Boglárka Anna Éliás

Food Security and Crises:
Analyses of Disruptions in Food Systems

Sustainability Management Program – Agricultural Economics

Supervisors:

Attila Jámbor, DSc

Judit Nagy, PhD

Corvinus University of Budapest

Doctoral School of Business and Management

Food Security and Crises:
Analyses of Disruptions in Food Systems

Doctoral Dissertation

Boglárka Anna Éliás
Budapest, 2025

Table of Contents

List of Tables

List of Figures

Acknowledgements

I would like to express my deepest gratitude to my family, especially my husband and my mother, whose unwavering support and assistance made it possible for me to complete this dissertation while raising our daughter. Their love, encouragement, and understanding were the foundations that sustained me throughout this journey.

I am profoundly grateful to my supervisors, Dr. Attila Jámbor and Dr. Judit Nagy. Dr. Attila Jámbor's invaluable professional guidance, collaborative research efforts, and steadfast encouragement were instrumental in bringing this work to fruition. Dr. Judit Nagy's constructive comments enriched the quality of my research, for which I am sincerely thankful.

Finally, I extend my heartfelt thanks to my colleagues, particularly Dr. Zsuzsa Molnár and Dr. Gyöngyi Jankuné Kürthy, whose expertise and professional advice significantly enhanced specific aspects of this dissertation.

“Give us each day our daily bread.”

Luke 11:3 The Lord’s Prayer

1. Introduction

1.1. Relevance of the research subject

Food security remains a critically important issue, addressing one of the most fundamental human needs and characterized by a challenging cyclical pattern. Despite significant advances, each time stability seems within reach, new crises emerge to undermine progress. However, the efforts to enhance food security yield remarkable benefits, lifting millions of families from malnutrition and ensuring their daily access to sufficient and nutritious food. The importance of these efforts cannot be overstated, especially in light of recurrent crises. The COVID-19 pandemic and the conflict between Russia and Ukraine have escalated global challenges, contributing to a significant increase in undernourishment worldwide. In 2022, there were approximately 120 million more undernourished individuals than in 2019. Including both moderate and severe food insecurity, there is a surplus of almost half a billion people compared to 2019 (FAO *et al.,* 2023). In 2024, amidst strong uncertainties in economic, geopolitical, and climate prospects, it's critical, without resorting to pessimism, to analyze the interplay between crises and food security. Such analyses can be vital not only to enhance our understanding and address current challenges but also to build greater resilience against future shocks.

My research examines the impact of crises on food availability, accessibility, and utilization – i.e. on the food security dimensions – at regional, national, and household levels. My approach to the topic is formed by identified gaps in the existing literature. Specifically, most studies addressing the impacts of crises on food security focus on only one or two dimensions of food security and examine a limited subset of actors within the food system. Consequently, these studies often fail to explore the interactions between different dimensions of food security and between the various components of the food system – an understanding that is crucial for developing more crisis-resilient food systems and effective crisis management strategies. This gap in the literature led to the formulation of my first research question: **Could a comprehensive, 3+1 dimensions analysis contribute to discovering new results regarding crisis-caused impacts and their interplays in the food system?**

To address the first research question, I employed two distinct methodological approaches. In the initial phase of my research, I collaborated with one of my supervisors, Attila Jámbor, to conduct a systematic literature review. This review analyzed empirical studies examining the effects of COVID-19-related measures on the food system without geographical limitations. The findings of this study were published in 2021 and are included in this dissertation as "Publication 1". In the second phase of my research, I investigated the effects of the 2022–2023 food price surge in Hungary on food security and tested hypotheses regarding change in food consumption due to the food price increase and dietary quality differences between high- and low-income families. This research utilized official secondary data and my own questionnaire-based data collection, employing both descriptive and mathematical statistical methods (Publication 2). In both studies, I analyzed the 3+1 dimensions of food security, as well as the interactions between these dimensions and between the crisis coping strategies employed by food system actors. The assumption embedded in the research question was validated, as both studies revealed interactions – both between dimensions and between actors – that had not previously been explored within the context of this topic.

Through a review of the literature, I identified studies that employed panel data logistic regression models to determine the factors influencing food security. Building on this approach, my aim was to apply the same method to test whether crises act as a determinant of food security, thereby addressing my second research question: **Can well-established statistical methods – commonly used to identify food security determinants – be effectively applied to assess the deterministic effect of crises on food security?** In order to work with a larger data panel, we included more regions in our research with Attila Jámbor. We chose the East, South and Southeast Asian regions due to their prominent role in the global food system, both as producers and consumers, and the very diverse food security picture of the countries from these regions (Publication 3). Although the applied model only partially confirmed the deterministic effects of crisis events on food security, it provided several new insights that contribute to the existing literature on the relationship between food security and economic factors, as well as on the overall food security status of the examined regions. Additionally, the study yielded valuable lessons for model-building in future research on the topic.

Besides these two methodology-driven main research questions (Q1–2), the three research parts/studies raised and answered further subquestions (SQ1–3) and tested

hypotheses (H1–10) to deepen the relationship between crisis events and food security status and the interplay between food security dimensions in times of crisis.

The second subchapter of the “Introduction” introduces the key concepts and definitions, followed by a literature review (1.3.) that developed the research approach summarized above. In subchapter 1.4., the research gaps identified in the literature are discussed in greater detail, and my research questions, subquestions and hypotheses are presented. Subchapter 1.5. outlines the methodologies and data used in my studies. Chapters 2–7 provide a bibliometric overview, a brief summary of the objectives and key findings of my three published studies and include the full texts of them. Chapter 8 presents the main conclusions of my research and its contributions to the existing literature.

1.2. Theoretical framework

1.2.1. Concept of food security

What are the preconditions to ensure and secure food consumption at the household, national, and global levels? The attempt to answer this question dates back to the 1970s. Two significant phenomena were recognized during this time. Firstly, the world had to acknowledge that the green revolution had not led to the anticipated eradication of poverty and hunger. Secondly, the 1972–1974 global crisis underscored the fragility of the global food system (FAO, 2003a). In 1971, the government of the United States decided to suspend the fixed-price gold convertibility of the dollar. The new exchange rate regime shook international trade and was especially hard to adapt to by the developing countries (FAO, 1991). In the following year, grain production dramatically decreased in the main producing areas. Subsequently, in 1973, oil prices soared, leading to a buying panic that tripled cereal prices (FAO, 1993). These realizations emphasized the need for policy adjustments.

Given that accurate situational assessment is the foundation of effective political decision-making, there is a necessity for clear definitions and methodologies concerning the state of food consumption to conduct such situational assessments. Therefore, the concept of *food security* was born, but its definition(s) employed in contemporary academic and political discourse are the result of decades of evolution.

At the 1974 World Food Summit, the first official definition of food security focused on the production aspect of food supply: “Stressing the urgent need to ensure availability at all times of adequate world supplies of basic foodstuffs, particularly so as to avoid acute food shortages in the event of widespread crop failure, natural or other disasters, to sustain a steady expansion of food consumption in countries with low levels of *per capita* intake and to offset fluctuations in production and prices” (United Nations, 1975, p. 14).

In the following years, the focus shifted from national and global food security levels to the household level. It became evident that food availability at the national level does not necessarily guarantee food security at the household level. Put differently, self-sufficient production of basic food commodities alone does not ensure food security if individuals cannot afford to purchase the produced food or if the food products are not physically accessible to them. In this recognition, Amartya Sen’s study “Poverty and

Famines" (1981) played an influential role. In Sen's "food entitlement theory", entitlement to food covers the various means to acquire food, such as income, social support, ability to grow their own food commodities, etc. The study argues that the main cause of famine is not the absence of available food in a given country, but the collapse of individuals' entitlement to food. In 1983, the concept of *access* was incorporated into the definition: "...ensuring that all people at all times have both physical and economic access to the basic food that they need" (FAO, 2003a, p. 27).

The 1986 World Bank report "Poverty and Hunger" introduced the "quality" aspect of food security as it defined it as "access by all people at all times to enough food for an active and *healthy life*" (Reutlinger, 1986, p. 1). In addition, it defined the concept of *food insecurity*, differentiating between *chronic food insecurity,* "caused by the inability to acquire food" (op. cit.), and *transitory food insecurity,* which can result from "instability in food prices, food production, or household incomes" (op. cit.). It can be triggered by wars and natural disasters or their combination (op. cit.), as witnessed during the Ethiopian Famine between 1983 and 1985 (de Waal, 1991), which significantly influenced the ongoing food security dispute.

In 1996, the World Food Summit Plan of Action defined food security in the Rome Declaration on Food Security as the state achieved "when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life" (FAO, 1996a, World Food Summit Plan of Action paragraph 1.). Furthermore, the declaration outlined levels of measurement for food security: individual, household, national, and global. This definition was complemented in 2001 by the term "social/cultural access" (FAO, 2001), thus articulating the four dimensions/pillars, which serve as the conceptual bases for most food security-related research to date (FAO and European Commission, 2008):

- Availability: availability considers the supply, the quantity side of food security. It is determined at the national level by food production, stocks, and trade.
- Access: access considers the physical, the economic – and if it's relevant the social/cultural – ability to acquire food at the individual and household levels. The main determinants of access are the state of food distribution systems, incomes, expenditures, and food prices.
- Utilization: utilization considers the quality side of the food consumed at the individual level; thus, it covers a wide range of meanings. On the one hand, it refers

to the nutritional status of individuals, which depends on good nutritional practices (adequate energy and protein intake, a balanced and diverse diet) and the ability of the human body to absorb nutrients, and on the other hand, it includes food quality, i.e., food safety, health, and general hygiene, and also addresses the problem of food wasting.

- Stability: Stability here means that all three dimensions listed above are achieved and the food system is resilient; therefore, in my dissertation I mostly refer to all food security dimensions together as "3+1 dimensions", where the "+1" dimension is stability.

Sequential conditionality exists among the first three dimensions. Proper utilization of nutrients, in both quality and quantity, is feasible only when food is accessible both financially and physically. Food accessibility requires availability and sufficient supply. The concept presented above – commonly referred to as the *"*1996 FAO definition" or the "definition of the Rome Declaration 1996" – stands as the official concept of food security by the Food and Agriculture Organization of the United Nations *(FAO)*. While other organizations also address food security, the FAO holds particular relevance due to its capacity to collect and analyze data on a global scale, making it the most influential in this regard. Due to the expansive nature of the food security concept, encompassing four levels and four dimensions, each covering a wide range of determinants and influenced by the unique characteristics of the studied group, researchers often find it necessary to complement the official concept. As a result, numerous definitions exist in the literature. In the early 1990s, Maxwell and Smith (1992) for example, identified over 180 definitions. However, it is important to note that most of these definitions are slightly reshaped versions of the official concept.

Since food security considers both food supply and food consumption, it would not be sufficient to examine crisis effects on *agriculture* or *agri-food industry* or *food supply chain* or *food consumption*. The conceptualization of my research demanded a broader, more comprehensive understanding of the interrelations between various actors and actions that ultimately form food security. Therefore, I preferred to apply the concept of food system, which is an extension of the concept of food supply chain, where in addition to production, collection, processing, distribution, consumption, and disposal of food products (i.e., the actors of food supply chain), the societal, political, and economic environment where the food supply chain's actors are operating is also taken into

consideration (FAO Agricultural Development Economics Division, 2018); thus, the concept of food system is able to include the aspects of food security since it considers not only the supply but the consumer side's ability to reach and to acquire food as well.

1.2.2. Concept of "crisis"

We commonly understand the notion of a "crisis", yet there is no universally accepted definition. Crises are typically characterized by their **unexpected** nature. Although there may be signs that a crisis is imminent, it is usually an unforeseen event or a combination of such events that triggers the crisis. According to Ibrahim *et al*. (2003), crises are always man-made, stemming from economic, political, or disaster-related issues. – However, there appears to be a contradiction in this assertion, as the same study acknowledges that disasters can also be natural. – These unforeseen events pose direct or indirect **threats** to the fundamental values or life-sustaining systems of a community, thereby raising the stakes significantly (Al-Dahash *et al*., 2016; Boin *et al*., 2018). A crisis has the potential to destroy an organization or a system (Mitroff *et al*., 1996, as cited in Ibrahim *et al*., 2003). In the wake of a crisis, **urgent** responses are required (Ibrahim *et al*., 2003; Boin *et al*., 2018). Scarcity of information often compounds the limited time available, resulting in decisions under a high degree of **uncertainty**. Rapid **adaptation** to new situations is crucial in decision-making to mitigate negative impacts and to develop strategies to prevent future crises. Several studies demonstrate that, despite the general negative perception, the term "crisis" can evoke optimism by suggesting a temporary state (Ibrahim *et al*., 2003; Boin *et al*., 2018). Moreover, crises often provide opportunities for structural changes that can lead to improvements, even to exceeding pre-crisis levels of development. Darling (1994) and Davies and Walters (1998) take this idea further, defining a crisis as a turning point for better or worse. Holling's *adaptive cycle* also supports the theory of "first it gets worse and then it will become better" as it describes the life cycles of systems as a growing phase followed by a slowing down phase due to the increased resource and energy demand, and the system loses its flexibility due to growing interconnectivity. The next phase is the phase of the crisis when the structure of the system collapses and finally a reorganization phase closes the round of a cycle, and the new cycle will start (Holling, 1986, 2001 cited by Walker *et al*., 2006).

The literature classifies crises in a variety of ways. One method of differentiation is to assess whether the situation involves conflict. Crises with conflict elements are termed

"dissensus crises". Conversely, when there is no conflict, the situation can be categorized as a "consensus crisis". Examples of consensus crises typically include natural disasters, epidemics, and financial or economic crises, which are generally viewed as lacking a conflict element (Quarantelli and Dynes, 1977). Ibrahim *et al*. (2003) introduce another classification, distinguishing between "community" and "non-community" types of crises. The latter refers to crises that do not affect the functioning of the community. However, the applicability of labeling situations as "non-community crises" is debatable, given their negligible impact on the fundamental structure of society.

It is important to differentiate a crisis from other phenomena, such as disasters or emergencies. Boin *et al*. (2018) assert that the presence of three key components – threat, urgency, and uncertainty – is essential for a situation to be perceived as a crisis. Without these elements, the situation does not invoke the sense of crisis. For example, although climate change presents a long-term threat to food security, it doesn't have the same immediate urgency as a refugee crisis after armed conflict, where an immediate risk of food shortage exists. Ibrahim *et al*. (2003) suggest that a crisis is a more comprehensive situation, in contrast to a disaster, which is more event-specific. While disasters tend to concentrate in time and space, crises often extend over time. Tulach and Foltin (2020) refer to the description of the three phases to disaster by Christian and Griffiths (2016): 1.) deviation, when outcomes start to diverge from usual without any deliberate change in the system; 2.) disruption, a radical change in the structure; and 3.) disaster, a temporary irreversible effect. Similarly, emergencies, like crises and disasters, emerge unexpectedly and carry significant risk. However, a distinguishing feature of emergencies is that they presuppose the existence of prepared decision-making processes and step-by-step solutions for mitigation (Al-Dahash *et al*., 2016).

