These scores then form composite indices based on the respective weights.

3 Results and discussion

3.1. Performance of FSI and GFSI in rice-producing countries

Every country must prioritise domestic food security while contributing to global efforts to enhance food security. This will ensure an adequate and sustainable food supply for the world's population. Table 1 shows the rankings of the FSI and GFSI for several rice-producing countries, along with details of the scores for various components assessed in these indexes. This comparison can guide policy decisions and interventions to improve food security in each country. They can also foster international cooperation by identifying common challenges and sharing solutions. There is a relationship between FSI and GFSI because FSI is one of the factors used in calculating GFSI. FSI is closely related to food loss and waste, sustainable agriculture, and nutritional challenges. These factors are also considered in GFSI, along with other factors such as food availability, quality, safety, and sustainability. Therefore, countries with high FSI scores usually also have high GFSI scores, indicating better overall food security.

Table 1. Overall FSI and GFSI ranking and score breakdown 2021 of rice-producing countries.

Country	FSI (78 countries)					GFSI (113 countries)					
	Overall ranking	Overall score	Food loss and waste	Sustainable agriculture	Nutritional challenges	Overall ranking	Overall score	Affordability	Availability	Quality and safety	Sustainability and adaptation
Indonesia	51	59.0	55.3	56.4	65.3	63	60.2	81.4	50.9	56.2	46.3
Vietnam	53	58.5	54.8	59.7	60.8	46	67.9	84.0	60.7	70.2	52.2
Philippines	47	59.6	48.0	67.9	63.1	67	59.3	71.5	55.2	65.3	41.8
Egypt	43	60.9	54.8	64.2	63.9	77	56.0	65.2	54.2	45.9	55.8
Japan	2	75.7	78.9	68.1	80.1	6	79.5	89.8	81.2	77.4	66.1
China	33	65.3	64.1	55.6	76.3	25	74.2	86.4	79.2	72.0	54.5
India	38	61.5	71.9	56.2	56.3	68	58.9	59.3	62.3	62.1	51.2
Brazil	41	61.2	60.5	57.6	65.7	51	65.1	63.0	58.6	83.9	56.3
Average	39	62.3	58.4	64.2	64.5	57	62.2	69.0	57.8	65.9	54.1

Source: [3,4]

Japan is one of the countries with the highest FSI and GFSI scores. This is due to sustainable agriculture practices, low food loss and waste, and high food quality and safety in the country [5]. As a result, Japan has a very high level of food security. Countries like Indonesia, Vietnam, and the Philippines have lower FSI and GFSI scores. These countries face many challenges in practising sustainable agriculture, achieving low food loss and waste, and improving nutritional foods. China and India have higher GFSI scores than their FSI scores, indicating that despite challenges in food security, they may have better levels of food availability, quality, safety, and sustainability in their food systems. Brazil also has a high GFSI score, primarily due to high food availability and sustainability, although there are still challenges in sustainable agriculture.

The global improvement in the FSI (Food Sustainability Index) and GFSI (Global Food Security Index) indicates an increase in food security levels in various countries. This can depict an increase in food production and availability, which, in turn, can impact food prices

and levels of hunger in society. The improvement in GFSI also reflects increased stability and accessibility of food in the global market, which can affect a country's agricultural export and import activities. On the other hand, a decrease in GFSI can indicate instability in the global food supply, potentially affecting the agricultural economy and national food security [6,7].

In the context of the relationship between FSI and GFSI, Table 2 provides an overview of developments in rice-producing countries and efforts to understand the correlation between the increase or decrease in FSI and GFSI indices. For instance, Indonesia has consistently increased its FSI value from 50.77 in 2016 to 59.00 in 2021, while the GFSI value has also increased from 60.0 in 2016 to 60.2 in 2021, indicating national improvements in food security. Vietnam has also shown an increase in GFSI values, rising from 64.0 in 2016 to 67.9 in 2021, reflecting global improvements in food security. From 2011 to 2021, rice production in Vietnam increased from 42.4 million tons to 43.85 million tons. Additionally, the Philippines recorded an increase in GFSI values from 57.5 in 2016 to 59.3 in 2021, indicating global improvements in food security.

Table 2. Scores and rankings of FSI and GFSI from 2016/2017 to 2021 for some rice-producing countries.

