Drivers, Trade-Offs and Synergies of Food Security under SDG 2: An Integrative Review and Lessons for Malaysia

Nur Hidayah Zaini*, Wan Hasmat Wan Hasan, Fariha Aiza Ramly, Ainaa Idayu Iskandar, Afzan Nor Talib

Faculty of Business and Management, Universiti Teknologi MARA, Malaysia

***Corresponding Author**

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ABSTRACT

Food security is central to Sustainable Development Goal 2 (Zero Hunger), but it is shaped by forces that cut across economic, social and environmental goals. This review aimed to identify the positive and negative drivers of food security, map how SDG 2 interacts with other SDGs, and assess what this evidence means for Malaysia. The integrative review followed Whittemore and Knafl's five-stage method and was reported using PRISMA 2020. A structured search of Scopus and PubMed, combined with a preliminary ScienceDirect search, identified 23 peer-reviewed studies published between 2020 and 2026. Study quality was appraised with the Hawker et al. (2002) tool, and findings were synthesised thematically under four themes: positive drivers, negative drivers, SDG interlinkages and Malaysian evidence. Economic growth, agricultural productivity, well-designed interventions, access to water and greater gender and income equality strengthen food security. Cereal import dependency, food price inflation, trade and income shocks, climate variability and natural resource depletion weaken it. SDG 2 shows synergies with SDGs 1, 3, 5, 6, 10 and 12. Its links with SDGs 7, 13 and 15 depend on the pathway chosen: expansion-based production creates trade-offs, while efficiency-, resilience- and clean-energy-based pathways create synergies. Malaysian studies point to declining rice production efficiency, climate risks to rice and coastal areas, exposure to rice imports, competition between energy and farmland, rising food waste and food insecurity among excluded groups. Because the evidence comes from varied designs and settings, findings are presented as patterns rather than pooled effects. The review proposes an evidence-linked conceptual framework and a research agenda for Malaysia.

Keywords: food security, SDG 2, sustainable development goals, Malaysia, integrative review

INTRODUCTION

Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food (FAO, 2008). The 2030 Agenda places this aim at the centre of Sustainable Development Goal 2 (SDG 2), which commits countries to end hunger, achieve food security, improve nutrition and promote sustainable agriculture (United Nations, 2015). Progress has stalled since 2015, and hunger remains above pre-pandemic levels (FAO et al., 2024).

SDG 2 cannot be achieved in isolation. Food systems depend on income, water, energy, land and climate, so progress on one goal can support or undermine progress on another (Nilsson et al., 2016; Pradhan et al., 2017). Food systems are responsible for a large share of greenhouse gas emissions, deforestation and freshwater use, which binds food security to environmental goals in both directions (Saccone & Vallino, 2022). Yet many of these interactions remain empirically unexplored, and scholars have called for each goal to be analysed explicitly in connection with the others (Saccone & Vallino, 2022).

A recent body of work has begun to answer this call. Studies have quantified the economic, trade and price drivers of food security in Europe (Rabbi et al., 2025), the climate and resource pressures on cereal production in East Africa (Werku et al., 2026), and the effects of international sanctions on SDG 2 globally (Liu & Qiu,

2024). Others have examined the ecosystem foundations of food, water and energy security (Muhirwa et al., 2025), land-use trade-offs between food and renewable energy (Pandey et al., 2025), and the food–energy nexus in urban poverty (Shupler et al., 2021). These studies use different methods and settings, and their findings have not been brought together.

Malaysia offers a useful case for applying this evidence. As an upper-middle-income country, it generally maintains adequate national food supplies, yet food insecurity persists among low-income households, Orang Asli communities, students and older adults (Sulaiman et al., 2021). Malaysian research has examined rice self-sufficiency (Nodin et al., 2022), agri-food supply networks (Abdul Ghani, 2026), food waste (Nazibudin et al., 2025) and excluded groups (Qandeel et al., 2026). These studies each address one part of the food system, and none links them to the drivers identified internationally.

This review addresses that gap. Its objectives are to:

1. Synthesize recent evidence on the positive and negative drivers of food security under SDG 2.
2. Identify the trade-offs and synergies between SDG 2 and other SDGs.
3. Map the Malaysian evidence against these international findings.
4. Propose an integrated conceptual framework and a research agenda for Malaysia.

The review contributes by bringing economic, environmental and social evidence on SDG 2 into one framework. It also translates international findings into specific lessons and research priorities for Malaysian food security policy.

METHODOLOGY

This section describes how the review was conducted. It follows the five stages of the integrative review method set out by Whittemore and Knafl (2005): problem identification, literature search, data evaluation, data analysis and presentation. Reporting follows the PRISMA 2020 statement (Page et al., 2021) where its items apply to an integrative review.

Review design

An integrative review was chosen because evidence on the drivers of food security and its links with other SDGs comes from different disciplines and research designs, including econometric studies, simulation models, qualitative fieldwork and systematic reviews. Unlike a meta-analysis, an integrative review can combine these designs, but it requires a transparent search, explicit selection criteria and an appraisal of study quality (Whittemore & Knafl, 2005). The review therefore aims for conceptual coverage of the main drivers and SDG links rather than statistical pooling of effect sizes.

Search strategy

The search was conducted in two stages. First, a preliminary search of ScienceDirect identified the 12 studies (11 empirical or review studies and one editorial) that formed the initial version of this review. Second, to broaden coverage beyond a single publisher, a structured search of Scopus and PubMed was run. Two search strings were used: S1 targeted international evidence on the drivers of food security and its interactions with other SDGs, and S2 targeted Malaysian evidence. Both were limited to journal articles and reviews published in English between 2020 and 2026. Table 1 reports each string and the number of records retrieved. The reference lists of included studies were also checked for further eligible studies.