It is important to note that in my research, besides crisis events in line with the above definitions, I consider disasters and emergency-type events as well in case they significantly affected the food system. Furthermore, in line with food security studies, my research focuses only on those from the above-defined phenomena that cause damage to one or more dimensions of food security in the given country or region. To use a theoretical example, there is a severe drought and crop harvest collapse in a country, but this country owns the necessary capital to purchase food from external markets, and their increased import does not lead to significant growth of world market prices of crops (because the country's population, i.e. demand, is small, or because there is a surplus on

the international markets due to high global crop production that year); therefore it does not affect the economic access to food of lower-income countries. In this case, this natural disaster caused agricultural crisis is not relevant in my research.

The structural problems that are the cause of chronic food insecurity are not in line with the presented "crisis" definition, and neither I refer to them as crises; however, structural problems have relevance in my work in light of their role in generating a crisis, and they have a key role in resilience to the crisis.

Given crises' unpredictable nature, it is impossible to prevent them with absolute certainty, i.e., we are not able to completely tame crises into emergencies for which we have a precise and effective protocol to manage them. However, by thoroughly analyzing past crises and their impacts, we can accumulate valuable information that enables us to make more informed decisions. Even in situations where time is scarce, this knowledge can significantly reduce harm.

1.2.3. "Crisis" in the global food security agenda

There is a strong connection between the concept of food security and crisis phenomena. The crisis of the early 1970s drove the need to conceptualize the issue of feeding the world's population. In the elaboration of the food (in)security definition, certain food shocks and famines played a crucial role. A review of the FAO's annual food security reports reveals that the global food security agenda almost always prioritizes crisis-related issues such as conflict, epidemics, natural disasters, economic crises, and food price crises. In Table 1, the main focus of each publication and the crisis events that appear in the reports are presented year by year.

Table 1. Special focus of the global food security agenda 1990–2023

YEAR	Main focus of the food security agenda	Crises which affected regional food security	Source
1990	New economic policies after the collapse of the USSR	Oil crises (1973–1974; 1979); debt crisis	FAO, 1991
1991	Economic slowdown in 1990–1991	Economic crisis of former USSR countries and the former socialist East-Central European countries	FAO, 1992a

1992	Conflict in Yugoslavia, droughts and civil war in southern and eastern Africa	Conflict in Yugoslavia; droughts and civil war in southern and eastern Africa; effects of debt crisis	FAO, 1992b
1993	Uruguay Round, challenges for biotechnology	Debt crisis; Gulf crisis	FAO, 1993
1994	Uruguay Round, AIDS epidemic, state of forestry	Economic crisis of former USSR countries and the former socialist East-Central European countries; conflict in former Yugoslavia; AIDS epidemic	FAO, 1994
1995	Agricultural trade, trade liberalization		FAO, 1995
1996	Urban agriculture, desertification, food policies		FAO, 1996b
1997	Forests, women in agriculture, climate change		FAO, 1997
1998	Urban food security, fishery	Floods associated with El Niño	FAO, 1998
1999	Nutrition of children	Southeast Asian bank crisis: Indonesia; Central Asian floods and droughts; Middle Eastern natural disasters and armed conflicts	FAO, 1999
2000	External debts, bioresearch		FAO, 2000
2001	Natural and human-induced disasters, AIDS epidemic	AIDS epidemic	FAO, 2001
2002	Conflict and hunger	*theoretical analysis*	FAO, 2002
2003	Agricultural trade		FAO, 2003b
2004	Globalization, urbanization, changing food systems	Complex crises: natural disasters, structural problems and security crises in Africa.	FAO, 2004
2005	Education, gender equality, AIDS epidemic	AIDS epidemic	FAO, 2005
2006	Agricultural growth, trade, investment		FAO, 2006
2007	Environmental services	Food price crisis of 2007–2008	FAO, 2007

2008	Effects of high food prices on poor households and on nutrition		FAO, 2008
2009	Food and economic crisis	Food price crisis of 2007–2008 and the Global Economic Crisis of 2008–2009	FAO, 2009a
2010	Protracted crisis	*theoretical analysis*	FAO, 2010
2011	Price volatility	*theoretical analysis*	FAO, 2011
2012	Role of economic and income growth in hunger reduction		FAO, 2012
2013	Indicators for measuring the four food security dimensions		FAO, 2013
2014	Elaborating complex approaches to reduce hunger	Political crisis of Madagascar (2009); the "Arab Spring" (2011)	FAO, 2014
2015	Evaluation of the 2015 hunger target achievements		FAO, 2015
2016	Climate change (adaptation and its effects)		FAO, 2016
2017	Conflict resiliency	Conflict related economic crises	FAO *et al*., 2017
2018	Climate resiliency	Natural disaster related economic crises	FAO *et al*., 2018
2019	Resilience to economic slowdowns and downturns		FAO *et al*., 2019
2020	Affordable healthy diet	COVID-19 pandemic related economic crisis	FAO *et al*., 2020
2021	Affordable healthy diet, effects of COVID-19	COVID-19 pandemic related economic crisis	FAO *et al*., 2021
2022	Policy support for affordable healthy diet	Recovering from COVID-19 pandemic related economic crisis, Ukrainian war related economic crisis	FAO *et al*., 2022
2023	Urbanization, transformation of agri-food systems, affordable healthy diet	Recovering from COVID-19 pandemic related economic crisis, Ukrainian war related economic crisis	FAO *et al*., 2023

Source: Own compilation based on FAO annual reports.

By reviewing the annual food security reports of FAO, the crises with the biggest impact on food security of the last decades could be summarized as follows:

In the early 1990s, the accumulated external debts were in focus. The oil crisis of 1973-74 forced net oil-importing developing economies to borrow from the private financial markets. Five years later, the Iranian Revolution caused another oil price shock. This oil crisis escalated the ongoing worldwide inflation. In the early 1980s, the most developed economies turned into recession, which led to a decline in their demands for the products of developing countries. The developing countries had to face high oil prices and low demand, i.e., low prices of their own products, and the force from private banks repaying their debts; the occurring capital shortage led to the accumulation of debt in many developing countries (FAO, 1991).

Despite the debt relief programs, due to debt repayment, the net transfer of resources exceeded more than 40 billion USD annually at the end of the 1980s from developing countries to the most developed ones (FAO, 1991). In the Sub-Saharan region, the per capita income fell to the level of the early 1970s, and besides 9 countries out of 45, the per capita food production was also decreasing. In most countries of the region, the terms of trade decreased during the 1980s. The most severe situation in food security occurred in those countries where the unfavorable international economic environment was accompanied with armed conflicts and/or natural disasters. In the early 1990s, 17 of the Sub-Saharan countries faced severe food shortages. The outbreak of the Gulf crisis deepened the economic crisis in the Sub-Saharan and South American regions with higher oil prices and by slowing down the growth of demand for their agricultural products and caused food shortages in several Middle Eastern countries (FAO, 1992a).

The East and Southeast Asian bank system crisis in 1997–1998 hit the economy of all the countries in the regions; however, most of the countries recovered relatively fast (except Indonesia, FAO, 1999).

Around the turn of the millennium, sociodemographic characteristics gained attention as determinants of food (in)security. The 2007–2009 economic and food price crisis drew attention to food price volatility and the importance of incomes in resilience to price shocks. In contrast to previous crises, the food price and the financial crisis simultaneously hit every region; therefore, in addition to high prices and potential loss of employment, the value of remittances – which usually take up to 2-5 percent of developing countries' GDP – decreased, i.e., the abroad-working family members could

not afford to send home the same amount of money as before since the economy they lived and worked in was very likely in crisis as well (FAO, 2009a).

The world market prices of staples decreased slowly in 2008 due to the prolonged "re-appreciation" of USD (the currency of most international trade transactions); in addition, the price transmission between world markets and domestic markets lagged. At the turn of 2008 and 2009, staple food domestic prices were 17 percent higher than two years before (FAO, 2009a).

In the following years, the role of household incomes in resilience to conflict or climate-related crises and in maintaining a healthy diet was strongly emphasized in the food security agenda. There is a special focus on the existing and potential negative consequences of climate change on food security since the 2010s. Meanwhile, conflict-related food insecurity has always been a central subject of hunger reduction agendas.

The conclusion of the FAO's food security agenda on COVID-19 could be summarized as the following: Food production was moderately affected by labour shortages due to border restrictions, but global food production in 2020 was still above average. The transport restrictions caused temporary disruptions of global supply chains. However, income loss due to lockdown, the general slowdown of economy, and investment resulted in a significant increase in food insecurity (FAO *et al*., 2020; FAO *et al*., 2021). In 2021, more than 350 million more people struggled with moderate or severe (in ratio of 60:40) food insecurity than before COVID-19 in 2019 (FAO *et al*., 2022).

The consequences of the war in Ukraine hit the global food and energy markets and slowed down the recovery of national economies from COVID-19. This conflict, despite the acts of war being localized in the Eastern Ukrainian territories, has a global significance, as the two actors of the conflict are together the supplier of around 30 percent of wheat, 20 percent of maize, and 80 percent of sunflower seeds globally. Besides, the Russian Federation is the number one exporter of natural gas, nitrogen, potassium, and phosphorus fertilizers, and the second biggest oil exporter. As a consequence of the war, the price of agricultural inputs grew, and there were disruptions in crop trade. In addition, the disruption in energy trade and the subsequent economic sanctions against Russia destabilized financial markets, causing inflation, increasing debt levels, and halting economic growth worldwide (FAO *et al*., 2022, 2023).

FAO projection predicts that by 2030, the number of people suffering from hunger will be around 590.3 million. This increase, amounting to 0.24% between 2015 and 2030,

suggests that the Sustainable Development Goal 2 (SDG2), aimed at reducing hunger during the 2015–2030 period, may not be met. Although the proportion of people living in hunger relative to the total population might decrease due to population growth, failing to meet the SDG2 targets remains a significant concern. Before the COVID-19 pandemic, the FAO's 2019 estimate anticipated a 19.9% reduction in global hunger (2015–2030). Amid the pandemic but pre-Ukrainian war projection of 2021, it showed a remarkably reduced expectation of a 3.6% decline in hunger. However, as seen above, the 2022 projection reverses this trend, predicting a slight 0.24% increase in global hunger from 2015 to 2030 (FAO *et al*., 2022, FAOSTAT). In all three scenarios of the FAO, the number of undernourished people remains stable from 2025 onwards, which means decreasing prevalence of undernourishment (PoU) value due to expected population growth, but it also means that 120 million more people will be undernourished in 2030 than it was expected before the COVID-19 pandemic.

1.3. Empirical framework

On the following pages, I will present a synthesis of the empirical literature regarding crises impacts on food security. The article-based dissertation design implies that a substantial part of the literature reviewed is referred to in my three published articles (Publication 1–3), in which I present the results of my research. In order to avoid repetition, I will present here those literatures that have contributed to a deeper understanding of the topic but have not been included in my articles. This literature review, together with those in the articles, guided the construction of my conceptual framework.

This literature review considers crises of any nature (conflict, economic, weather extremes, epidemic) that have an impact on food security, and it follows the structure of the food security theoretical framework, i.e., the findings are presented by food security dimensions, except stability. The dimension of stability is less articulated in the relevant literature, since stability means that in the other three dimension food security is fulfilled.

1.3.1. Availability

Crises have various adverse effects on food production. In case of armed conflicts, the physical extent of military operations can involve and destroy arable land, and the conscription of agricultural workers into combat could lead to labor shortages (FAO *et al*., 2017). Epidemic crises can pose the same threat to agricultural labor. In the 25 most

HIV-affected countries, 7 million agricultural workers died of AIDS between 1985 and 2001 (FAO, 2001; FAO, 2003b). FAO analyzed the regions that are the most severely affected by weather extremes and estimated that 25 percent of the economic losses caused by weather extremes belonged to agriculture (FAO, 2016). According to FAO, crises that cause food price increases have an ambiguous impact on food production; the key element here is the difference between retail price and farmgate price. On one hand, increased demand-driven higher food prices are incentives for agricultural production, but on the other hand, if the price boom is resulting from the increase of oil prices, the difference between the previous and the new, higher world market price is very likely to represent the additional transport costs due to higher fuel prices, and farmers may find themselves unable to reflect their rising input costs in the farmgate prices (FAO, 2008; FAO, 2011).

The resilience of agricultural production to crises is determined, on the one hand, by the development of agriculture in a given country (including technology and agricultural policy as well) and, on the other hand, by the severity of the crisis. The First and Second Congo Wars in 1996–1997 and in 1998–2003, in Eastern Congo (Democratic Republic of Congo), had a devastating effect on agri-food production. The agri-food production generally decreased by 12 percent, the production of cereals dropped by 33, and the production of vegetables by 42 percent between 1996 and 2004 (Vlassenroot and Raeymaekers, 2008). In Uganda, as a consequence of the repeatedly outbreaking violent conflicts, a significant shift is observed in the structure of agricultural production. Due to the general insecurity, despite the higher profitability of livestock husbandry, rural households started to prefer crops over livestock, since animals are easy to loot and crops require less attention and their harvest time is more flexible (Rockmore, 2020).

Regarding weather extremes, Wei *et al*. (2017) simulated a precipitation crisis scenario based on the data between 1980 and 2008 and chose for every province in China the precipitation data of those years in which the maize production damage contributed to precipitation was the highest (it might be a very low level of precipitation or extremely heavy rainfalls). They found that even in this worst-case scenario, the maize production would decrease only by 4 percent due to the technological development of the sector.

There is evidence that the lockdowns and travel restrictions in the time of the COVID-19 crisis caused a temporary agricultural labor shortage in the spring of 2020 in India (Ceballos *et al*., 2020; Kumaran *et al*., 2021) and in the countries of Sub-Saharan Africa (Nchanji *et al*., 2021). – There are implications (Ben Hassen and El Bilali, 2022; Leal

Filho *et al*., 2023) that there is an agricultural labor shortage in Ukraine as a result of the war, but I have not found empirical results in the literature.