Country	FSI						GFSI					
	Overall ranking			Overall score			Overall ranking			Overall score		
	2021 (78)	2016 (25)	↑↓	2021	2016	+-	2021 (113)	2017 (113)	↑↓	2021	2017	+-
Indonesia	51	21	21(25) to 51(78)	59.0	50.77	+8.23	63	61	↑2	60.2	60.0	+0.2
Vietnam	53	n/a	n/a	58.5	n/a	n/a	46	55	↑9	67.9	64.0	+3.9
Philippines	47	n/a	n/a	59.6	n/a	n/a	67	72	↑5	59.3	57.5	+1.8
Egypt	43	23	23(25) to 43(78)	60.9	48.85	+12.05	77	73	↑4	56.0	53.2	+2.8
Japan	2	2	2(25) to 2(78)	75.7	66.66	+9.04	6	10	↑4	79.5	78.5	+1.0
China	33	13	13(25) to 33(78)	65.3	57.50	+7.80	25	34	↑9	74.2	70.4	+3.8
India	38	25	25(25) to 38(78)	61.5	43.17	+18.33	68	60	↓8	58.9	60.8	-1.9
Brazil	41	20	20(25) to 41(78)	61.2	51.86	+9.34	51	65	↓14	65.1	69.9	-4.8
Average	39	12	12(25) to 39(78)	62.3	57.10	+5.20	56/57	56/57	xxx	62.2	61.6	+0.6

Source: [3,4]

Similarly, Egypt recorded an increase in the FSI value from 48.85 in 2016 to 60.9 in 2021, indicating improved food sustainability. The GFSI value also increased from 53.2 in 2016 to 56.0 in 2021, reflecting global improvements in food security. From 2011 to 2021, rice production in Egypt decreased from 5.68 million tons to 4.84 million tons. This quantity is supported by the fact that rice supply in Egypt decreased from 57.58 kg/cap/year to 48.16 kg/cap/year. Japan has shown improvement in both FSI and GFSI values from 2016 to 2021, indicating enhanced national and global food sustainability/security. Meanwhile, China noted an increase in the FSI value from 57.50 in 2016 to 65.3 in 2021, reflecting improved food sustainability, and the GFSI value also increased from 70.4 in 2016 to 74.2 in 2021, indicating global improvements in food security.

On the other hand, India saw an increase in the FSI value from 43.17 in 2016 to 61.5 in 2021, indicating improved food sustainability, while the GFSI value decreased from 60.8 in 2016 to 58.9 in 2021, showing a global decline in food security. Brazil recorded an increase in the FSI value from 51.86 in 2016 to 61.2 in 2021, indicating improved food sustainability. Still, the GFSI value decreased from 69.9 in 2016 to 65.1 in 2021, showing a global decline in food security.

Overall, in aggregate terms, the average FSI values increased from 2016 to 2021, reflecting global improvements in food sustainability, and the average GFSI values also increased during the same period, indicating enhanced global food security.

3.2 Leveraging ranking improvement

To improve Indonesia's rankings in FSI and GFSI, the Indonesian government has promoted specific policies to achieve a score that equals the world average. Such an achievement was attained in 2016. The indicators targeted to be improved are listed in Tables 3 and 4.

3.2.1 FSI for Indonesia

Table 3 shows that the Ministry of Agriculture of the Republic of Indonesia plays a strategic role in improving food sustainability. These indicators are interconnected, which is crucial in achieving sustainable food security [8]. The policies being implemented encompass the following aspects [9–11]: (1) support for Agriculture in Indonesia, focusing on market prices and food self-sufficiency; (2) the National Food Agency (BAPANAS): stabilising prices and ensuring food availability; (3) the Ministry of Agriculture's five key focus areas: developing the food system; (4) investment in rural areas of Indonesia: achieving inclusive and sustainable economic growth.

Table 3. List of leverage options for ranking Indonesia's FSI indicators.