Table 1. Search strings, dates and records retrieved

Database	Search string	Search	Records
Scopus	TITLE("food security" OR "food insecurity") AND TITLE-ABS-KEY("SDG 2" OR "SDG2" OR "SDG-2" OR "zero hunger" OR "sustainable development goal*") AND TITLE-ABS-KEY(driver* OR determinant* OR "trade-off*" OR tradeoff* OR synerg* OR interlinkage* OR interaction* OR nexus)	S1	189
Scopus	TITLE-ABS-KEY("food security" OR "food insecurity") AND TITLE-ABS-KEY(Malaysia*) AND TITLE-ABS-KEY("sustainable development goal*" OR SDG* OR "zero hunger" OR sustainab*)	S2	185
PubMed	("food security"[Title] OR "food insecurity"[Title]) AND ("SDG 2"[tiab] OR "SDG2"[tiab] OR "zero hunger"[tiab] OR "sustainable development goal*"[tiab]) AND (driver*[tiab] OR determinant*[tiab] OR "trade-off*"[tiab] OR synerg*[tiab] OR interlinkage*[tiab] OR interaction*[tiab] OR nexus[tiab])	S1	46
PubMed	("food security"[tiab] OR "food insecurity"[tiab]) AND Malaysia*[tiab] AND ("sustainable development goal*"[tiab] OR SDG*[tiab] OR "zero hunger"[tiab] OR sustainab*[tiab])	S2	26
Total			446

Note: Scopus searches were limited to articles and reviews in English published 2020–2026; PubMed searches were limited to journal articles and reviews in English published 2020–2026. S1 = drivers and SDG interlinkages; S2 = Malaysian evidence.

Eligibility criteria

Studies were assessed against the criteria in Table 2. To be included, a study had to identify a driver of food security, examine an interaction between SDG 2 and at least one other SDG, or analyse a component of Malaysia's food system, and it had to report empirical, modelling or systematic review evidence.

Table 2. Eligibility criteria

Criterion	Included	Excluded
Publication type	Peer-reviewed journal articles and review articles	Editorials, commentaries, book chapters, conference papers, theses and grey literature
Period	Published 2020–2026	Published before 2020
Language	English	Other languages
Focus	Identifies a driver of food security, an interaction between SDG 2 and another SDG, or a component of Malaysia's food system	Food safety, clinical nutrition or agronomy studies with no food security outcome or SDG link
Evidence	Primary empirical data, modelling, or a systematic review	Conceptual or opinion papers without data or a systematic method
Access	Full text available	Full text unavailable

Screening and selection

Records from the two databases were merged and duplicates were removed using DOIs and titles. Titles and abstracts were then screened against the eligibility criteria, and the full texts of potentially eligible studies were assessed. Screening was carried out by the first author and checked by a second author, with disagreements resolved by discussion. Figure 1 shows the flow of studies through the review.

At the full-text stage, a purposive rule was applied to keep the review focused and to avoid duplicating evidence. Where several eligible studies examined the same driver in the same type of setting with the same type of design, the most recent and methodologically strongest study was retained. The aim was to cover each driver and each SDG link with at least one appraised study, rather than to count every study on a given topic. This is consistent with the purpose of an integrative review, which is to build a comprehensive picture of a topic across designs rather than to estimate a pooled effect (Whittemore & Knafl, 2005). Studies excluded under this rule are counted separately in Figure 1.

The database searches returned 374 records from Scopus and 72 from PubMed. After removing 62 duplicates and 7 records published outside 2020–2026, 377 records were screened on title and abstract, and 192 were excluded. Of the 185 eligible records, 167 were not retained under the purposive rule. Full texts were sought for the remaining 18 studies. One could not be retrieved, and the next eligible study on the same driver was assessed in its place. Of the 17 full texts assessed, one was excluded because it was a narrative review without a reported search or selection method. The 16 included database studies comprised 12 new studies and 4 studies already identified in the preliminary search. The other 7 studies from the preliminary search also met the criteria, giving 23 included studies. The preliminary search had also included one editorial (Saccone & Vallino, 2022), which does not meet the evidence criterion and is now cited only as background.