During the COVID-19 crisis, many producers had to face increased prices and delayed delivery of inputs due to the supply shortage resulting from the disruption of supply chains in Visegrad countries (Blažková *et al*., 2023), in India (Kumaran *et al*., 2021), and in Senegal (Middendorf *et al*., 2021), as well as other countries of Sub-Saharan Africa (Nchanji *et al*., 2021).

1.3.2. Access

The two sides of the economic access deprivation coin are income loss and price increase. The impact of each of them or the combination of them is widely discussed in the literature. A qualitative survey (n=50, female and male farmers) was carried out in Kamituga at the last period of the Second Congo War (1998–2003) in 2003. The farmers reported a 25% drop in their incomes compared to the pre-war period (Vlassenroot and Raeymaekers, 2004). This finding implicates risks for availability – as the incentives for agricultural production decrease –, but the more direct impact on food security appears in the decrease of economic access of these farmers to food from markets. In rural Kenya, the drought had a negative impact on both agricultural and non-agricultural income (Wineman *et al*., 2017). In addition, Sietz *et al*. (2012) assessed the determinants of food security vulnerability to El Niño related weather extremes in Peru by cluster analysis and concluded that lack of non-agricultural income and education deprivation characterized the most vulnerable group of households, and having both agricultural and non-agricultural income characterized the least vulnerable cluster.

The role of income in a crisis situation is relevant not only in the case of a loss of income as a result of the crisis but also because of the relationship between the level of income and resilience to the crisis situation. During the time of the economic (2014–) and political (2016) crisis in Brazil, Sousa *et al*. (2019) conducted logistic regression analysis applying data from the Brazilian National Household Sample Survey from 2004 as a pre-crisis baseline and Gallup World Poll from 2015, 2016, and 2017 as “amid crisis” data. Their results show a strong association between income and food security levels. The poorest respondents had a 6 times bigger chance of falling into food insecurity during the crisis.

In developing countries, 97 percent of urban households and three-quarters of rural households are net food buyers (estimated from the data of 9 developing countries, FAO,

2008). Therefore, urban citizens perceive only negative impacts of food price increases, while net food producer rural smallholders (i.e., they produce more than they consume) could benefit from the higher price of their products if they are able to manifest their cost in the farmgate prices (FAO, 2008; FAO, 2011). Empirical findings of Das *et al*. (2020) support the theory of FAO. They surveyed 106 rural and 106 urban households (with comparable distribution in income level) and analyzed the responses by multinomial logistic regression and found that the factor of living in an urban area determines vulnerability to the current crisis the most. The impacts of the food price crisis 2007–2008 on households in Burkina Faso were assessed through two cross-sectional surveys in 2007 (pre-crisis) and 2008 (amid crisis). From the over 3000 respondents, the share of food-secure households dropped by 11 percent (from 33% to 22%) between the two surveys due to the 18 percent rise in household food expenditures as the price of cereals increased by 53 and the price of vegetable oils by 44 percent in Burkina Faso (Martin-Prevel *et al*., 2012).

1.3.3. Utilization

In Uganda, as a consequence of the repeatedly outbreaking violent conflicts, a significant shift is observed in the structure of agricultural production. Due to the general insecurity, rural households prefer crops over livestock (see in subchapter: Availability). In terms of nutritional supply, this shift poses a threat to dietary deterioration among those smallholder households who mostly depend on their own production for their food consumption (Rockmore, 2020). Parigi (2024) examined the association between the energy intake, dietary diversity of households, and conflict in 2011–2012 in Iraq. The results based on household survey and conflict-related national data showed that dietary diversity worsened; however, caloric intake grew in this conflicted period. The former explains the latter, since a change in diet appears as a shift from the lower-energy but micronutrient-rich foods to macronutrient-rich carbohydrates and fats. Wineman *et al*. (2017) have found a drop in both agricultural and non-agricultural income (see above), but have not recognized a change in caloric intake, because despite lower income, even agricultural households could counterbalance their production loss-driven food shortage from markets (Wineman *et al*., 2017). These findings – according to which household income decreased, food supply from own production decreased, but the energy intake remained at the previous level – are raising questions. Wineman *et al*. (2017) explain this by the important role of market access for rural households in times of weather extremes;

however, in accordance with the lessons from Parigi (2024, see above), change in dietary diversity could be the actual explanation, which factor was not included in the model of Wineman *et al*. (2017).

The relationship between mental health and dietary quality has received some attention during the COVID-19 pandemic. A literature review of 32 empirical studies (Bakaloudi *et al.,* 2022) found that snacking (both salty and sweet) increased by 18.9–45.1 percent and fast-food consumption by 15.0–41.3% between March and May 2020 according to the 32 studies included in the review. Mental distress led to a decrease in dietary quality in Israel after the Israel-Gaza conflict flared up in 2023. 15 percent of the respondents of a representative survey (n=501) reported consuming more alcohol, 13 percent lost weight, and 36 percent gained weight due to following a less healthy diet since October 7th, 2023 (Shamir-Stein *et al.,* 2024).

1.3.4. Coping strategies

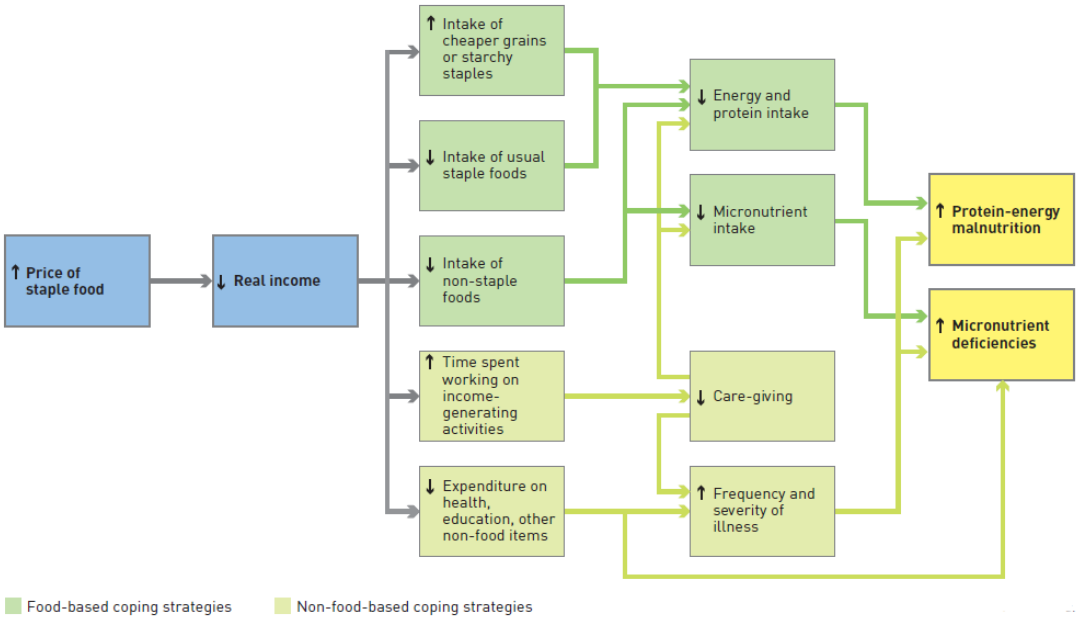
Coping and adaptive strategies during times of food insecurity have been examined by the FAO and some researchers across various crisis situations. From the perspective of my research, these strategies represent the tangible effects of a crisis, as they mean decisions and actions taken in direct response to crisis-induced pressures.

In 2001, 36 million people were infected by HIV worldwide, which means close to 200 million people (including relatives in the same household) who were affected by the negative downward spiral, when the infected adult of the household had to stop work and spend more money on health care because of the symptoms of AIDS (acquired immunodeficiency syndrome). To mitigate the financial losses, children stop going to school and try to earn money; however, because of their low educational level, their income prospects are very poor. If the partner becomes sick as well, the situation worsens (FAO, 2001; FAO, 2003b).

FAO examined the coping and adopting strategies of households in the time of the 2007–2009 food price and financial crises as well. As real income decreased due to an increase in staple food price, households tended to consume cheaper staple food alternatives instead of the usual ones and cut their consumption of non-staples such as vegetables, fruits, meat, and fish, therefore, their macro- and micronutrient intake decreased. Parallel to changes in diet, they work more to increase their income and decrease their non-food expenditures as well, such as non-food products, health care, and

education. Depending on the extent of these changes, this process can lead to malnutrition and micronutrient deficiency (Figure 1, FAO, 2008).

Figure 1. Household coping behaviours and nutrition impacts of a sudden rise in internationally traded staple food prices



Source: FAO (2008). The State of Food Insecurity in the World 2008, Rome, ISBN 9789251060490, p. 28.

In case of a conflict with severe impact on food supply, the coping possibilities of households are very limited. First, households might make milder changes in diet, later start to skip meals. The next stage is the irreversible or hardly reversible actions, such as selling their assets, including livestock and machinery, inputs for agricultural production. If the supply still has not been restored, the next option might be fleeing from the region to avoid starvation and death (FAO *et al*., 2017).

The empirical literature that focuses precisely on household coping strategy when a sudden disruption occurs shows a more nuanced picture of coping difficulties. Segovia (2017), based on the findings in Columbia, adds illegal activities to the list of coping mechanisms against hunger in times of conflict. Reducing the quality and/or quantity of consumed food is backed up by empirical studies. Ngongi and Urassa (2014) collected information by a survey from 150 randomly selected farms and found that respondents tend to purchase less preferred food products to cope with high food prices. In Nigeria, according to the sample (n=800) of a household survey, 92.6% of the respondents reduced the quantity of food consumed, 77.8% skipped meals, 72.3% bought less preferred food,

and 31.3% borrowed food and money and 10.0% sold assets to cope with the high food price inflation in 2018 (Kassy *et al*., 2021). Das *et al*. (2020) conducted a survey of 106-106 rural and urban households amid the COVID-19 crisis in Bangladesh. The 27 percent of rural households that adopted financial coping strategies such as selling assets or borrowing money, and 32 percent, besides financial strategy, also applied the strategy of reducing food quality and/or quantity. In the case of urban households, 61 percent of the respondents applied both.

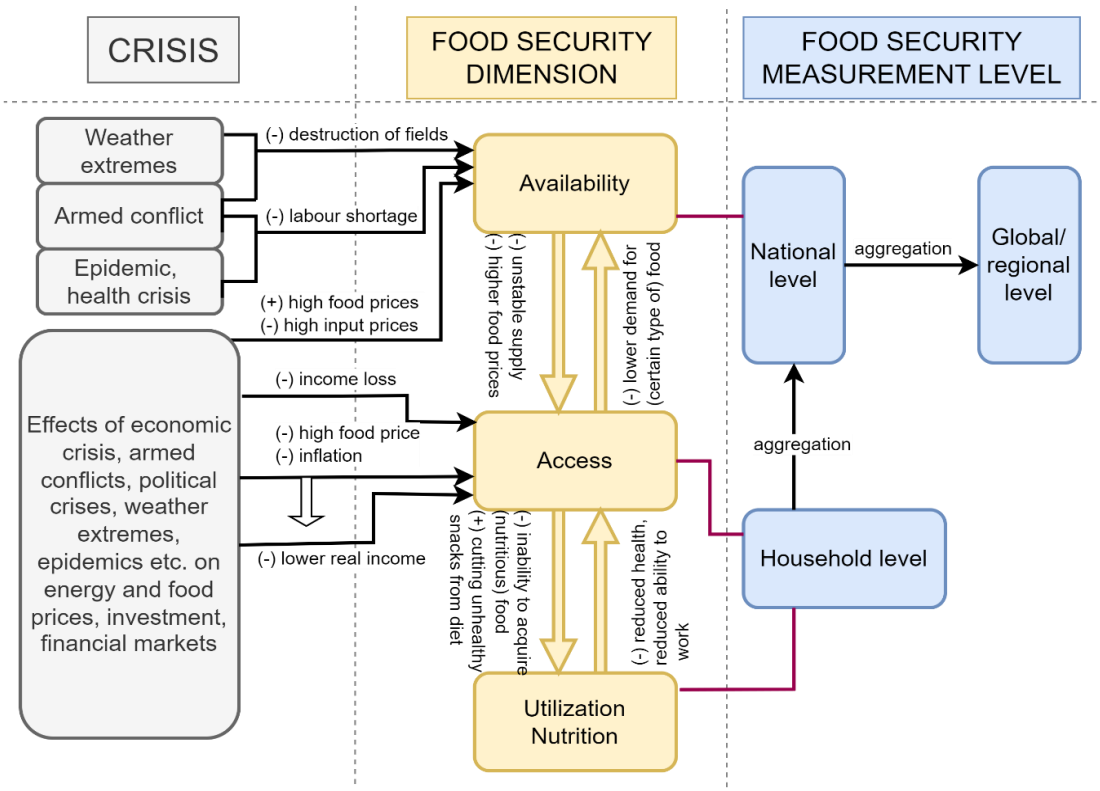
1.3.5. Conceptual framework

Overviewing the development of the relevant theories, definitions, and concepts and the review of the related existing empirical studies formed the following conceptual framework.

Crises can be caused by armed conflicts, economic or political collapses, weather extremes, epidemics, etc. Crisis is a disruption in life-sustaining systems. The well-functioning food system, i.e., food security, is one of the existentially fundamental life-sustaining systems, and this dissertation focuses on those crisis events only that are disrupting the stability of food security.

Armed conflicts and epidemics can lead to agricultural labour shortages. Armed conflicts and weather extremes can have a directly destructive effect on arable land and thus on crops, putting food supply/food availability at risk. While the impact of each crisis event on food security has its own specific characteristics, in principle, apart from the two types of direct impact mentioned, in most cases, the crisis event affects food security through the macroeconomic and financial effects it induces (Figure 2).

Figure 2. Conceptual Framework



Source: Own compilation.

Remark: "Stability" dimension is not displayed on the figure since only availability, access, and utilization dimensions are involved in empirical examinations, and the determination of stability is based on the empirical results regarding the other three dimensions.

The impact of crisis events on the economy can trigger a vicious circle of food insecurity. Food supply shortages due to disruption in food or agricultural supply chains, inflation, and rising energy prices all increase food prices, i.e., reducing real income. The unstable business environment due to a crisis event can end up decreasing investment and ultimately decreasing employment. Income loss can occur resulting from loss of employment or from loss of agricultural income from own production due to the above-mentioned disruption in production. Each change, food price raise, or income loss, but especially the combination of them, reduces the financial and economic accessibility to food for affected households. Low-income households that already had a high food expenditure share tended to shift their diet to a bigger share of cheaper macronutrient-dense but micronutrient-poor staples; in severe cases, they started to reduce the amount of meals they consumed. Poor nutrition can cause health conditions that reduce the ability to work, resulting in further income loss, creating a vicious cycle. The lower demand for (certain kinds of) food can reduce prices if the food insecure group is significant enough

in the given market. If the producers find new markets, the prices may not reduce enough to be affordable to the food insecure group. If producers do not find new markets and due to high input prices, they cannot afford the low local market prices, production and availability will decrease. In an ideal scenario, equilibrium would be restored after short-term shocks through the resolution of crises and the recovery of investment, employment, and household incomes.