No	Indicators	Note/Ministry/Agency
1	The participation rate of youth in farming (%) is 11.3 to 12	Back in 2016, the Ministry of Agriculture
2	Food loss strategy (score) 2 to 1.03 ; storage solutions (score) 0 to 0.41 ; quality of the road infrastructure (score) 1 to 2.06 ; food waste strategy (score) 1 to 0.87 ; food waste targets (score) 1 to 0.53 ; market-based instruments (score) 1 to 0.26 ; food waste legislation (score) 0 to 0.99 ; food waste agency (score) 0 to 0.35 ; voluntary agreements (score) 0 to 0.26 ; private institutions (score) 2 to 1.56 ; food waste research (score) 1 to 0.65 ; arable land under organic agriculture as a % of agricultural land (%) 0.4 to 3.81 ; land diverted to animal feed and biofuels (%) 2.77 to 3.27 ; permanent subsidies (score) 0 to 0.23 ; capped subsidies (score) 0 to 0.44 ; regressive subsidies (score) 0 to 0.40 ; quality of animal welfare regulation (score) 3 to 3.83 ; gross production value / agricultural land area (USD / ha) 2,010.61 to 3,000.40 ; distribution of agricultural holders by sex (% female) 8.8 to 17 ; working conditions of workers in agriculture and along the value chain (score) 1 to 2.67 ; % of rural population with a bank account (47 to 63.75); % of rural population that made/received digital payments (33.43 to 63.75); availability of insurance for farmers (score) 1 to 2.12 ; sovereign debt risk (normalised score) 50 to 48.01 ; opportunities for investing in sustainable agriculture (score) 0 to 1.19	World average; Ministry of Agriculture
3	Percentage of cultivated land equipped for irrigation (%) 3.58 to 4.12 ; policies for sustainable water management (0-1) 0 to 0.54	World average; Ministry of Agriculture /Ministry of Public Works and Public Housing of Republic of Indonesia
4	Agricultural water withdrawal as % of total renewable water resources (%) 9.4 to 137.08 ; baseline and groundwater stress (score) 2.22 to 4.48	Back in 2016, the Ministry of Agriculture /Ministry of Public Works and Public Housing of the Republic of Indonesia
5	Fish stocks overexploited or collapsed (% of total catch) from 21.16 to 25.02	World average; Ministry of Marine Affairs and Fisheries
6	Degree of property rights protection (score) 3 to 3.71 Land acquisition protection (score) 0 to 0.72	World average; Ministry of Agriculture / Ministry of Home Affairs / Ministry of Agrarian Affairs and Spatial Planning
7	Environmental biodiversity and protection of natural habitats (score) 75.63 to 87.20 ; deforestation (ha/year) 28,001,915 to 25,649,754	World average; Ministry of Environment and Forestry

Table 3. List of leverage options for ranking Indonesia's FSI indicators (continued)

No.	Indicators	Note/Ministry/Agency
8	Government R&D expenditures (% of GDP) 0.23 to 1.11	World average; National Research and Innovation Agency
10	GHG emissions from agriculture (Gg CO ₂ eq) 177,872.17 to 6,679.63 ; GHG emissions per 1,000 hectares of agricultural land (Gg CO ₂ eq/1,000 ha) 2.86 to 2.46 ; Animal emissions (Gg CO ₂ eq) 40,121.58 to 33,496.72 ; fertilizer emissions (Gg CO ₂ eq) 41,945 to 19,059.50 ; net emissions/removals (CO ₂ eq) from land use total (Gg CO ₂ eq) 969,280.73 to 21,431.12	World average; Ministry of Agriculture/Ministry of Environment and Forestry
12	Prevalence of undernourishment (% of population) (%) 6.5 to 6.3 ; vitamin A deficiency (% of general population) (%) 19.62 to 19.4	Decrease based on 2016; Ministry of Health
13	% of stunted children under five years old (height for age) 30.8 to 15.50 ; the prevalence of wasting, weight for height (% of children under 5) (%) 10.2 to 3.99 ; the prevalence of underweight (% of adults) (%) 12.54 to 5.40 ; Prevalence of anaemia among women of reproductive age (% of women ages 15-49) (%) 31.2 to 25.88 ; access to an improved water source (%) 34.84 to 65.86 ; life expectancy at birth, total (years) 71.72 to 73.71 ; healthy life expectancy (HALE) (years) 62.8 to 64.65 ; the prevalence of overweight in children (5-19 years of age) (%) 31.2 to 11.50	World average; Ministry of Health

Fluctuations in a single indicator can trigger a ripple effect, either beneficial or detrimental, on interconnected factors. Thus, there is a critical requirement for comprehensive and integrated agricultural and food security policies that consider these multifaceted dimensions to attain the desired objectives. These collaborative efforts underscore the significance of adopting a holistic approach to sustainable agriculture. Through concerted actions, these ministries can address the interrelated challenges within agriculture, encompassing issues such as water management, land rights, and environmental impacts. This results in more effective policies and actions and ensures that enhancements in one aspect positively influence others, thereby contributing to the overall sustainability of the agricultural sector. Indonesia's national policy on sustainable agriculture is a complex issue that involves various ministries and sectors. Several key points are included in this policy framework, such as food sovereignty and food self-reliance outlined in the 2012 Food Law. The BAPANAS was established to maintain food price stability, availability, and safety. Inter-ministerial collaboration and efforts to support sustainable and inclusive agricultural value chains are also integral to this approach. Additionally, government strategies include climate change mitigation efforts.