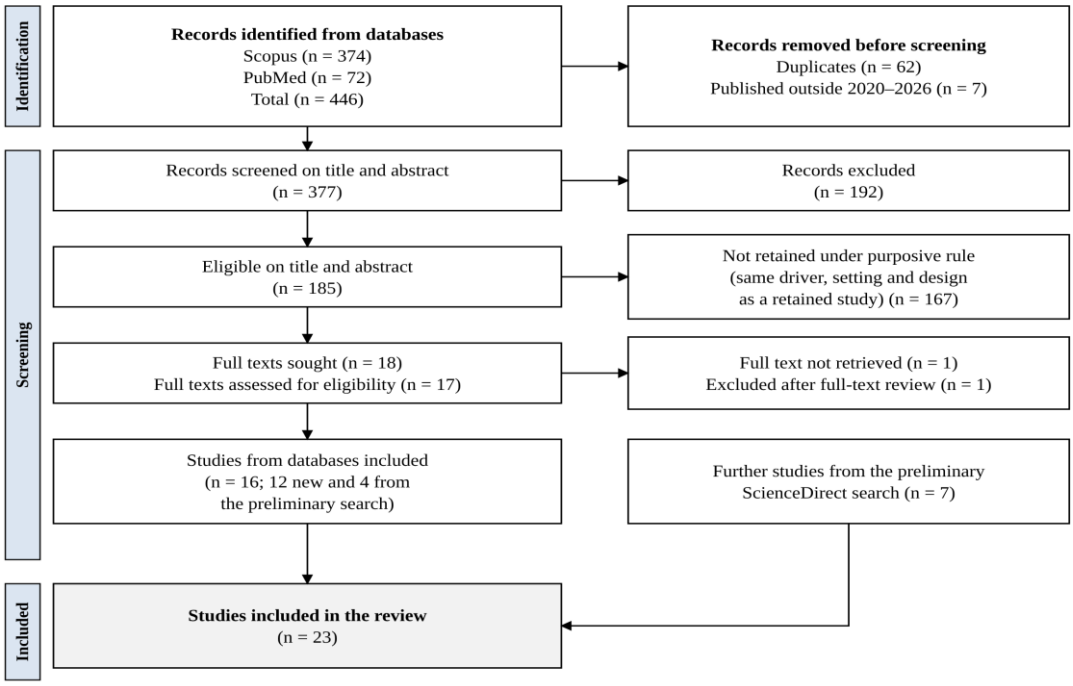

Figure 1. PRISMA 2020 flow diagram of study selection

Quality appraisal

The methodological quality of each included study was appraised using the tool developed by Hawker et al. (2002) for reviewing evidence from different research designs. The tool rates nine items, from the abstract and title to the implications of the study, on a scale from 1 (very poor) to 4 (good), giving a total score from 9 to 36. Studies scoring 30–36 were rated high quality, 24–29 medium quality and 9–23 low quality. Two authors appraised each study independently and resolved differences by discussion. Quality ratings were not used to

exclude studies. Instead, they were used to weight the synthesis: findings supported mainly by low-quality evidence are reported as tentative. Table 4 presents the scores.

Data extraction and synthesis

For each study, the author, year, setting, design, main findings and SDG links were extracted into a summary matrix (Table 3). The findings were then coded thematically, following the stages of familiarisation, initial coding, theme development and review (Braun & Clarke, 2006). Four themes emerged: positive drivers of food security, negative drivers of food security, trade-offs and synergies between SDG 2 and other SDGs, and Malaysian evidence.

Because the included studies differ in design, setting and outcome measures, their findings were not pooled. Studies were first compared within groups of similar design and setting, and only then across groups. Each theme reports the design, setting and quality of the evidence behind it, and effect sizes from one setting, such as path coefficients for European countries, are reported as indicating direction and relative importance rather than as values that apply elsewhere.

SDG links were coded with one rule throughout the review. A link was coded as a synergy when a study reported that progress on the other goal supports food security, or the reverse; as a trade-off when progress on one goal undermines the other; and as context-dependent when studies reported both. The same coding is used in Tables 3 and 5, Figure 2 and the conclusion.

RESULTS

Overview of the included studies

The 23 included studies comprise 11 international studies, three Southeast Asian studies and nine Malaysian studies. They use four broad types of design: quantitative analyses of secondary data (13 studies), modelling and simulation (four), systematic reviews (two) and qualitative fieldwork or household surveys (four). They also measure food security differently, from household experience scales to national food production indices and composite indices. Most were published from 2024 onwards. Table 3 summarises each study, and Table 4 reports its quality appraisal.

Table 3. Summary of the included studies

No.	Author (year)	Setting	Design	Key findings	SDG links*	Quality
1	Rabbi et al. (2025)	8 EU member states	Structural equation modelling	GDP growth is the strongest positive driver (0.845); cereal import dependency (−0.709) and food price inflation (−0.697) are the main inhibitors	1, 6	High
2	Werku et al. (2026)	9 East African countries, 2014–2023	Panel regression (pooled OLS, FE, RE)	Temperature, rainfall, humidity, land use and natural resource depletion significantly affect cereal and food production	13, 15	Medium
3	Liu & Qiu (2024)	Global, 1950–2019	IV/2SLS and gravity model (PPML)	International sanctions raise undernourishment and stunting, cut domestic production and raise import prices	3	High