1.4. Research structure

1.4.1. Research gaps in the literature

Through the review of the empirical literature, I discovered an either-or problem. The literature typically contains either comprehensive four-dimensions food security analyses that are unrelated to crises or we find crisis impact analyses focusing on only one or two food security dimensions. While the former, the general food security evaluations have small relevance in my research, the latter provide important information for my topic – as can be seen in the literature review above – however, these studies mostly persist in their lack of causal analysis of the impacts of crises on the whole food system. It could not be otherwise, since – as I have presented in the "Concept of food security" subsection – the different dimensions of food security are interdependent; therefore, when we look only at, for example, the availability dimension, we get a picture of the precondition of food security, not of its fulfillment, or when we look only at the utilization dimension, we get a picture of the fulfillment of food security but not of the underlying interplay between actors and actions of the food system. Although the conceptual framework figure (Figure 2) illustrates interactions between dimensions, these findings are derived from separate studies conducted at different times, during various crisis events, and across different groups. What **the literature has not provided is a comprehensive analysis of all dimensions in the context of a specific crisis event**.

As the above-presented literature review demonstrates, the vast majority of the relevant studies focus on the economic access and/or utilization dimensions, which means they are analyzing food security on household level and, in terms of methodology, mainly applying household surveys. Therefore, **another detected gap in the literature is national/regional level statistical analysis of the relationship between crises and food security**. The relevant literature review is introduced in the text of Publication 3 and explaining that random and fixed effects regression, in particular, is a widely used and

effective method for identifying food security determinants. However, I was unable to locate a study that utilizes this method to ascertain whether crisis is a determinant of food security status.

In summary, examining the literature through food security dimensions, crisis impact and methodological lenses, two approaches appeared to be missing from the theoretical body of crisis impact on food security research:

1.) analyzing the impact of a crisis event on all (3+1) food security dimensions to discover the triggered interplays in the food system;
2.) conducting statistical analysis beyond the household level to explore the relationship between crisis events and food security status.

1.4.2. Research questions and structure

The lack of the above-listed approaches led me to form the following two main research questions:

Q1. Could a comprehensive, 3+1 dimensions analysis contribute to discovering new results regarding crisis-caused impacts and their interplays in the food system?

Q2. Can well-established statistical methods—commonly used to identify food security determinants—be effectively applied to assess the deterministic effect of crises on food security?

To find answers to these questions, I divided my research into two parts and published my research results in three publications. In addition to these two methodology-driven main research questions (Q1–2), in the case of each publication, subquestions emerged (SQ1–3), and hypotheses formed (H1–10) specific to the characteristics of the crisis event or economic, food security features of the examined country or region (Table 2).

Table 2. Research structure

Research Part I.
Q1. Could a comprehensive, 3+1 dimensions analysis contribute to discovering new results regarding crisis-caused impacts and their interplays in the food system? → 3+1-dimension analysis of a certain crisis event
• Publication 1: a systematic literature review limited to the COVID-19 pandemic crisis-related effects on food security, without geographical limitation.
SQ1. What segments of food security have been affected by the COVID-19 lockdown and pandemic?

SQ2. Are the COVID-19-related food security problems temporary and “crisis specific” or are they rooted in structural weaknesses?
SQ3. Are new food security objectives needed to mitigate the negative effects of the pandemic and prepare for a possible future pandemic?
• Publication 2: a national-level statistical analysis of the impact of the food price surge in Hungary 2022–2023 on food security.
H1. Despite the overall improvement in food security in Hungary between 2015 and 2020, significant differences in dietary quality persisted across households with different income levels.
H2. Food availability in Hungary remained stable even during the disruptions to food supply chains caused by the COVID-19 pandemic and the Russian-Ukrainian war.
H3. The food price surge in 2022–2023 induced changes in food purchasing patterns through deteriorating affordability.
H4. The change in consumption is not reflected in a reduction in total energy intake but rather in a decrease in the consumption of micronutrients and dietary fiber.
H5. The gap between the dietary quality of the lowest and highest income groups increased in 2022–2023.
Research Part II. **Q2. Can well-established statistical methods—commonly used to identify food security determinants—be effectively applied to assess the deterministic effect of crises on food security?**
• Publication 3: applying a panel data logistic regression model to detect food security determinants and the deterministic feature of crisis events on food security in East, South, and Southeast Asia between 2001 and 2021.
H6. Higher performance of the agriculture sector decreases food insecurity.
H7. The growth of average economic size fosters food security.
H8. Open economic activities positively influence food security.
H9. Higher changes in average temperature are against food security.
H10. Crisis situations cause food security to decrease.

Source: Own compilation.

1.5. Materials and methods

1.5.1. Main methodological approaches in food security research

As the definition of food security evolved, methodological approaches in food security studies also underwent changes. Initially, with a focus on food production, quantitative

methods dominated this research field. However, as the definition expanded to include the household and individual levels, encompassing access to food and nutrition, qualitative methods gained importance. The choice of method depends on various factors such as the level of analysis (individual, household, national, regional, global, or any targeted group or community), the food security dimension, and the characteristics of the study's subject.

Assessment of state of availability is usually measured on national level. The traditional methods to measure availability are the self-sufficiency ratio of main food commodities, food balance sheets, and crop and livestock surveys. It is important to note that although availability is often examined at the regional or global level, the data is, in almost every case, an aggregation of national-level measurements; therefore, in terms of methodology, we cannot talk about global or regional level.

Access (economic, physical, and social/cultural) is primarily measured at the household level, with analyses often relying on household surveys that collect data on income, expenditures, and consumption patterns. While household surveys are crucial for understanding access in depth, statistical analysis of national-level income, expenditure, and consumption data by socioeconomic groups can aid in identifying vulnerable groups for further examination. Additionally, monitoring market prices provides crucial information for estimating or projecting economic access to food.

Special forms of household surveys, such as nutritional surveys and dietary diversity surveys, are applied to measure utilization. In this dimension, data about sanitation, general hygiene, and the level of food wastage are also relevant.

The stability dimension focuses on vulnerability to structural shortcomings or shocks. This involves recognizing vulnerable groups by analyzing the state of the other three dimensions using the aforementioned methodological approaches. It also entails identifying exposure to risk factors such as natural disasters, conflict, or economic instability by monitoring weather patterns, crop yields, geopolitical and market situations.

As agricultural, food, and economic policies have significant influence on all the four dimensions, literature-based approaches also play an important role in food security research.

Most studies on food security employ a range of quantitative/qualitative empirical and literature-based methods. However, certain indicators have been created to encapsulate the state of food (in)security of countries with a single value, facilitating comparisons for

targeted aid, food, and economic policies. These indicators are multidimensional and rely on descriptive and/or quantitative statistical approaches.

One indicator that must be mentioned is the widely used and referenced Prevalence of Undernourishment (PoU) by the FAO. To calculate PoU, the FAO initially examines Dietary Energy Consumption and Minimum Dietary Energy Requirement. If consumption falls below the minimum requirement, the population is considered to be undernourished. The minimum dietary energy requirement is tailored to each country, considering factors such as sex, weight, and activity distribution within the population. Caloric intake is determined using the Food Balance Sheet (FBS) formula: FBS = P + T – (FW + NFU), where P is food production, T is trade, FW is waste, and NFU is non-food use. The calorie intake per capita is derived from the Food Balance Sheet and the population size. Recognizing the unequal distribution of calories among inhabitants, the FAO seeks to establish a coefficient for the degree of inequality through household surveys (FAO Asia and Pacific Commission on Agricultural Statistics, 2014). PoU, therefore, involves availability and access dimensions and implicates the state of stability.

The Global Food Security Index of the Economist Intelligence Unit has an even more complex structure as it captures availability, affordability (economic access), and quality (utilization) through 28 indicators. Unlike PoU, the Global Food Security Index doesn't hold special relevance in my research; therefore, I do not find it necessary to describe the methodology behind all the 28 indicators. However, this index, by annually measuring 113 countries, creates the most prominent global food security ranking and, therefore, should be mentioned.

1.5.2. Applied methods and data

Depending on the approach required by the level and dimension, both quantitative and qualitative methods have been used in my research. In this chapter, first a level–dimension map of the applied methods and indicators is presented (Table 3), followed by a more detailed description of the methodology of the research. Since article design requires a concise summary of methodology applied, I omitted the description of the *development* of certain methods in my publications and instead introduced the *final* method. In the second part of this chapter, I add some details about methodological dilemmas, impasses that emerged during the process of building the methodological design of each research phase.

Table 3. Methods and data applied in the research by food security dimension and level

		Measurement level of food security		
Dimension of food security		Individual/household	National	Regional
	Availability		Self-sufficiency ratio of main food commodities	→ national results aggregated on regional level
			cereal import dependency ratio	
			Statistical analysis of • production of main agri-food commodities • net trade of main food commodities • supply (food, protein, fat)	→ national results aggregated on regional level
			Prevalence of	
	Access	Household survey on • socioeconomic characteristics; • income; • food and general expenditures; • food purchasing patterns; • place of food purchase • influential factors in food purchasing decisions	Undernourishment	
			Food Expenditure Share	
			Share of basic expenditures	
			Statistical analysis of • food consumption; • income and expenditure by socioeconomic groups	
	Utilization	Nutritional survey	→ household level nutritional survey results aggregated on national level	
	Stability	Household survey on • responds to food price shock	Literature based weather related risk analysis Global Climate Risk Index Analysis of data of conflict • refugees • number of deaths in battle	Literature based geopolitical analysis

Source: Own compilation

1.5.2.1. Qualitative methods

1.5.2.1.1. Systematic literature review – qualitative analysis

The first phase of my research (Publication 1) focused on understanding the impacts of the COVID-19 pandemic-related economic issues on the 3+1 dimensions of food security. Therefore, with one of my supervisors, Attila Jámbor, we conducted a systematic literature review based on the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses, Page *et al*., 2020) method, which was originally created for meta-analysis of literature of medical science; however, the transparent and logical structure of the PRISMA guidelines made it popular in other than medical research fields as well. In food security research da Silva *et al*. (2020), Nosratabadi *et al*. (2020), Gassara and Chen (2021) and Sahu *et al*. (2024) applied it recently.

PRISMA guidelines have a 27-item checklist covering each phase of the literature review (search strategy, review protocol, meta-analysis, etc.). The data collection started in October 2020, and we ran our last search in April 2021. During this period, we conducted regular searches and systematized the literature found and kept notes of this process throughout.

1. Search Strategy: Databases, Keywords
    a. Time of literature collection: from October 2020 to April 2021
    b. Search engines: Web of Science, Scopus: The decision to select Scopus and Web of Science as our search platforms was influenced by the rigorous peer review process utilized by the majority of journals indexed in these databases.
    c. Keywords: Initially, we searched using a basic pairing of the terms "food security" along with “covid” or “coronavirus”. However, we overlooked certain pertinent studies, particularly those related to dietary habits. Therefore, we broadened our search criteria to include "food choice" and “food access”.
2. Eligibility Criteria
    a. Research article
    b. The article provides empirical data on the impact of COVID-19 on food security, encompassing perspectives from consumers and/or producers.
    c. Quality requirements: transparent data collection, grounded analysis methods, well-argued conclusion.

3. Removing Duplicates
    a. Number of duplicates removed: 359
    b. Articles remained after removing duplicates: 426
    c. Method: We used the Microsoft Word compare tool to examine the bibliographies from both search engines.
4. Screening based on abstracts:
    a. Number of remaining articles: 139
    b. Method: By reviewing the titles and abstracts, we filtered out studies that were unrelated to our topic. Whenever an abstract detailed the methodology, we excluded reviews, comments, and notes. We chose not to restrict our search exclusively to “articles only”, since, based on our experience, this filter isn't always accurate, and we wanted to avoid mistakenly omitting a study that might have fulfilled our criteria.
5. Eligibility, inclusion:
    a. Number of remaining articles: 51
    b. Method: After examining the full text of the remaining articles, we filtered out those that (1) did not contain original empirical findings contrary to what their abstracts indicated, and (2) did present empirical findings but failed to meet our criteria for transparent data collection and methodological robustness.
6. Analysis
    a. Qualitative analysis: Despite the quantitative results in the articles, the variability of sampling and analysis methods across the articles made it impossible to conduct a statistical meta-analysis, we were still able to carry out an overview and summary focusing on the research design aspects of the articles and undertake a qualitative analysis.
    b. Sorting articles by research-design-related characteristics (sample size, time of data collection, and place of data collection).
    c. Predefined groups: We followed our eligibility criteria (see above) which determined two groups:
        i. GROUP1 – consumer/demand/household/access/utilization: Food consumers embody the market demand, and, within the concept of food security, they offer insights at the household level regarding the access and utilization of food.

ii. GROUP2 – producer/supply/availability: Food producers create the supply for consumers, and in terms of food security, their output dictates the availability of food.

d. Groups developed from the literature: Given that the aforementioned two groups were integral to our inclusion criteria, by the conclusion of our selection phase, the articles had naturally segregated into two primary categories. Subsequently, we assigned codes to the articles reflecting the themes of their findings regarding the COVID-19 pandemic's impact on food security. These coding categories emerged from the articles' findings rather than being predetermined. Through a process of comparison and synthesis of our codes, we created our final subgroups.

1.5.2.1.2. Semi-structured interview

In the second phase of my research (Publication 2), where I was exploring the impact of the 2022–2023 food price surge in Hungary on national and household levels, I faced a lack of information about the actual number of undernourished people in Hungary. Hungary is considered to be a food-secure country (being a high-income economy and net food exporter); consequently the country-level food security reports and analyses present the lowest value used by them for undernourishment (less than 2.5% PoU by FAOSTAT) or do not present data in this regard at all (GFSI, 2022). However, the Hungarian Food Bank reported that they donated food for 248 thousand people in need in the first half of 2023 (Élelmiszerbank, 2023). I considered the Food Bank to be a relevant source of information on the level of undernourishment in Hungary since they are the biggest food-donating organization in the country. I reached out to the directorate of the Food Bank and conducted a semi-structured interview with one of the management board members.