Moreover, several standalone ministries of the Republic of Indonesia also have important roles in improving the FSI, such as the National Research and Innovation Agency, the Ministry of Environment and Forestry, and the Ministry of Health, which focus on the relationship between ecology, economics, and human well-being. This will lead to the progress of a country or region in achieving sustainable development goals, as outlined in the Sustainable Development Goals (SDGs) initiated by the United Nations [12].

3.2.2 GFSI for Indonesia

Table 4 shows that the Ministry of Agriculture of the Republic of Indonesia plays a strategic role in improving the GFSI score. The primary focus of this ministry is on early-warning measures/climate-smart agriculture [13], which is closely related to the national agricultural adaptation policy and sustainable agriculture. All of these efforts centre around addressing the impacts of climate change and promoting sustainable farming practices [14]. Access to Extension Services also supports empowering women farmers by providing them with knowledge and training, enabling them to contribute more actively to agriculture [15]. Other

Indonesian indicators, such as the food security strategy, national nutrition plan or strategy, and food safety mechanisms, are linked to the well-being of society and food security [16]. These are also essential goals in agriculture and food security. For example, food security strategies can influence dependency on chronic food aid, while dietary availability of zinc and protein quality can impact the overall nutrition and health of the population [17]. Share of non-starchy foods and share of sugar consumption are also related to public health issues, as a healthy diet can support balanced nutrition and reduce the risk of nutrition-related diseases [18].

Table 4. List of leverage options for ranking Indonesia's GFSI indicators.

No	Indicators	Note/Ministry/Agency
1	Access to extension services (qualitative rating 0-2; 2=best) 1 to 1.58 ; community organisations (qualitative rating 0-2; 2=best) 1 to 1.67 ; empowering women farmers (qualitative rating 0-2; 2=best) 0 to 0.57 ; land degradation (proportion of land that is degraded over the total land area -%) 21 to 19.79 ; early-warning measures / climate-smart agriculture (qualitative rating 0-2; 2=best) 0 to 0.88 ; national agricultural adaptation policy (qualitative rating 0-2; 2=best) 0 to 2 ; sustainable agriculture (qualitative rating 0-2; 2=best) 1 to 1.27 ; risk management coordination (%) 18 to 39.73	World average; Ministry of Agriculture
2	Access to agricultural technology, education, and resources (%) 0.0088 to 0.02; Commitment to innovative technologies (Qualitative rating 0-3; 3=best) 0 to 1.65	World average; National Research and Innovation Agency
3	Irrigation infrastructure (%) 10.79 to 10.84 ; Road infrastructure (Qualitative rating 0-4; 4=best) 1 to 1.82 ; Agricultural water risk – quality (Risk rating 1-5, where 5=highest risk.) 5 to 3.34	World average; Ministry of Public Works and Public Housing
4	Dependency on chronic food aid (Qualitative rating 0-1; 1=best) 0 to 0.65 ; Food security strategy (qualitative rating 0-1; 1=best) 0 to 0.60 ; share of non-starchy foods (% non-starchy foods in dietary consumption) 32 to 52.46 ; share of sugar consumption (%) 8.5 to 9.25 ; national nutrition plan or strategy (qualitative rating 0-1; 1=best) 0 to 1 ; dietary availability of zinc (mg/person/day) 6 to 8.46 ; protein quality (grams) 49.1 to 70.15 ; food safety mechanisms (score 0-100, 100 = best) 60 to 68.67	World average; National Food Agency/ Ministry of Agriculture
5	Corruption (qualitative rating 0-4; 4=highest risk) 3 to 2.42	World average; Corruption Eradication Commission
6	Gender inequality (index score 0-1, where 0=most equal) 0.48 to 0.34	World average; Ministry of Women Empowerment and Child Protection
7	Temperature rise (Index score, 0=least vulnerable) 140.7 to 71.63 ; Drought (Risk rating 0-4, where 4=highest risk) 3 to 2.29 ; Flooding (% change in flood hazard) 5.75 to 4.90 ; Sea level rise (Index score 0-1, where 0=least vulnerable) 0.02 to 0.03	World average; Meteorology, Climatology, and Geophysical Agency
8	Grassland (net emissions/removals (co2), gigagrams) 12,150.9 to 470.50 ; forest change (change in forest area as % of total land area) - 5.94 to -0.66 ; commitment to managing exposure (qualitative rating 0-13, where 0 = no commitments to 13 = full commitment) 2 to 5.03	World Average; Ministry of Environment and Forestry
9	Climate finance flows (USD per capita; in 2019 dollars) 6.33 to 17.95	World average; all ministry

Most of the other indicators are largely beyond the control of the Ministry of Agriculture. However, policies issued by the ministry can impact food sustainability, ultimately affecting the agricultural sector. For instance, well-maintained irrigation and road infrastructure can reduce risks related to water availability and access for agriculture. Good water quality is also crucial for sustainable farming [19]. Additionally, corruption can undermine the management of infrastructure, including irrigation and road infrastructure, as well as the allocation of funds meant to address climate change risks. Corruption can also affect the agricultural sector and the management of natural resources, impacting food security and the environment [20].