4	Muhirwa et al. (2025)	Global, 2000–2020	Composite ecosystem sustainability index	Ecosystem-based food security fell from 1.2 to 0.9, below the critical threshold; 62% of countries at risk	6, 7, 15	Medium
5	Bizikova et al. (2020)	Low- and middle-income countries	Systematic review of 73 evaluations	67% of agricultural interventions improved food security; design features mattered more than intervention type	1	High
6	Shupler et al. (2021)	Nairobi informal settlement, Kenya	Longitudinal household survey	During the COVID-19 lockdown, 95% of households lost income and 88% were food insecure; some switched to polluting fuels	1, 7	High
7	Pandey et al. (2025)	Australia, Chad, Iran	Simulation modelling of agrivoltaics	Dense solar panels can cut meat output by almost 50% in high-biomass areas but aid production in semi-arid areas	7, 13	Medium
8	Pulle et al. (2026)	146 countries, 1993–2023	Panel ordered probit	Urbanisation, agricultural land and higher income raise the odds of high food production; greenhouse gas emissions and renewable energy share lower them	7, 13	High
9	Sackitey et al. (2026)	Mexico, Indonesia, Nigeria, Turkey, 1990–2023	Panel regression with Driscoll–Kraay errors (FMOLS, DOLS checks)	Income inequality and inflation reduce food security; urbanisation raises it; trade openness has a weak direct effect	10	High
10	Mane et al. (2025)	137 countries, 792,000 individuals, 2014–2022	Individual-level regression and decomposition	Women are more likely to be food insecure after controls; closing gaps in education, income and work would close 52% of the gender gap	5, 10	High
11	Liu et al. (2022)	Global, 2017 and 2030 projections	Scenario modelling of diets and 11 SDG indicators	Shifting to healthy diets raises SDG scores in most countries, but the best diet differs by region	3, 12, 13	High
12	Su et al. (2026)	Southeast Asia, 2003–2022	Random forest, GeoDetector and CMIP6 projections	Food security improved except in Myanmar, but disparities widened; diurnal temperature range is the dominant climate driver	13	High
13	Jiang et al. (2026)	ASEAN-5 including Malaysia, 2000–2023	Panel FGLS, Driscoll–Kraay and quantile regression	Energy security, green finance and communication technology raise food production; climate change lowers it	7, 13	High
14	Asmawi et al. (2025)	Malaysia and Vietnam, 2018–2022	Comparative analysis of Global Food Security Index scores	Malaysia scores well on affordability and quality but is weak on climate resilience and food imports; higher-income countries are more food secure regardless of productivity	13	Low

15	Nodin et al. (2022)	Malaysia, rice sector, 2009–2018	Bootstrap data envelopment analysis	Rice self-sufficiency favours output over resource saving; efficiency deteriorated over the period	12, 15	High
16	Abdul Ghani (2026)	Malaysia, agri-food networks	Qualitative socio-ecological system modelling	Supply networks are fragmented and import-reliant; local databases and stakeholder participation are needed	12	Low
17	Nazibudin et al. (2025)	Malaysia	Systematic review of 20 studies	Food waste is rising, dominated by households, with heavy reliance on landfills	12	Medium
18	Qandeel et al. (2026)	Kuala Lumpur and Multan	Interpretative phenomenological analysis, 16 participants	Homeless older adults faced food insecurity among seven intersecting challenges during COVID-19	1, 3, 10	High
19	Osabohien et al. (2024)	Malaysia, 1990–2022	Time series (FMOLS)	Electricity consumption, arable land and agricultural employment did not support growth in food production	7	Low
20	Mohd Sohimin & Go (2026)	Malaysia	Agrivoltaic scenario modelling and PESTLE analysis	Solar farms compete with farmland; agrivoltaics with cabbage (LER 1.74) and tea (1.53) outperform palm and paddy	7	Medium
21	Zhang et al. (2023)	Malaysia, 1980–2019	ARDL and nonlinear ARDL	Rises in temperature and rainfall reduce rice productivity; cultivated area raises it; effects are asymmetric	13	High
22	Kh'ng et al. (2021)	Pantai Acheh, Penang	Groundwater and vegetation simulation (MANTRA)	A 1-m sea level rise could cut mangrove cover by 22% and salinise groundwater, undermining SDG 2 and SDG 6	6, 13	Medium
23	Sifullah et al. (2026)	Undocumented Bangladeshi migrants in Malaysia, Iraq and Libya	Interpretative phenomenological analysis, 27 participants	COVID-19 cut food availability and access, leading to cheaper diets and hunger; migrants relied on informal support and loans	1, 10	High

SDG links other than SDG 2, coded with the rule in the Methodology. INT = international; studies 12–14 are Southeast Asian and studies 15–23 are Malaysian. Quality from Table 4.

Of the 23 studies, 14 were rated high quality, 6 medium quality and 3 low quality (Table 4). The most common weaknesses were limited discussion of bias and of how far findings transfer to other settings. The low-quality studies (Asmawi et al. (2025); Abdul Ghani (2026); Osabohien et al. (2024)) are used only alongside other evidence.

Table 4. Quality appraisal of the included studies (Hawker et al., 2002)

Study	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**Total**	**Quality**
Rabbi et al. (2025)	4	4	3	3	4	2	4	2	4	30	High

Werku et al. (2026)	4	3	3	3	3	2	3	2	3	26	Medium
Liu & Qiu (2024)	4	4	4	4	4	3	4	3	3	33	High
Muhirwa et al. (2025)	4	3	3	4	3	2	4	3	3	29	Medium
Bizikova et al. (2020)	4	4	4	3	3	3	4	3	4	32	High
Shupler et al. (2021)	4	4	4	3	3	4	4	2	4	32	High
Pandey et al. (2025)	4	4	3	2	3	2	3	2	3	26	Medium
Pulle et al. (2026)	4	4	4	4	4	2	4	3	4	33	High
Sackitey et al. (2026)	4	4	4	3	4	2	4	2	4	31	High
Mane et al. (2025)	4	4	4	4	4	3	4	4	4	35	High
Liu et al. (2022)	4	3	4	4	3	3	4	3	3	31	High
Su et al. (2026)	4	4	4	3	4	3	4	3	3	32	High
Jiang et al. (2026)	4	4	4	3	4	2	4	2	3	30	High
Asmawi et al. (2025)	3	3	2	2	2	1	3	2	3	21	Low
Nodin et al. (2022)	4	4	4	3	4	2	4	2	4	31	High
Abdul Ghani (2026)	3	3	2	2	2	3	2	2	3	22	Low
Nazibudin et al. (2025)	4	3	3	3	3	2	3	3	3	27	Medium
Qandeel et al. (2026)	4	4	4	3	4	4	4	2	4	33	High
Osabohien et al. (2024)	3	3	3	2	3	1	3	2	3	23	Low
Mohd Sohimin & Go (2026)	4	4	3	2	3	2	4	2	4	28	Medium
Zhang et al. (2023)	4	4	4	3	4	3	4	2	4	32	High
Kh'ng et al. (2021)	4	3	4	2	3	2	3	2	4	27	Medium
Sifullah et al. (2026)	4	4	4	3	4	4	4	2	4	33	High