My first intention was to conduct a structured interview by preparing a survey and requesting certain values and statistics, but during the preparation for the interview, I realized that the fact that the information is extremely limited in regard to this issue, it would be a better decision to give more space for free association and generally allow this person who is working in food donating to introduce the situation to me in his/her own way. Semi-structured interviews serve precisely this purpose.

I followed the guidance of Gill *et al*. (2008). According to the interviewee's current life situation, a telephone interview was the most executable solution. I informed the

interviewee about me being a PhD student of the Corvinus University of Budapest and about the topic of my research and made it clear that the results will be published. Instead of a well-defined question, I told the interviewee the fact that I cannot find data on undernourishment in Hungary, and I would like to know his/her experiences, knowledge, or even data if he/she has any. – Although I understand that asking for data blurs the line between structured and semi-structured interviews and between quantitative and qualitative data collection, but for the sake of my research, I had to accept the crossover between methodological categories, since if the interviewee could provide data, it would greatly contribute to clarifying my research questions and clarifying the state of food security in Hungary. A couple of times during the interview, the interviewee was hesitant and said things like "I don't know if you were thinking about something like this". I confirmed that "yes, exactly, and I would like to hear more about this topic", but there was no need to press the issue during the interview. We agreed on anonymity; however, in contrast to the recommendation of Gill *et al*. (2008), I brought up this issue at the end of the interview, since at the beginning I forgot it due to my excitement. We also agreed that before publication I will e-mail to him/her the respective paragraphs for confirmation. My interviewee requested minor corrections in the text and agreed on publication.

1.5.2.2. Quantitative methods

1.5.2.2.1. Quantitative data collection

In my household-level research (Publication 2) I conducted a household survey to 1.) fill the gap of official data (food expenditure and consumption data available only until 2020), 2.) identify changes in food purchasing and food consumption habits that are especially related to the food price surge.

The questionnaire was shared on the social network in the form of a Google form. The initial sharing locations were chosen to cover as wide a socio-demographic spectrum of respondents as possible, and then, after the initial sharing, many respondents reshared it in a snowball manner on their own platforms or in online groups they visited. The questionnaire consisted of two parts. The first part asked for socio-demographic data and the average monthly income, total expenditure, and food expenditure of the respondent's household, while the second part contained questions exploring changes in food purchasing habits and their reasons for change between January 2022 and the time the questionnaire was completed. In designing the questionnaire, particular attention was paid to food security problems and threats previously identified in the literature and inferred

from the analysis of public data. After cleaning, the data were analyzed using descriptive (distribution, mean) and mathematical statistical methods.

The questionnaire was available for completing in November 2023. The final sample size after cleaning of the 321 completed questionnaires received was 300.

1.5.2.2.2. Descriptive statistical methods

1. Household-level research (Publication 2): Descriptive statistics were applied in this research phase to systematize and understand the data from my survey and to see how the survey sample differs from the national average values.
2. National level research (Publication 2): Descriptives were important to be able to calculate on a national level in a manageable way (on income, expenditure, consumption, etc.), and be able to observe trends.
3. Regional level research (Publication 3): In the regional research phase, descriptive methods were useful, especially to position the regions in the world in terms of their importance as food producers and consumers by comparing mean values belonging to each region to each other and to the global values.

1.5.2.2.3. Mathematical statistical methods

1. Spearman's Rank Correlation

a. Publication 2
b. Objective: Assess the relationship between income level and dietary quality.
c. Theoretical background: Schober *et al*. (2018)
d. Variables
    i. Net **income** per capita by income deciles (HUF), Data source: Hungarian Central Statistical Office: Data table: Nr. 14.8.1.5.
    ii. Cereals; Meat and Meat Products; Fish and Fish Products; Fats; Fruits; Vegetables and Potatoes annual food **consumption** volume per capita by income deciles (kilogram), Data source: Hungarian Central Statistical Office: Data table: Nr. 14.1.1.27.
e. Assessing data normality
    i. Graphical method – Histogram

ii. Result: According to the histogram, income data obviously does **not** perform bivariate normal distribution.

f. Choosing a correlation method: Since the data is not normally distributed, the Pearson Correlation Coefficient should not be applied; however, Spearman Rank Correlation – which is basically a Pearson Correlation only it is calculated not by the actual values but with the rankings of values – is a compatible solution.

g. Calculation:

i. Calculation conducted in Microsoft Excel Software

ii. Formula of Spearman Rank Correlation, when $\boldsymbol{\rho}$ = Spearman Rank Correlation Coefficient, $\mathbf{d_i}$ = difference of the ranks of each observation, **n** = number of observations:

$$\rho = 1 - \frac{6\Sigma\, \mathrm{d}_i^2}{n(n^2-1)}$$

iii. Using "RANK" formula to rank the variables within their data line for both income and cereals, meat etc. consumption variables.

iv. Calculate the difference between the rank of the observations (d).

v. Calculate the Spearman Correlation Coefficient (p-value) by the formula above.

h. Interpretation of the r-values.

2. Pearson Correlation Coefficient

a. Publication 2

b. Objective: Assess the relationship between average monthly per capita income and food expenditure rate for different socio-demographic groups.

c. Theoretical background: Schober *et al*. (2018)

d. Variables

i. Average monthly per capita income (HUF). Source: own household survey detailed above.

ii. Food expenditure rate for different socio-demographic groups (age, sex, education, municipality type, employment status). Source: own household survey detailed above.

iii.

e. Assessing data normality

i. Graphical method – Histogram
ii. Result: Data performs bivariate normal distribution → Pearson's Correlation Coefficient is applicable.

f. Calculation:
   i. Calculation conducted in Microsoft Excel Software.
   ii. Formula of the Pearson Correlation Coefficient, when **r** is the Pearson Correlation Coefficient, and **x** and **y** are the sample means.

$$r = \frac{\sum(x-\bar{x})(y-\bar{y})}{\sqrt{\sum(x-\bar{x})^2 \sum(y-\bar{y})^2}}$$

g. Interpretation of the r-value.

3. Generalized Least Square Random Effects Regression Model

a. Publication 3
b. Objective: 1.) Identify the determinants of food security in East, Southeast, and South Asia between 2001 and 2021, based on a dataset containing 357 observations. 2.) Assessing if "crisis" variables are determinants of food security.
c. Variables:

Table 4. Description of variables

Variable name	Variable description	Unit of measurement	Data source	Expected sign on POU
POU	Prevalence of undernourishment	%	FAOSTAT	N/A
POP	Total population of the country	1000 people	FAOSTAT	+
GDP	GDP (annual value)	Million $, 2015 prices	FAOSTAT	-
FDI	FDI-inflow	Million $, 2015 prices	FAOSTAT	-
EXCH	Exchange rate of local currency to USD	Local currency/$	FAOSTAT	+
CIDR	Cereals import dependency ratio	%	FAOSTAT	+
AGREMP	Share of agricultural employment in total employment	%	FAOSTAT	-

GPVAGRI	Gross production value of agriculture	1000 $, 2014-2016	FAOSTAT	-
PPRICEAGRI	Producer prices of agricultural products	%, 2014-2016 =100%	FAOSTAT	+
TEMP-CHANGE	Temperature change on land	Celsius	FAOSTAT	+
REFUGEE	Dummy: refugees 1= share of refugees in the host country's population bigger or equal to 0.01% 0= share of refugees in the host country's population smaller than 0.01%	Binary	World Bank	+
DEATHS	Dummy: fatalities in battle 1= fatal casualties happened on battlefield on the territory of the country 0= no fatal outcomes of battle on the territory of the country	Binary	Uppsala Conflict Data Program	+
PRICEBOOM	Dummy: price boom in East, South, Southeast Asia 1= the years of remarkable food price increases in the three regions: 2007, 2008, 2011, 2014, 2019, 2020 0=rest of the years	Binary	-	+
CRISES	Dummy: crises 1= years of the food price crisis in 2007, 2008, years of COVID19 in 2020, 2021 0= rest of the years	Binary	-	+
DELAYED-CRISES	Dummy: delayed crises 1= dummy-crises+1 year 0= rest of the years	Binary	-	+

Source: Jambor, A. and Éliás, B. A. (2024). Determinants of Food Security: A Comprehensive Analysis Across East, South, and Southeast Asia. *Journal of Sustainability Research*, *6*(2), p. 7.

d. Applied formula when *i:* given country, *t*: given year, (abbreviations of the variables are represented in Table 4).

$$POU_{it} = \alpha_0 + \alpha_1 POP_{it} + \alpha_2 GDP_{it} + \alpha_3 FDI_{it} + \alpha_4 EXCH_{it} + \alpha_5 CIDR_{it} + \alpha_6 AGREMP_{it} + \alpha_7 GPVAGRI_{it} + \alpha_8 PPRICEAGRI_{it} + \alpha_9 TEMPCHANGE_{it} + \alpha_{10} REFUGEE_{it} + \alpha_{11} DEATHS_{it} + \alpha_{12} PRICEBOOM_i + \alpha_{13} CRISES_i + \alpha_{14} DELAYEDCRISES_i + v_{ij} + \varepsilon_{ij} \quad (1)$$

e. Calculation: by STATA software.

f. Interpretation of results.

2. Brief introduction of Publication 1

2.1. Bibliometrics

Éliás, Boglárka Anna and Jámbor, Attila. (2021). Food security and COVID-19: a systematic review of the first-year experience. *Sustainability*, 13(9), 5294; **https://doi.org/10.3390/su13095294**.

Ranking of journal in year of publishing:

Hungarian Academy of Science – IV. Section of Agricultural Sciences: A,

SJR Q1.

2.2. Targeted research question

Q1. Could a comprehensive, 3+1 dimensions analysis contribute to discovering new results regarding crisis-caused impacts and their interplays in the food system?

2.3. Research gap(s)

In addition to the original research question (Q1) of my PhD research, I identified a gap in the literature while reviewing findings related to the impact of the COVID-19 crisis on food security in the autumn of 2020. Despite the publication of several relevant empirical results at that time, there was no available review that focused solely on these empirical results. Most of the articles published as reviews were theoretical policy recommendations and implications for potential impacts of the COVID-19 situation on food security. New waves of COVID-19 infections appeared around the world, and policies such as curfews, lockdowns, and travel and transportation restrictions were still ongoing; therefore, there was a need for synthesizing the evidence-based empirical results of the first year of the crisis.

2.4. Subquestions:

SQ1. What segments of food security have been affected by the COVID-19 lockdown and pandemic?

Our goal was to address this query by analyzing empirical results from the first year of the worldwide pandemic. The question targets both food consumers and producers to encompass all dimensions of food security and most components of the food system.

SQ2. Are the COVID-19-related food security problems temporary and “crisis specific” or are they rooted in structural weaknesses?

In terms of policy development, it's important to determine whether the observed decline in food security is a temporary problem that will disappear after the pandemic or whether it is due to long-standing structural problems that have been exacerbated by the pandemic. If it's the latter, simply vaccinating the population and reducing infection rates will not be enough to mitigate the effects.

SQ3. Are new food security objectives needed to mitigate the negative effects of the pandemic and prepare for a possible future pandemic?

Having answered the two research questions above, we compare our claims with the previous global food security narrative and assess whether new global food security goals emerge from the pandemic.

2.5. Key findings

SQ1. What segments of food security have been affected by the COVID-19 lockdown and pandemic?

According to our findings, the COVID-19 pandemic and lockdowns have impacted all dimensions of food security, primarily affecting economic access to food mostly in line with previous literature (Laborde *et al*., 2020; Béné, 2020). Financial challenges, such as low household income (31.8% of the articles focusing on household food security reported this problem), income loss (43.2%), and rising food prices (4.5%), were the main reasons for increased food insecurity, particularly in low-income countries.

Dietary shifts included reduced consumption of healthy foods due to affordability issues (22.7%) and emotional stress (27.3%), leading to less nutritious eating habits, while some individuals adopted healthier diets for immunity (9.1%) or weight management (4.5%).

Physical access to food was also hindered by movement restrictions and fear of infection, leading to temporary food shortages in the households (6.8%).

The pandemic disrupted food production through decreased demand and sale prices (77.7% of the articles focusing on food availability/food production reported this problem) labor shortages (33.3%), increased costs (22.2%) and transportation difficulties (33.3%) but did not significantly reduce overall production levels.

SQ2. Are the COVID-19-related food security problems temporary and "crisis specific" or are they rooted in structural weaknesses?

Our review found some effects being temporary and expected to revert to pre-pandemic conditions once restrictions are lifted and case numbers decrease. Temporary effects

include limited physical access to food due to panic buying, movement restrictions, or infection fears, and negative dietary changes driven by anxiety and loneliness, which are likely to improve with the restoration of social connections. For producers, the resolution of market access and labour mobility issues is also anticipated post-restrictions.

However, the review highlights that the most significant and persistent challenge is the low income of households. Low-income households, lacking sufficient savings and the ability to bulk purchase, face difficulties affording nutritious food due to income loss and rising prices, impacting demand for producers. This issue reflects a deeper, structural problem within global food security, underscoring low income as the core factor detrimentally affecting food security during the crisis.

SQ3. Are new food security objectives needed to mitigate the negative effects of the pandemic and prepare for a possible future pandemic?

We concluded that the primary lesson from the COVID-19 pandemic for food security is not the need for new global objectives but a heightened focus on poverty reduction and increasing the income of low-income households. This approach is deemed essential for preparing for future crises by ensuring that households have economic access to food through adequate wages, which enhances food security under normal conditions and builds resilience against various crises. The pandemic has shown that while it's possible to prepare for some disruptions, unforeseen challenges like COVID-19 present novel problems. Strengthening structural weaknesses, such as financial insecurity, can mitigate the broader impacts of crises on food security.

2.6. Author contributions

Conceptualization, B.A.É. and A.J.; methodology, B.A.É.; software, B.A.É.; validation, A.J.; formal analysis, B.A.É.; investigation, B.A.É.; resources, A.J.; data curation, B.A.É.; writing — original draft preparation, B.A.É.; writing — review and editing, A.J.; visualization, B.A.É.; supervision, A.J.; project administration, A.J.; funding acquisition, A.J.