Furthermore, gender inequality can affect women's access to agricultural resources and infrastructure [21]. Addressing climate change also needs to consider the gender differences in vulnerability and adaptation capacity. Gender and climate inequality intertwine, impacting agriculture and adaptation. Women face climate's harshest effects, deepening gender disparities. Their pivotal roles in resource access and agriculture make them more vulnerable during environmental crises. Yet, women can drive adaptation as change agents. Integrating gender considerations into adaptation ensures effectiveness, equity, and inclusive decision-making. In agriculture, women form a substantial workforce, bearing heavier burdens in climate-induced male outmigration scenarios. Moreover, the impacts of climate change can affect agriculture, infrastructure, and community resilience [22]. Good infrastructure can help reduce flood impacts, while resilience to drought needs to be enhanced with efficient irrigation. Regarding the environment, changes in land cover and deforestation can affect water cycles, climate regulation, and agricultural sustainability. Proper forest management can reduce greenhouse gas emissions and support sustainable agriculture [23]. Adequate climate funding can support climate-resilient infrastructure projects, sustainable agriculture, and climate change mitigation efforts. This commitment is crucial for coordinating efforts to address climate change, including the development of climate-resilient infrastructure, protection against extreme impacts, and safeguarding natural resources [24].

3.2.3 Enhancing Indonesia's FSI and GFSI

The analysis results indicate several key points regarding efforts to enhance the FSI (Food Sustainability Index) and GFSI (Global Food Security Index) indices, where the targeted scenario aims to improve Indonesia's FSI ranking from 51 to 42, surpassing countries such as Romania, Egypt, Bangladesh, Malta, Jordan, Philippines, Saudi Arabia, United Arab Emirates, and Russia. Furthermore, the targeted scenario aims to improve Indonesia's GFSI ranking from 63 to 52, surpassing countries like Bolivia, the Dominican Republic, Argentina, Belarus, El Salvador, Morocco, Guatemala, South Africa, Honduras, Serbia, and Tunisia. These improvements can be achieved through collaboration among relevant institutions, primarily by promoting the following agendas.

(1) *Sustainable agricultural development.* One crucial aspect of improving both FSI and GFSI indices lies in the development of sustainable agriculture [25]. This can be achieved by increasing operational scale through upstream-downstream integration and incorporating technology within the scope of business entities. These measures are essential for enhancing the competitiveness of agricultural commodities, both for domestic consumption and export purposes.

(2) *Significance of staple food farming.* Staple food farming, particularly rice cultivation, plays a pivotal role in the context of sustainability. This encompasses aspects such as human resources, support for organic-based agricultural infrastructure, balanced dietary patterns, environmental plant balance, and macro indicators that support socio-economic issues, considering biological and demographic factors [26–33]. These points underscore the importance of interagency collaboration and heightened attention to staple food farming, particularly rice production, in the context of sustainability. This involves various factors, including technology, environmental considerations, and socio-economic aspects, all of which must be considered to improve the FSI and GFSI indices.

4. Conclusions and policy recommendations

Countries must prioritise domestic food security while contributing to global efforts. The Food Sustainability Index (FSI) and Global Food Security Index (GFSI) rankings offer insights into food security. Japan excels due to sustainability. Indonesia, Vietnam, and the

Philippines have faced sustainability and nutritional challenges. China and India show better food availability. Brazil scores high but struggles with sustainability. Both FSI and GFSI values improved from 2016 to 2021, indicating global food sustainability and security improvements.

While the role of the Ministry of Agriculture is pivotal in food availability and food security issues, the effort to achieve better scores for FSI and GFSI needs substantial collaboration with other institutions. The collaborative efforts with related ministries and agencies are vital for sustainable agriculture, climate change, and women's empowerment in agricultural development. Some important measures like climate-smart agriculture, infrastructure development, and infrastructure maintenance can enhance FSI and GFSI scores. Likewise, collaboration and technology integration can be important instruments to increase food sustainability competitiveness and socio-economic stability factors.

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