A = abstract and title; B = introduction and aims; C = method and data; D = sampling; E = data analysis; F = ethics and bias; G = results; H = transferability; I = implications and usefulness. Each item is scored 1 (very poor) to 4 (good). Quality: high = 30–36, medium = 24–29, low = 9–23.

The synthesis produced four themes. Themes 1 and 2 identify the positive and negative drivers of food security, Theme 3 examines how SDG 2 interacts with other SDGs, and Theme 4 maps the Malaysian evidence onto these drivers and links. Each theme states the design, setting and quality of the evidence behind it, because the studies differ too much to be compared directly.

Theme 1: Positive drivers of food security

Economic growth and household income.

Income is the most consistent positive driver across the reviewed studies. Rabbi et al. (2025) find GDP growth to be the strongest driver of food security in eight EU countries, with a path coefficient of 0.845. Across 146 countries, higher income groups were more likely to fall into the high food production category (Pulle et al., 2026). The reverse holds when income collapses: in a Nairobi informal settlement, 95% of households lost income during the COVID-19 lockdown and 88% reported food insecurity (Shupler et al., 2021). The EU coefficient comes from a small sample of high-income countries, so it indicates the direction and relative importance of income rather than an effect size that applies elsewhere.

Agricultural productivity, technology and well-designed interventions.

Raising agricultural output improves availability and rural incomes, but design matters. Bizikova et al. (2020) found that 67% of 73 evaluated agricultural interventions improved food security, 23% had no measurable effect and 10% had negative effects. Positive outcomes were linked to complementary interventions, pro-poor targeting and collaboration with local institutions. In the ASEAN-5, energy security, green finance and communication technology raised food production over 2000–2023 (Jiang et al., 2026). Rabbi et al. (2025) similarly identify agricultural investment as a key enabler.

Water and ecosystem health.

Access to safe water supports the utilisation dimension through hygiene, food preparation and health (Rabbi et al., 2025). At a broader scale, Muhirwa et al. (2025) argue that eco-efficiency and ecological resilience underpin long-term food, water and energy security.

Equality of income and gender.

Two studies show that how income is distributed matters as well as its level. In Mexico, Indonesia, Nigeria and Turkey, higher income inequality reduced food security over 1990–2023 (Sackitey et al., 2026). Using data on 792,000 people in 137 countries, Mane et al. (2025) find that women are more likely than men to be food insecure even after controlling for income, employment and education. Closing gender gaps in education, income and labour-force participation would close 52% of this gap.

Evidence base: these drivers are supported mainly by high-quality studies using several designs and settings. Several macro-level studies measure food security through the food production index, which captures availability rather than access, as Pulle et al. (2026) acknowledge; the income and equality findings are therefore stronger where they are confirmed by household-level evidence (Mane et al., 2025; Shupler et al., 2021). Positive drivers act mainly through the availability and access dimensions; water access and gender equality also act through utilisation.

Theme 2: Negative drivers of food security

Import dependency and trade shocks.

Reliance on imported staples exposes countries to external disruption. Rabbi et al. (2025) find cereal import dependency to be the largest negative factor in the EU (−0.709). Liu and Qiu (2024) show the mechanism: when international sanctions disrupt agricultural trade, import volumes fall, import prices rise, and undernourishment and child stunting increase. In Southeast Asia, Malaysia scores well on food affordability and quality in the Global Food Security Index but is weak on food imports and climate resilience (Asmawi et al., 2025). However, import dependency is not always harmful. Muhirwa et al. (2025) find that Singapore achieves high ecosystem-based food security partly because heavy imports reduce pressure on domestic ecosystems.

Food price inflation.

Rising prices erode purchasing power, especially for low-income households. Food price inflation is the second-largest inhibitor in the EU (−0.697; Rabbi et al., 2025), and general inflation also reduced food security in the MINT economies (Sackitey et al., 2026).

Climate variability and natural resource depletion.

Climate pressure is the most widely documented negative driver. Werku et al. (2026) show that temperature, rainfall, humidity, land use and resource depletion significantly affect cereal production across nine East African countries. In Southeast Asia, food security improved over 2003–2022 except in Myanmar, but disparities widened, and diurnal temperature range emerged as the dominant climate driver under future scenarios (Su et al., 2026). Climate change also reduced food production in the ASEAN-5 (Jiang et al., 2026), and greenhouse gas emissions lowered the odds of high food production across 146 countries (Pulle et al., 2026). Globally, the ecosystem-based food security index fell from 1.2 to 0.9 between 2000 and 2020, below the critical threshold of 1 (Muhirwa et al., 2025).

Shocks to vulnerable households.

Crises hit food security hardest where households have the least buffer. During the COVID-19 lockdown in Nairobi, households that lost more income were more likely to change the foods they ate (Shupler et al., 2021). Homeless older adults in Kuala Lumpur and Multan, and undocumented Bangladeshi migrants in Malaysia, Iraq and Libya, experienced food insecurity alongside financial exclusion and lack of social protection (Qandeel et al., 2026; Sifullah et al., 2026).