3. Complete text of Publication 1

Food Security and COVID-19: A Systematic Review of the First-Year Experience

Abstract

For decades, global food security has not been able to address the structural problem of economic access to food, resulting in a recent increase in the number of undernourished people from 2014. In addition, the FAO estimates that the number of undernourished people drastically increased by 82–132 million people in 2020 due to the COVID-19 pandemic. To alleviate this dramatic growth in food insecurity, it is necessary to understand the nature of the increase in the number of malnourished during the pandemic. In order to address this, we gathered and synthesized food-security-related empirical results from the first year of the pandemic in a systematic review. The vast majority (78%) of the 51 included articles reported household food insecurity has increased (access, utilization) and/or disruption to food production (availability) was a result of households having persistently low income and not having an adequate amount of savings. These households could not afford the same quality and/or quantity of food, and a demand shortfall immediately appeared on the producer side. Producers thus had to deal not only with the direct consequences of government measures (disruption in labor flow, lack of demand of the catering sector, etc.) but also with a decline in consumption from low-income households. We conclude that the factor that most negatively affects food security during the COVID-19 pandemic is the same as the deepest structural problem of global food security: low income. Therefore, we argue that there is no need for new global food security objectives, but there is a need for an even stronger emphasis on poverty reduction and raising the wages of low-income households. This structural adjustment is the most fundamental step to recover from the COVID-19 food crises, and to avoid possible future food security crises.

Keywords: COVID-19; food security; pandemic; low-income; income loss; vulnerable groups; systematic review; household food security; food production; food price; input shortage

Introduction

On the 22nd of January in 2020, the mission of the World Health Organization in Wuhan, China confirmed evidence of the first human-to-human infection case of SARS-CoV-2 (COVID-19) (WHO, 2020a). In less than two months, on 11th of March, Dr Tedros Adhanom Ghebreyesus, Director-General of the World Health Organization, described the COVID-19 outbreak as a global pandemic (WHO, 2020b). In the following weeks the whole world experienced a rapid global spread of the virus. National governments began to reorganize their healthcare system, ordered lockdowns, curfews, travel and transportation restrictions, and further measures which they considered to be important to slow the spread of infections. Since the outbreak of the pandemic, more than 2.7 million people have lost their life due to COVID-19 infection (Worldometers, 2021) (according to estimations from the IMF), the global real GDP growth rate dropped by more than seven percent from 2019 to 2020 (IMF, 2020) (a deeper recession than during the financial crisis of 2008–2009, Laborde, *et al.,* 2020), and, simultaneously, the number of undernourished people has possibly increased by between 82 and 132 million in 2020 (FAO, 2021).

This dramatic increase has boosted the devastating trend of the number of undernourished people increasing since 2014, after a decade of decline. In 2019, the estimated number of undernourished people reached 687.8 million, an almost 60 million increase compared with 2014 (FAO, 2021). Note that, in 2019, 13 countries provided new data about population, food supply and the results of household surveys for FAO. One of the 13 countries was China, with around 19 percent of the world's population; consequently, the new data caused a significant change. After the revision of previous estimations, it was found that the number of undernourished people was overestimated by around 150 million people. According to FAO projections, the number of undernourished people will reach 841.4 million by 2030, ceteris paribus. However, this calculation did not take into account the effects of COVID-19, implying significant changes compared with the pre-COVID-19 structural problems of global food security (FAO, 2021).

Several food security concepts exist; we followed the most widespread concept, FAO's concept, which divides the complex food security issues into four clear dimensions:

availability, access, utilization, and the stability of the previous three (FAO, 2009b). In addition to the four dimensions, we can also distinguish between structural and temporary food security problems (World Bank, 1986). After the improvement in availability and physical access through producing more than enough food for the global population and developing rural infrastructure in several regions, the global food security focus shifted to the issue of economic access, which is still the deepest structural obstacle to reducing under- and malnutrition. The narrative that economic growth must reach even the poorest has been a constant part of the objectives of the FAO for many years, and data showed that the growth of income inequality increases the likelihood of severe food insecurity (FAO, 2019). Low income has a negative impact on several layers of food insecurity, it is responsible for hunger, undernourishment (food quantity) and malnutrition (food quality) (FAO, 2021). Furthermore, adequate income and savings are crucial parts of food consumer resilience (Béné*,* 2020), which is essential to avoid food shocks during such unexpected negative events as income loss, sickness, environmental disasters, pandemics, etc. In other words, a structural problem of food security is obstructing the effective resolution of a temporary crisis.

Today, we are experiencing a global temporary food security crisis together with the COVID-19 pandemic. Its effect has a strong and complex relationship to pre-existing structural weaknesses. The aim of this paper is to investigate how the COVID-19 pandemic has affected global food security, after one year of the virus outbreak, based on the available empirical results.

As food supply was one of the major concerns at the beginning of the first lockdown, as panic-buying clearly showed, reviews and policy recommendations were published even in the early months of the pandemic on this subject. These papers had crucial importance in supporting decision-making by emphasizing the present challenges and the potential mid- and long-term threats.

The early publications warned that economic access/affordability were threatened from two directions: households were losing their income partially or completely as a result of lockdowns (Béné, 2020; Laborde *et al.,* 2020); and, at the same time, food prices could increase due to supply shortages caused by transport and travel restrictions (Béné, 2020; Devereux *et al.,* 2020; Laborde *et al.,* 2020;) and the retention of cereal exports from major suppliers, such as Russia, Kazakhstan, Vietnam and Cambodia (Workie *et al.,* 2020). In parallel with income loss, non-staple food, such as fruits, vegetables and animal

protein, became less affordable (Laborde *et al.,* 2020). Low-income households may be further burdened by the loss of school meals as a result of school closures in many places (Laborde *et al.,* 2020). In addition to economic access reduction, some physical-access-related problems emerged as well because of movement restrictions (Béné, 2020; Devereux *et al.,* 2020; Workie *et al.,* 2020; Naja and Hamadeh, 2020). The fear of losing physical access to food resulted in panic-buying (food hoarding that caused a short, temporary supply shortage at the beginning of the first wave of the pandemic) and put those who were not fast enough or could not afford buying in large amounts at once in a difficult situation (Workie *et al.,* 2020; Naja and Hamadeh, 2020).

However, there was a consensus in the literature that food access is the most vulnerable dimension; some articles drew attention to potential threats to availability/production. Movement restrictions could cause a decline in demand and disruption in labor and other inputs' supply (Béné, 2020). Laborde *et al*. (2020) projected that the effect is more severe on low-income countries, where farming is more labor-intensive than high-income countries that have widespread large-scale mechanized farming with farmers that are less exposed to infection. Workie *et al*. (2020) outlined a more detailed picture of the possible effects on agriculture in developing countries. According to their claims, supply shortages will hit developing countries to a smaller extent, compared with developed counties, because developing countries are less dependent on material inputs but more dependent on labor, and the labor shortage will cause obstructions in production.

The most negative effects are expected on both the consumer and producer sides in low-income countries, especially in South Asia and sub-Saharan Africa, as many people do not have sufficient savings or available social safety nets; therefore, the greatest decrease in food demand is expected to be in developing countries (Laborde *et al.,* 2020; Workie *et al.,* 2020).

As mentioned above, these early publications played an important role in supporting policymakers in a situation which the world has not experienced before. However, these papers could only rely on a small number of empirical results, as the availability of evidence-based empirical research results was limited in the first months of the COVID-19 pandemic. One year on from the outbreak of the global pandemic, it is important to gather and systematize the available empirical evidence and compare the initial projections to the experience gained over the past year; the sooner we understand the

effects of the COVID-19 pandemic and lockdowns on food security, the better measures taken to mitigate these negative effects in the long term can be.

The available systematic reviews related to this topic were published in the first months of the pandemic (Jámbor *et al.,* 2020; Rahman *et al.,* 2020) or limited to a certain country (Sereenonchai and Arunrat, 2021), thus, we consider that this systematic review will fill a gap in the analysis of empirical data from a one-year perspective; as far as we know, this will be the first paper to revise global food security objectives in consideration of the effects of the pandemic.

Research Questions

Q1. What Segments of Food Security Have Been Affected by the COVID-19 Lockdown and Pandemic?

We aimed to answer this question through empirical evidence from the first year of the global pandemic. This question focusses on food consumers and producers to cover all four food security dimensions.

Q2. Are the COVID-19-Related Food Security Problems Temporary and "Crisis Specific" or Are They Rooted from Structural Weaknesses?

For policymaking, it is crucial to understand whether the experienced drop in food security is temporary and will recover when the pandemic ends, or it is coming from pre-existing structural problems which have become even deeper because of the pandemic. In the second case, vaccination and reducing the number of infections is not sufficient—further measures are required.

Q3. Are New Food Security Objectives Needed to Mitigate the Negative Effects of the Pandemic and Prepare for a Possible Future Pandemic?

After answering both research questions above, we compare our claims to the former global food security narrative and assess whether there are new global food security goals emerging from the pandemic.

Materials and Methods

Our systematic data collection and analysis process was conducted by following the PRISMA (preferred reporting items for systematic reviews and meta-analyses) guidelines (Page *et al.,* 2021). As a first step, we set up our review protocol, a well-defined inclusion, and exclusion criteria and developed our search strategy. The data collection started in

October 2020 and we ran our last search in April 2021. During this period, we conducted regular searches and systematized the literature found and kept notes of this process throughout.

i. Search Strategy: Databases, Keywords

We used Scopus and Web of Science search engines for our data collection. The fact that vast majority of the journals that are included in the Scopus and Web of Science databases use a strict professional review procedure played a role in choosing these two search engines. First, we used the simple combination of "food security" and covid/coronavirus keywords, but this resulted in some relevant articles being missed, especially in regard to diet; thus, we extended our search with "food choice" and "food access" (Table 5) and limited the result to the years 2020 and 2021.

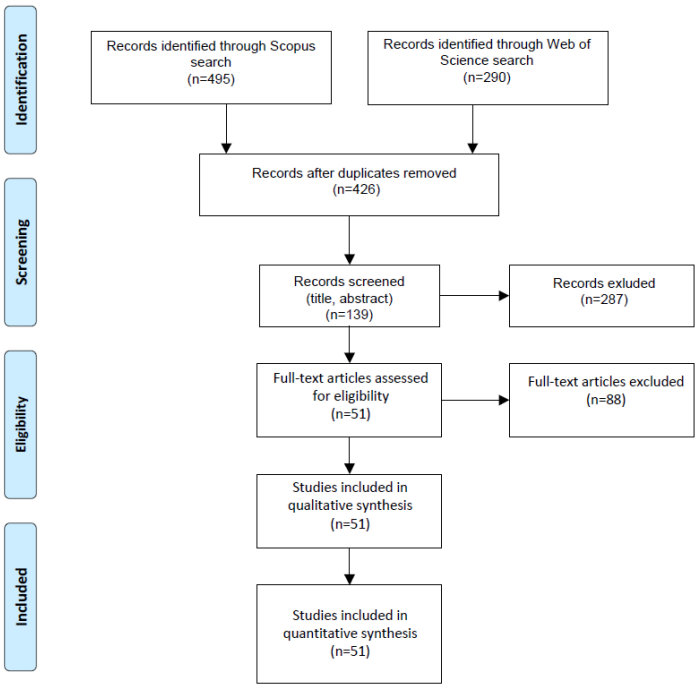
Table 5. Search keywords.

"food security"				
OR				
"food access"	AND	covid	OR	coronavirus
OR				
"food choice"				

ii. Selection

The PRISMA flow diagram (Figure 3) presents how the number of articles were reduced through the selection procedure.

Figure 3. PRISMA flow diagram.



Source: Own results presented through the PRISMA flow diagram composition of Page *et al*. (2021).

iii. **Eligibility Criteria**

The first step of the selection procedure started prior to data collection. In the research protocol, we defined the following eligibility/inclusion criteria:

1. Research article;
2. The article includes original empirical evidence related to COVID-19 effects on food security (from consumer and/or producer side);
3. Quality requirements: transparent data collection, grounded analysis methods, well-argued conclusion.

iv. **Duplicates**

After running multiple searches according to the strategy above, we found and removed 359 duplicates from the results. For detecting the duplicates, we used the Microsoft Word compare function to compare the bibliography list of the results from the two search engines and, by alphabetical sorting, we identified the duplicates within one search engine. This semi-manual semi-mechanical method allowed for fast but thorough filtration.

v. Screening

Through reading the titles and abstracts, we excluded papers which were not related to our subject. Where the abstract provided details about methodology, we screened out reviews, comments and notes. (We did not limit our search to "articles only" because, according to our experience, this function is not always reliable and we did not want to risk excluding a paper that otherwise would meet our requirements.) In the first months of the pandemic, the number of empirical research articles was greatly exceeded by the number of various reviews and policy recommendations, leaving only 139 articles at the end of the screening.

vi. Eligibility, Inclusion

We read the full text of the remaining articles and screened out (1) papers which, despite what the abstract suggested, did not include original empirical results and (2) papers that presented empirical results but lacked the quality requirements described above. We found 51 papers that met our eligibility criteria and were suitable for inclusion in qualitative synthesis.

Analysis

Although the quantitative results of the articles—due to the different data collection, sample and analysis methods—were not homogeneous enough for conducting a statistical meta-analysis, it was possible to perform an overview and summary about the research-design-related elements of the articles and conduct a qualitative analysis.

Research-Design-Related Characteristics

We systematized the articles according to their research design, sample size, time of data collection and place of data collection.

Qualitative Analysis

Predefined groups:

Our eligibility criteria determined two groups:

1. GROUP1: consumer/demand/household/access/utilization approach

Food consumers represent the demand on the markets and, in the food security concept they provide the household-level information about the state of food access and utilization.

2. GROUP2: producer/supply/availability approach

Food producers are providing the supply for the consumers, in food security terms their production determines the availability of food.

Groups developed from the literature

As the two groups presented above were part of the inclusion criteria, the articles were already divided into two main groups at the end of the selection process. Then, we coded the articles based on the topics of their findings related to the effects of the COVID-19 pandemic on food security. These codes were not predefined, they were developed from the findings of the articles. We then compared and synthesized our codes, and obtained our final subgroups, which are the following:

Subgroups of GROUP1:

GROUP1.1. INCOME_LOSS

GROUP1.2. VULNERABLE_GROUPS

GROUP1.3. LESS_HEALTHY_DIET

GROUP1.4. POSITIVE_CHANGE

Subgroups of GROUP2:

GROUP2.1. FACTORS_OF_PRODUCTION

GROUP2.2. PRICE

GROUP2.3. OUTPUT

GROUP2.4. TRANSPORT

Results

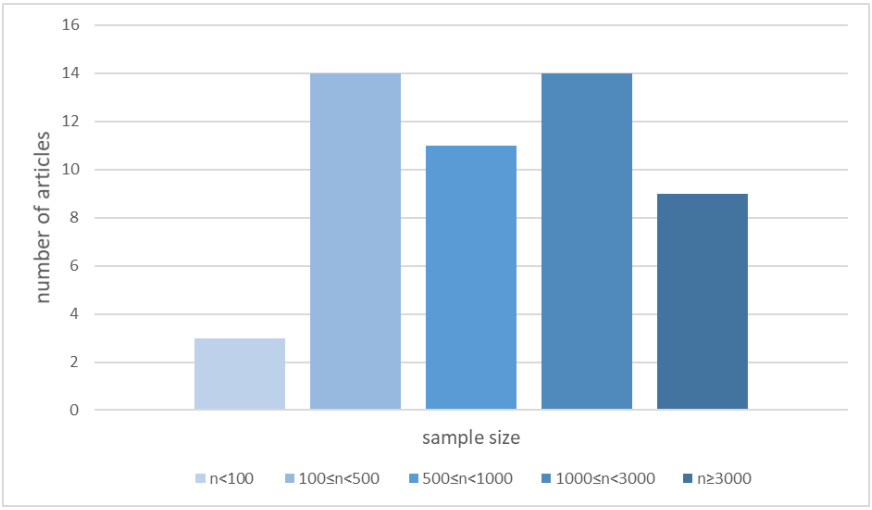
1. Research Design

All of the articles used a descriptive design and the survey data collection method. We assumed that survey design was the most suitable for the pandemic, given circumstances such as social distancing and movement restrictions, as surveys could be easily conducted online, contrary to qualitative data collection methods.

2. Sample Size

Figure 4 presents the number of articles with different sample sizes. 14 articles worked with data from 100–500 and another 14 with 1000–3000 respondents. The smallest sample size category (less than 100 respondents) was the least common, only three articles had this size of sample.

Figure 4. Number of articles by sample size.

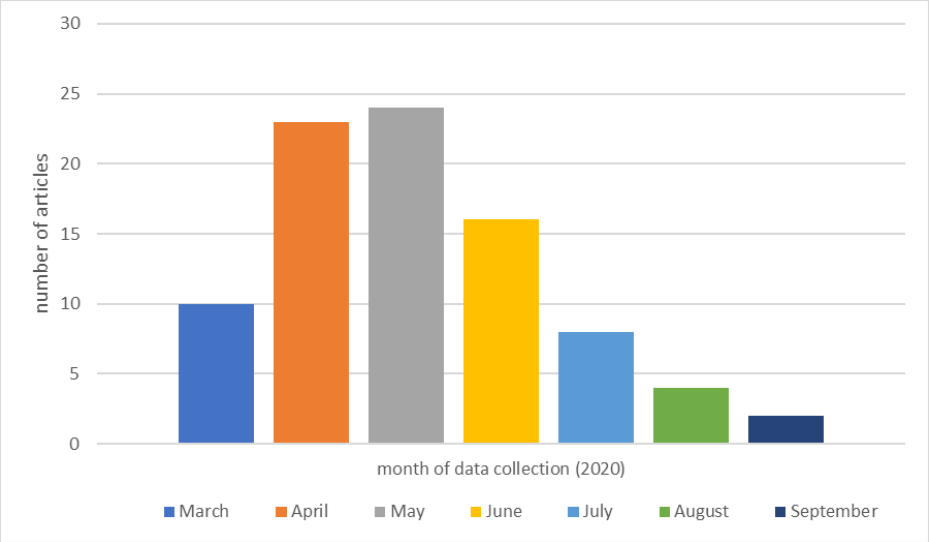


Source: Own calculations.

3. Time and Place of Collection

Figure 5 shows how many articles include collected data from certain months. On the figure, more articles appear than we have included in the review in total because if an article's data collection period lasted, for example, from May to July, it appears in each month's column. The articles which were available before April 2021 and used in our review lean on data mostly from the first months—mostly April and May—of the global pandemic.

Figure 5. Number of articles by month of data collection.



Source: Own calculations.

The time of data collection is particularly important in COVID-19-pandemic-related research. There may be large differences between food consumption and production experience of households and producers in periods with high numbers of new COVID-19 cases and lockdowns compared with periods in which restrictions were eased and the number of cases were lower. However, it is important to note that the high number of daily new cases and the introduction of restrictive measures usually (but not necessarily) go hand in hand. We examined the articles one by one to see if the date of data collection took place during a so-called pandemic wave (persistently high daily new cases); for this examination, we used the Worldometers website's coronavirus database which provides data about daily new cases and daily deaths since 15th of February 2020 by countries (Worldometers, 2021). We found that this was the case for 45 articles (88.2%). However, for six articles (11.8%), data collection was conducted in a period of very low numbers of daily new cases (Elsahoryi *et al.,* 2020; Fiorella *et al.,* 2021; Huss *et al.,* 2021; Kansiime *et al.,* 2021; Quaife *et al.,* 2020) or even without daily new cases (Steenbergen *et al.,* 2020), and problems still arose from both the consumer and producer sides. The reason for this was the introduction of preventive government measures. This finding supports the assumption in the early literature (Béné, 2020) that food security is primarily affected not by the health aspect of the pandemic but by the measures to prevent or mitigate the pandemic.

Table 6 summarizes how many articles collected data from certain countries. Of these articles, 29.4% present data from the United States, while the second most common countries for data collection were India and Kenya with 9.8%.

Table 6. Number of articles by country of data collection.

Country of Data Collection	Number of Articles	Country of Data Collection	Number of Articles
Australia	1	Mexico	1
Bangladesh	3	Mozambique	1
Brazil	1	Myanmar	1
Burundi	1	Nepal	1
Cameroon	1	Peru	1
Canada	3	Poland	2
China	1	Senegal	1
Congo (DR)	1	Slovenia	1
Denmark	1	Spain	1
France	1	Tanzania	1

Germany	1	Uganda	1
India	5	United Kingdom	2
Iran	1	United States	15
Italy	2	Vanuatu	1
Jordan	1	Zambia	1
Kenya	5	Zimbabwe	1
Malaysia	2		

Source: Own compilation.

4. Qualitative Results

4.1. Losing income

Many articles in our sample highlighted income loss as one of the most important impacts of COVID-19 on global food security. The extent of income loss and decline in food security varied widely across articles, but each article in this group identified income loss as the main reason (or one of the main reasons) for the drop in food security during the pandemic.

An obvious relationship was observed between income loss and food insecurity. Households who lost their income partially or completely were more likely to experience disruption in their food access (Clay and Rogus, 2021; Kent *et al.,* 2020; Owens *et al.,* 2020; Ruszczyk *et al.,* 2020). Most of the studies collected data on food security only during the lockdown period, however, some articles also provided comparative data on food security before and during lockdowns. Compared to the pre-COVID-19 period, Kansiime *et al*. (2021) reported a 38% increase in the number of food-insecure households in Kenya and a 44% increase in Uganda. The same rate was 45%, according to Kundu *et al*. (2021), while Hamadani *et al*. (2020) reported a 43% increase in Bangladesh. In Brazil, according to Rocha *et al*. (2021), the prevalence of food insecurity among mothers was 15% higher between July and September 2020 than it was in 2017.

There are five studies from the United States which provide comparative data on income loss and food insecurity. Each study processed data collected between March and June 2020; however, their surveys targeted different social groups, thus, the results also vary. Patrick *et al*. (2020) reported a 3–4% increase in food insecurity, while Adams *et al*. (2020) reported 20%. In the article by Dou *et al*. (2021), 30% more people reported worse food security than before the pandemic, one third of the people were more food insecure according to Niles *et al*. (2020), and 60% of the respondents of Mialki *et al*. (2021) claimed to be less food secure. In India (Harris *et al.,* 2020) and Kenya (Quaife *et al.,*

2020), 62% and 74% of respondents, respectively, experienced food insecurity related to decreased income. In some cases, in addition to the partial or total income loss, households even had to face rising food prices (Fiorella *et al.,* 2021; Ibrahim and Othman, 2020). In order to mitigate income-loss-related food insecurity of households, the most common strategy was launching food or financial benefit programs, mostly by governmental organizations (Rocha *et al.,* 2021; Adams *et al.,* 2020; Gupta *et al.,* 2021; Polsky and Gilmour, 2020), but there were examples of households taking loans or borrowing cash from formal or informal sources (Ibrahim and Othman, 2020; Gupta *et al.,* 2021). Ibrahim and Othman (2020) provided information from Malaysia about a third kind of strategy, where 32% of the respondents started to pick vegetables from the area around their house and 27% conducted online business.

4.2. Groups Vulnerable to Food Insecurity

A significant number of the articles identify the groups most vulnerable to food insecurity. We only assigned articles to this group in which the authors explicitly comment on this issue, we did not draw any conclusions from the samples and quantitative results alone. In most cases, persistently low-income households were identified as a group that proved vulnerable during the pandemic (Elsahoryi *et al.,* 2020; Steenbergen *et al.,* 2020; Kent *et al.,* 2020; Kundu *et al.,* 2021; Dou *et al.,* 2021; Ibrahim and Othman, 2020; Polsky and Gilmour, 2020; Gaitán-Rossi *et al.,* 2021; Larson *et al.,* 2021; Lauren *et al.,* 2021; Pakravan-Charvadeh *et al.,* 2021; Parnham *et al.,* 2020; Saxena *et al.,* 2020; Wolfson and Leung, 2020). The occupation of heads of families was closely linked to low incomes. Unstable and/or low-income jobs also made individuals and families vulnerable (Kent *et al.,* 2020; Kundu *et al.,* 2021; Pakravan-Charvadeh *et al.,* 2021). There is evidence from Australia and Bangladesh that living in the countryside is also a vulnerability factor (Kent *et al.,* 2020; Kundu *et al.,* 2021). Further factors that play a role in vulnerability include: living with disability (Kent *et al.,* 2020); living with dependents (Kent *et al.,* 2020; Polsky and Gilmour, 2020; Snuggs and McGregor, 2021); having fewer male children (Pakravan-Charvadeh *et al.,* 2021); travel restrictions (Steenbergen *et al.,* 2020; Wolfson and Leung, 2020); distrust in food (Wolfson and Leung, 2020); farmers having no storage capacity (Huss *et al.,* 2021;); being a younger (Snuggs and McGregor, 2021), especially male (Polsky and Gilmour, 2020), adult; relationship status (Polsky and Gilmour, 2020; Lauren *et al.,* 2021); race (Lauren *et al.,* 2021); and living far from food stores (Snuggs and McGregor, 2021).

4.3. Following A Less Healthy Diet

Various factors played a role in the fact that many people started to follow a less healthy diet during the lockdown. The most common reason was of financial origin. Due to the loss of income and/or the increase in food prices, households could not afford to buy certain foods (Fiorella *et al.,* 2021; Kansiime *et al.,* 2021; Harris *et al.,* 2020; Larson *et al.,* 2021; Litton and Beavers, 2021; Glabska *et al.,* 2020; Shen *et al.,* 2020; Scacchi *et al.,* 2021; Janssen *et al.,* 2021; Chee *et al.,* 2020). Another reason was the change in daily routine due to school closures, working in a home office, movement restrictions, etc. Snacks provided emotional compensation for those who felt bored or lonely (Adams *et al.,* 2020; Dou *et al.,* 2020; Glabska *et al.,* 2020; Shen *et al.,* 2020; Janssen *et al.,* 2021; Chee *et al.,* 2020; Carroll *et al.,* 2020; Marty *et al.,* 2021; Russo *et al.,* 2021; Bin Zarah *et al.,* 2020). Because of the fear of infection, some people went to buy food less often than their diet would have required (Fiorella *et al.,* 2021; Litton and Beavers, 2021), and in some cases, even if consumers went to buy food, there was a temporary shortage of food or of good quality food (Litton and Beavers, 2021). Consumption of non-perishable food, such as canned and frozen foods, increased during the lockdown as well as alcohol consumption (Janssen *et al.,* 2021).

The change in diet meant an increase in the consumption of snacks and processed food (Adams *et al.,* 2020; Larson *et al.,* 2021; Scacchi *et al.,* 2021; Chee *et al.,* 2020; Carroll *et al.,* 2020; Bin Zarah *et al.,* 2020; Sidor and Rzymski, 2020), a decrease in the consumption of fruits, vegetables (Kansiime *et al.,* 2021; Harris *et al.,* 2020; Litton and Beavers, 2021; Bin Zarah *et al.,* 2020) as well as meat and fish (Fiorella *et al.,* 2021; Harris *et al.,* 2020). From Italy, Scacchi *et al*. (2021) reported an increase in vegetable and fruit consumption, but a decrease in fish consumption. As a result of the negative diet shift and decreased exercise, people experienced varying degrees of weight gain (Adams *et al.,* 2020; Dou *et al.,* 2020; Sidor and Rzymski, 2020).

4.4. Positive Change

Although the pandemic generally raised concerns and barriers to food security, some empirical studies report positive changes. Harris *et al*. (2020) reported that 15% of the respondent farmers consumed more vegetables during the lockdown than before, and Larson *et al*. (2021) and Rodríguez-Pérez *et al*. (2020) also found that some of the respondents paid more attention to eating healthier to boost their immunity. Glabska *et al*. (2020) reported that health and weight control became a more important factor during the

pandemic than before and, according to Marty *et al*. (2021), weight control intentions improved the quality of diets. There is evidence from Nepal for a reduction in tobacco and alcohol consumption (Shrestha *et al.,* 2020). There are examples of an overall increase in food access (Molitor and Doerr, 2021; Mialki *et al.,* 2021; Pakravan-Chavradeh *et al.,* 2021). According to the articles, the reason behind these positive changes in food access could be the initial food gathering (Pakravan-Chavradeh *et al.,* 2021) and lockdown-related food assistance, as well as other benefits (Molitor and Doerr, 2021).

4.5. Factors of Production

The articles in this group are based on data collection between April and August 2020. Producers have experienced change in terms of material inputs (seeds, fertilizers), production areas and their workforce.

Two problems have arisen on the material input market: rising input prices and the unavailability of inputs. In India, 60.67% of the involved shrimp industry stakeholders recognized an input price increase in April (Kumaran *et al.,* 2021); in Zimbabwe, Kenya and Congo (DR) this proportion was 31%, 22.2% and 19.5%, respectively (Nchanji *et al.,* 2021). Seed unavailability was especially a significant problem in Mozambique, Congo (DR) and Zimbabwe (Nchanji *et al.,* 2021), and also in Senegal (Middendorf *et al.,* 2021) and Myanmar, where almost half of the input retailers and crop traders reported disruption in May (Boughton *et al.,* 2021). The fertilizer market proved to be more stable according to the reviewed articles; the highest proportion of respondents who reported fertilizer unavailability was 14.3% from Uganda (Nchanji *et al.,* 2021).

Of the 504 shrimp industry players in India, 81% reported a reduction in shrimp-farming area (Kumaran *et al.,* 2021).