Evidence base: the climate and import findings are supported by several high- and medium-quality quantitative studies. The household-shock findings come from qualitative and single-site studies, so they show mechanisms rather than prevalence. Negative drivers mainly weaken the availability, access and stability dimensions.

Theme 3: Synergies and trade-offs between SDG 2 and other SDGs

The reviewed studies link SDG 2 to nine other goals. Each link was coded with the rule set out in the Methodology. Table 5 summarises the links, the mechanisms and the supporting studies.

Table 5. Interlinkages between SDG 2 and other SDGs in the included studies

SDG link	Type	Mechanism	Evidence
SDG 1 No Poverty	Synergy	Higher income raises food access; income loss causes food insecurity	Rabbi et al. (2025); Shupler et al. (2021); Bizikova et al. (2020); Sifullah et al. (2026)
SDG 3 Good Health	Synergy	Food insecurity raises undernourishment and stunting; healthy diets raise SDG performance	Liu & Qiu (2024); Liu et al. (2022); Qandeel et al. (2026)
SDG 5 Gender Equality	Synergy	Closing gender gaps in education, income and work reduces food insecurity	Mane et al. (2025)
SDG 6 Clean Water	Synergy	Safe water supports food utilisation; groundwater salinisation threatens both goals	Rabbi et al. (2025); Muhirwa et al. (2025); Kh'ng et al. (2021)
SDG 10 Reduced Inequalities	Synergy	Income inequality and social exclusion reduce food access	Sackitey et al. (2026); Mane et al. (2025); Qandeel et al. (2026); Sifullah et al. (2026)

SDG 12 Responsible Consumption	Synergy	Reducing food waste and input overuse raises effective supply	Nazibudin et al. (2025); Nodin et al. (2022); Abdul Ghani (2026)
SDG 7 Clean Energy	Depends on pathway	Energy security and clean fuels support food production and household food budgets; solar farms and renewable expansion can compete for land	Jiang et al. (2026); Shupler et al. (2021); Pulle et al. (2026); Osabohien et al. (2024); Pandey et al. (2025); Mohd Sohimin & Go (2026)
SDG 13 Climate Action	Depends on pathway	Climate change lowers yields, so climate action supports SDG 2; rising food demand under current diets adds environmental pressure	Werku et al. (2026); Su et al. (2026); Zhang et al. (2023); Jiang et al. (2026); Pulle et al. (2026); Liu et al. (2022)
SDG 15 Life on Land	Depends on pathway	Healthy ecosystems sustain production; resource depletion and input overuse for output gains undermine both goals over time	Werku et al. (2026); Muhirwa et al. (2025); Nodin et al. (2022)

Two patterns stand out. First, every social link is a synergy: progress on poverty, health, gender equality, water, inequality and waste supports food security, and the reverse also holds. Second, every environmental link depends on the pathway used to pursue SDG 2. Expansion-based pathways, such as raising output through more land and heavy input use, create trade-offs with energy, climate and land goals (Nodin et al., 2022; Liu et al., 2022). Efficiency-, resilience- and clean-energy-based pathways turn the same links into synergies (Jiang et al., 2026; Muhirwa et al., 2025).

The SDG 7 link shows this most clearly. Energy security raised food production in the ASEAN-5 (Jiang et al., 2026), but a higher renewable energy share was associated with lower food production across 146 countries (Pulle et al., 2026), and electricity consumption did not support food production in Malaysia (Osabohien et al., 2024). Land is the key mechanism. High-density agrivoltaics cut meat output by almost 50% in high-biomass Australian regions, but improved production in semi-arid Iran (Pandey et al., 2025). In Malaysia, large solar farms planned under the National Energy Transition Roadmap compete with farmland, while agrivoltaics with cabbage or tea can produce both energy and food on the same land (Mohd Sohimin & Go, 2026). Because these studies use different designs and outcome measures, they show that the direction of the SDG 7 link depends on context rather than giving a single effect size.

Theme 4: Malaysian evidence

The nine Malaysian studies each map onto one or more of the drivers and links identified above.

Production efficiency.

After the 2007–2008 food price crisis, Malaysia shifted its rice policy towards self-sufficiency. Nodin et al. (2022) find that this approach favours output over resource saving, and that average efficiency deteriorated between 2009 and 2018. Osabohien et al. (2024) similarly find that arable land and electricity use were negatively associated with food production over 1990–2022, although this single-country study was rated low quality. Both studies point to the productivity driver in Theme 1 and to the SDG 12 and SDG 15 links in Theme 3: more inputs and land do not guarantee more food.

Climate risks.

Rising temperature and rainfall reduced Malaysian rice productivity over 1980–2019, while the effects of climate change were asymmetric (Zhang et al., 2023). On the coast, a 1-metre sea level rise could cut mangrove cover in Pantai Acheh, Penang, by 22% and salinise groundwater, undermining both SDG 2 and SDG 6 (Kh'ng et al., 2021). These findings match the climate driver in Theme 2.

Supply-chain structure and import reliance.

Abdul Ghani (2026) describes Malaysia's distribution and consumption networks as "locked and fragmented" and import-reliant. A comparison of Global Food Security Index scores shows the same weakness: Malaysia performs well on affordability and quality but poorly on food imports and climate resilience, unlike Vietnam, whose strength lies in production and exports (Asmawi et al., 2025). This corresponds to the import-dependency driver in Theme 2. Both Malaysian studies were rated low quality, so this finding is tentative, although it matches the stronger international evidence (Rabbi et al., 2025; Liu & Qiu, 2024).

Energy and land use.

Malaysia's renewable energy target creates competition for farmland, which agrivoltaics may ease. Among the crops modelled, cabbage and tea gave the highest land equivalent ratios (1.74 and 1.53), outperforming palm and paddy (Mohd Sohimin & Go, 2026). This is the Malaysian form of the SDG 7 pathway question in Theme 3.

Food waste.

Nazibudin et al. (2025) find that Malaysia generates a large and rising amount of food waste, mostly from households, with heavy reliance on landfills. Reducing waste would raise effective food supply without additional production, reflecting the SDG 12 synergy in Theme 3.

Excluded groups.

Homeless older adults in Kuala Lumpur were largely invisible to pandemic responses (Qandeel et al., 2026), and undocumented migrants in Malaysia relied on friends, loans and food aid when COVID-19 cut their income (Sifullah et al., 2026). Both studies link SDG 2 to SDGs 1 and 10.

Together, these studies show that Malaysia faces six of the pressures identified in the international evidence: low production efficiency, climate risk, import exposure, competition between energy and farmland, high food waste and the exclusion of vulnerable groups. However, each study examines only one pressure, and no Malaysian study estimates them together or measures their relative weight.

DISCUSSION

This section brings the four themes together in a conceptual framework, then sets out lessons for Malaysia, identifies gaps in the Malaysian literature and acknowledges the limitations of the review. Because most lessons come from studies outside Malaysia or from single Malaysian studies, they are framed as directions to test rather than proven effects.

Conceptual framework

Figure 2 brings the four themes together. Positive and negative drivers act on the four dimensions of food security, which determine progress on SDG 2. SDG 2 is reinforced by goals on poverty, health, gender, water, inequality and waste, and its links with energy, climate and land goals depend on the pathway chosen. The Malaysian evidence shows where these drivers operate in the national food system. Table 6 links each part of the framework to the studies behind it and to the quality of that evidence.

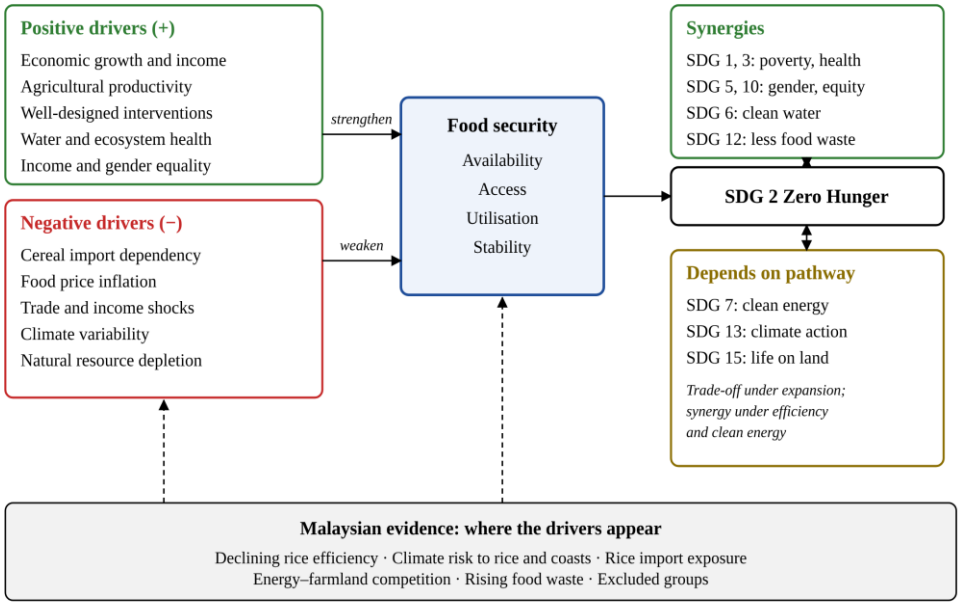

Figure 2. Conceptual framework of food security drivers and SDG interlinkages, synthesised from the 23 included studies

Table 6. Evidence supporting each component of the conceptual framework

Framework component	**Supporting studies (Table 3 no.)**	**Designs**	**Strength of evidence**
Positive drivers: income, productivity, water, equality	1, 4, 5, 6, 8, 9, 10, 13	Panel and cross-national econometrics, systematic review, household survey	Strong: mostly high quality, several settings
Negative drivers: imports, prices, climate, depletion, shocks	1, 2, 3, 4, 6, 8, 9, 12, 13, 14, 18, 21, 23	Econometrics, machine learning, index comparison, qualitative	Strong for climate and imports; moderate for household shocks
SDG synergies (1, 3, 5, 6, 10, 12)	1, 3, 4, 5, 6, 9, 10, 11, 15, 16, 17, 18, 22, 23	Econometrics, reviews, simulation, qualitative	Moderate to strong
Pathway-dependent links (7, 13, 15)	2, 4, 6, 7, 8, 11, 12, 13, 15, 19, 20, 21	Simulation, scenario modelling, econometrics, review	Moderate: consistent mechanism, effect sizes vary by setting
Malaysian pressures	14–23	Time series, DEA, simulation, reviews, qualitative	Moderate to weak: one or two studies per pressure, three rated low quality; no joint estimate

The framework shows that SDG 2 cannot be pursued through food production alone. Policies must strengthen the positive drivers, buffer the negative ones, and choose production pathways that turn environmental trade-offs into synergies.

Lessons for Malaysia

The review suggests that Malaysia's food security challenge is less about national food supply than about efficiency, exposure, waste and exclusion. Six lessons follow from the evidence.

Pursue efficiency-based, not output-based, self-sufficiency.

Bizikova et al. (2020) show that agricultural interventions succeed when they are well designed, not simply when they raise output. Malaysian rice policy has favoured output while efficiency declined (Nodin et al., 2022), and more land, electricity and labour have not raised food production (Osabohien et al., 2024). The National Agrofood Policy 2021–2030 could link support to efficiency gains, such as modern irrigation and precise input use, and prioritise the less efficient regions.

Manage import and price risk.

Cereal import dependency and food inflation are among the strongest threats in the international evidence (Rabbi et al., 2025; Liu & Qiu, 2024), and food imports are one of Malaysia's weakest areas in the Global Food Security Index (Asmawi et al., 2025). However, the Singapore case shows that imports can support food security when well managed (Muhirwa et al., 2025). The aim should be to manage import risk rather than eliminate imports, for example by diversifying suppliers, keeping strategic reserves and strengthening regional supply chains.

Plan for climate risk in rice and coastal areas.

Rising temperatures and rainfall already reduce rice productivity (Zhang et al., 2023), and sea level rise threatens coastal water and food security (Kh'ng et al., 2021). Climate-resilient rice varieties, water management and mangrove protection serve SDGs 2, 6 and 13 together.

Align energy transition with food security.

Large solar farms and food production compete for land (Mohd Sohimin & Go, 2026; Pandey et al., 2025). Siting rules and support for agrivoltaics with suitable crops would let Malaysia pursue its renewable energy target without reducing farmland.

Protect access for low-income and excluded groups.

Income shocks quickly turn into food insecurity (Shupler et al., 2021), and inequality reduces food access (Sackitey et al., 2026). Support targeted at B40 households, such as cash transfers adjusted for food inflation, may protect access more directly than broad price controls. Homeless older adults and undocumented migrants fall outside standard safety nets (Qandeel et al., 2026; Sifullah et al., 2026), so outreach should not depend on a fixed address or formal registration.

Treat food waste as food supply.

Reducing household and commercial food waste increases effective food supply without new land, water or energy (Nazibudin et al., 2025). This is one of the clearest synergies between SDG 2 and SDG 12.

Research agenda

The review identifies five gaps in the Malaysian literature, summarised in Table 7.

Table 7. Gaps in the Malaysian literature and suggested research

Gap	Suggested research	Approach
No joint estimate of food security drivers in Malaysia	Estimate how income, productivity, import dependency, food prices and climate affect food security in Malaysia and ASEAN	Panel econometrics using FAOSTAT and World Bank data, following Rabbi et al. (2025) and Jiang et al. (2026)

Climate evidence limited to rice output	Measure how temperature, rainfall, floods and sea level rise affect household food security, not only yields	State-level panel models linked to household surveys
Energy–land trade-offs not quantified nationally	Assess land competition between food, oil palm and solar energy at national scale	Scenario modelling, following Pandey et al. (2025) and Mohd Sohimin & Go (2026)
Food waste data are fragmented	Build national, sector-level food waste measurement	Waste audits and composition analysis
Excluded groups are under-researched	Measure food insecurity among homeless, migrant and Orang Asli populations	Mixed methods and household surveys

Limitations

This review has four limitations. First, although the search now covers Scopus and PubMed, other databases such as Web of Science were not searched, and some relevant studies may have been missed. Second, the purposive rule kept one study per driver, setting and design, so the review shows the range of evidence rather than how often each finding occurs. Third, the studies differ in design, setting and outcome measures, from household experience scales to national production indices, so their findings cannot be pooled statistically. Fourth, most international findings come from outside Southeast Asia, and each Malaysian pressure is supported by only one or two studies, so the lessons above should be tested with Malaysian data.

CONCLUSION

This integrative review synthesised 23 studies, identified through a structured search of Scopus and PubMed and a preliminary ScienceDirect search, on the drivers of food security and its links with other SDGs. Economic growth, agricultural productivity, well-designed interventions, access to safe water and greater income and gender equality strengthen food security. Cereal import dependency, food price inflation, trade and income shocks, climate variability and resource depletion weaken it. SDG 2 shows synergies with SDGs 1, 3, 5, 6, 10 and 12. Its links with SDGs 7, 13 and 15 depend on the pathway chosen: expansion-based production creates trade-offs, while efficiency-, resilience- and clean-energy-based pathways create synergies.

For Malaysia, the evidence points to six pressures: declining production efficiency, climate risk, exposure to import and price shocks, competition between energy and farmland, high food waste and the exclusion of vulnerable groups. The proposed framework (Figure 2) links these pressures to the four dimensions of food security and to the wider SDGs. Achieving SDG 2 in Malaysia will require efficiency-based self-sufficiency, better management of import risk, climate-resilient agriculture, an energy transition that protects farmland, targeted protection for low-income and excluded groups, and food waste reduction. Future research should test these links empirically, starting with a joint estimate of food security drivers in Malaysia and its ASEAN neighbours.

Declarations

Ethical approval: Not applicable. This review analysed published studies and did not involve human participants or animals.

Conflict of interest: The authors declare no conflict of interest.

Data availability: The search strings and selection counts are reported in Table 1 and Figure 1. The full screening log is available from the corresponding author on reasonable request.

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