Due to travel restrictions and the fear of infection, producers faced shortages of labour, which resulted in increased costs of hired labour (Kumaran *et al.,* 2021; Nchanji *et al.,* 2021; Ceballos *et al.,* 2020].

4.6. Decrease in Sales Prices

Producers from India (Harris *et al.,* 2020; Kumaran *et al.,* 2021; Ceballos *et al.,* 2020), Malaysia (Azra *et al.,* 2021), Peru (Vargas *et al.,* 2021), Kenya, Congo, Tanzania, Uganda, and Zimbabwe (Nchanji *et al.,* 2021) could only sell their products at a lower price than previously between April and August in 2020.

4.7. Output

During the pandemic, as a consequence of disruptions in input supply, planting and harvesting earlier or later than normal was reported from India (Ceballos *et al.,* 2020) and, less significantly, from Congo (DR), Zambia and Uganda (Nchanji *et al.,* 2021). Due to the drop of prices, wheat and black gram growers decided to store their harvest for future sale in India (Ceballos *et al.,* 2020) . In Kenya, in parallel with the fall of fish consumption, the number of active fishers and the fish stocks decreased in May and June 2020 (Fiorella *et al.,* 2021). In Senegal, more than half of the respondents anticipated their output would decrease by 26–50% as a result of input shortage (Middendorf *et al.,* 2021).

4.8. Transport

Transport restrictions not only caused a shortage in labour, but also caused disruption in input availability (Nchanji *et al.,* 2021) and difficulties or higher prices for reaching markets (Ceballos *et al.,* 2020; Azra *et al.,* 2021).

Table 7 shows how many articles belong to a group or subgroup, and what percentage of the articles can be classified into a certain group or subgroup. Of the articles, 31 belong to only one subgroup, 13 belong to two, three belong to three, and four belong to four subgroups. There are two articles that are included in both groups. The most common combinations of subgroups were INCOME_LOSS + LESS_HEALTHY_DIET and INCOME_LOSS + VULNERABLE_GROUPS with 5-5 articles classified into these subgroups at the same time.

Table 7. Number and percentage of articles belonging to groups and subgroups.

Group	Articles Belong to the Group (pc)	Articles Belong to the Group (%)	Subgroup	Articles Belong to the Group (pc)	Articles Belong to the Group (%)
Access, utilization	44	86%	Losing income	19	37%
			Vulnerable groups	16	31%
			Following less healthy diet	17	33%
			Positive change	9	18%
Availability	9	18%	Factors of production	5	10%
			Price	7	14%
			Output	4	8%
			Transport	3	6%

Source: Own composition.

Table 8 summarizes the articles included in our review by group and subgroup, while Table 9 provides a list of the articles in alphabetical order with the subgroups (and groups) they belong to.

Table 8. Groups and subgroups and the associated articles.

GROUP1 Consumer/Demand/Household/Access/Utilization Approach				GROUP2 Producer/Supply/Availability Approach			
GROUP1.1. INCOME_LOSS	**GROUP1.2. VULNERABLE_GROUPS**	**GROUP1.3. LESS_HEALTHY_DIET**	**GROUP1.4. POSITIVE_CHANGE**	**GROUP2.1. FACTORS_OF_PRODUCTION**	**GROUP2.2. PRICE**	**GROUP2.3. OUTPUT**	**GROUP2.4. TRANSPORT**
Adams *et al*. (2020)	Dou *et al*. (2021)	Adams *et al*. (2020)	Glabska *et al*. (2020)	Boughton *et al*. (2021)	Azra *et al*. (2021)	Ceballos *et al*. (2020)	Azra *et al*. (2021)
Clay and Rogus (2021)	Elsahoryi *et al*. (2020)	Bin Zarah *et al*. (2020)	Harris *et al*. (2020)	Ceballos *et al*. (2020)	Ceballos *et al*. (2020)	Fiorella *et al*. (2021)	Ceballos *et al*. (2020)
Dou *et al*. (2021)	Gaitán-Rossi *et al*. (2020)	Carroll *et al*. (2020)	Larson *et al*. (2020)	Kumaran *et al*. (2021)	Fiorella *et al*. (2021)	Middendorf *et al*. (2021)	Nchanji *et al*. (2021)
Fiorella *et al*. (2021)	Huss *et al*. (2021)	Chee *et al*. (2020)	Marty *et al*. (2021)	Middendorf *et al*. (2021)	Harris *et al*. (2020)	Nchanji *et al*. (2021)	
Gupta *et al*. (2021)	Ibrahim and Othman (2020)	Dou *et al*. (2021)	Mialki *et al*. (2021)	Nchanji *et al*. (2021)	Kumaran *et al*. (2021)		
Hamadani *et al*. (2020)	Kent *et al*. (2020)	Fiorella *et al*. (2021)	Molitor and Doerr (2021)		Nchanji *et al*. (2021)		
Harris *et al*. (2020)	Kundu *et al*. (2021)	Glabska *et al*. (2020)	Pakravan-Charvadeh *et al*. (2020)		Vargas *et al*. (2021)		
Ibrahim and Othman (2020)	Larson *et al*. (2020)	Harris *et al*. (2020)	Rodríguez-Pérez *et al*. (2020)				

Kansiime *et al*. (2021)	Lauren *et al*. (2021)	Janssen *et al*. (2021)	Shrestha *et al*. (2020)
Kent *et al*. (2020)	Pakravan-Charvadeh *et al*. (2020)	Kansiime *et al*. (2021)	
Kundu *et al*. (2021)	Parnham *et al*. (2020)	Larson *et al*. (2020)	
Mialki *et al*. (2021)	Polsky and Gilmour (2020)	Litton and Beavers (2021)	
Niles *et al*. (2020)	Saxena *et al*. (2020)	Marty *et al*. (2021)	
Owens *et al*. (2020)	Snuggs and McGregor (2021)	Russo *et al*. (2021)	
Patrick *et al*. (2020)	Steenbergen *et al*. (2020)	Scacchi *et al*. (2021)	
Polsky and Gilmour (2020)	Wolfson and Leung (2020)	Shen *et al*. (2020)	
Quaife *et al*. (2020)		Sidor and Rysmski (2020)	
Rocha *et al*. (2020)			
Ruszczyk *et al*. (2020)			

Source: Own composition.

Table 9. Articles and the subgroups they belong to.

Article	GROUP			
Adams *et al*. (2020)	INCOME_LOSS (G1)	LESS_HEALTHY_DIET (G1)		
Azra *et al*. (2021)	PRICE (G2)	TRANSPORT (G2)		
Bin Zarah *et al*. (2020)	LESS_HEALTHY_DIET (G1)			
Boughton *et al*. (2021)	FACTORS_OF_PRODUCTION (G2)			
Carroll *et al*. (2020)	LESS_HEALTHY_DIET (G1)			
Ceballos *et al*. (2020)	FACTORS_OF_PRODUCTION (G2)	PRICE (G2)	OUTPUT (G2)	TRANSPORT (G2)
Chee *et al*. (2020)	LESS_HEALTHY_DIET (G1)			
Clay and Rogus (2021)	INCOME_LOSS (G1)			
Dou *et al*. (2021)	INCOME_LOSS (G1)	VULNERABLE_GROUPS (G1)	LESS_HEALTHY_DIET (G1)	
Elsahoryi *et al*. (2020)	VULNERABLE_GROUPS (G1)			
Fiorella *et al*. (2021)	INCOME_LOSS (G1)	LESS_HEALTHY_DIET (G1)	PRICE (G2)	OUTPUT (G2)
Gaitán-Rossi *et al*. (2020)	VULNERABLE_GROUPS (G1)			
Glabska *et al*. (2020)	LESS_HEALTHY_DIET (G1)	POSITIVE_CHANGE (G1)		
Gupta *et al*. (2021)	INCOME_LOSS (G1)			
Hamadani *et al*. (2020)	INCOME_LOSS (G1)			
Harris *et al*. (2020)	INCOME_LOSS (G1)	LESS_HEALTHY_DIET (G1)	POSITIVE_CHANGE (G1)	PRICE (G2)
Huss *et al*. (2021)	VULNERABLE_GROUPS (G1)			
Ibrahim and Othman (2020)	INCOME_LOSS (G1)	VULNERABLE_GROUPS (G1)		
Janssen *et al*. (2021)	LESS_HEALTHY_DIET (G1)			
Kansiime *et al*. (2021)	INCOME_LOSS (G1)	LESS_HEALTHY_DIET (G1)		
Kent *et al*. (2020)	INCOME_LOSS (G1)	VULNERABLE_GROUPS (G1)		
Kumaran *et al*. (2021)	FACTORS_OF_PRODUCTION (G2)	PRICE (G2)		
Kundu *et al*. (2021)	INCOME_LOSS (G1)	VULNERABLE_GROUPS (G1)		
Larson *et al*. (2020)	VULNERABLE_GROUPS (G1)	LESS_HEALTHY_DIET (G1)	POSITIVE_CHANGE (G1)	
Lauren *et al*. (2021)	VULNERABLE GROUPS (G1)			

Litton and Beavers (2021)	LESS_HEALTHY_DIET (G1)			
Marty *et al*. (2021)	LESS_HEALTHY_DIET (G1)	POSITIVE_CHANGE (G1)		
Mialki *et al*. (2021)	INCOME_LOSS (G1)	POSITIVE_CHANGE (G1)		
Middendorf *et al*. (2021)	FACTORS_OF_PRODUCTION (G2)	OUTPUT (G2)		
Molitor and Doerr (2021)	POSITIVE_CHANGE (G1)			
Nchanji *et al*. (2021)	FACTORS_OF_PRODUCTION (G2)	PRICE (G2)	OUTPUT (G2)	TRANSPORT (G2)
Niles *et al*. (2020)	INCOME_LOSS (G1)			
Owens *et al*. (2020)	INCOME_LOSS (G1)			
Pakravan-Charvadeh *et al*. (2020)	VULNERABLE GROUPS (G1)	POSITIVE_CHANGE (G1)		
Parnham *et al*. (2020)	VULNERABLE GROUPS (G1)			
Patrick *et al*. (2020)	INCOME_LOSS (G1)			
Polsky and Gilmour (2020)	INCOME_LOSS (G1)	VULNERABLE_GROUPS (G1)		
Quaife *et al*. (2020)	INCOME_LOSS (G1)			
Rodríguez-Pérez *et al*. (2020)	POSITIVE_CHANGE (G1)			
Rocha *et al*. (2020)	INCOME_LOSS (G1)			
Russo *et al*. (2021)	LESS_HEALTHY_DIET (G1)			
Ruszczyk *et al*. (2020)	INCOME_LOSS (G1)			
Saxena *et al*. (2020)	VULNERABLE GROUPS (G1)			
Scacchi *et al*. (2021)	LESS_HEALTHY_DIET (G1)			
Shrestha *et al*. (2020)	POSITIVE_CHANGE (G1)			
Shen *et al*. (2020)	LESS_HEALTHY_DIET (G1)			
Sidor and Rysmski (2020)	LESS_HEALTHY_DIET (G1)			
Snuggs and McGregor (2021)	VULNERABLE GROUPS (G1)			
Steenbergen *et al*. (2020)	VULNERABLE GROUPS (G1)			
Vargas *et al*. (2021)	PRICE (G2)			
Wolfson and Leung (2020)	VULNERABLE GROUPS (G1)			

Source: Own composition.

Discussion and Conclusions

Q1. What Segments of Food Security Have Been Affected by the COVID-19 Lockdown and Pandemic?

The reviewed empirical results prove that each of the four dimensions/pillars of food security have been affected by the pandemic and lockdowns, though to a different extent. Our findings are mostly consistent with the claims of the early literature. The empirical evidence from the last year confirmed the statement of Laborde *et al*. (2020) and Béné (2020) that, during the pandemic and lockdowns, the most vulnerable food security dimension is access; more precisely, economic access. The vast majority of the reviewed papers name financial issues as the primary reason for experiencing food insecurity during the pandemic. The most important financial issues included belonging to a persistently low-income household, losing income partially or completely, or experiencing food price increases. The most vulnerable were those who had to cope with a combination of these factors. Although our sample is not representative in terms of low-, middle- and high-income countries, our results indirectly confirm the assumption of FAO (2019) and Laborde *et al*. (2020) that low-income countries are affected the most by food insecurity during the COVID-19 crisis, because of their large low-income population.

In addition to the effects on economic access, in some cases, disruption to physical access occurred and caused temporary food insecurity. We add to the literature that physical access was not only disrupted by restrictions on movement (Béné, 2020; Naja and Hamadeh, 2020), but also fear of infection, which resulted in some consumers not leaving their homes or visiting supermarkets.

The early literature warned about the following potential threats in food production: decline in demand and disruption in labor and input supply (Béné, 2020). Each of these presumptions were proved through our results. Decline in demand and sale prices were reported and, simultaneously, disruption in availability of workforces and inputs resulted in higher costs for labor and other material inputs, travel and transport restrictions also caused further costs by increasing the price of reaching markets. Based on our findings, we have no reason to assume that the pandemic would have caused a major drop in production, but it did affect the time of harvest or, due to low prices, forced farmers to store their products. The contradictory assumptions of Laborde *et al*. (2020) and Workie *et al*. (2020) about the agriculture of developing countries being more or less exposed to

the effects of the pandemic cannot be judged through our systematic review—a large-scale data analysis would provide more details.

Several articles provided results about a negative shift in diet. In accordance with the literature (Laborde *et al.,* 2020), in the articles included in our review, the most frequently mentioned reason for following less healthy diet was affordability. Another significant reason was also outlined in our review: emotional and psychological needs to cope with the fear of infection and losing social ties, which often resulted in eating snacks or processed food for temporary comfort. Consumption of vegetables, fruits and animal proteins declined the most. Obesity concerns also emerged in some cases. Positive changes in diet due to the pandemic were also reported. In order to boost immunity or control their weight, some people started to follow a more conscious diet.

Q2. Are the COVID-19-Related Emerging Food Security Problems Temporary and "Crisis Specific" or Are They Rooted in Structural Weaknesses?

All the changes in food security reported in this review were triggered by events which are strongly linked to the COVID-19 pandemic and lockdowns. Some of the effects are due solely to the circumstances caused by the pandemic, are of a temporary nature, and will return to pre-pandemic conditions once the number of cases is reduced and restrictions are lifted. Such an effect is, for example, limited physical access due to stock shortages after panic-buying, movement restrictions, or fear of infection. Negative dietary changes caused by anxiety and loneliness are also likely to recover once social connections can be revived. For the producer side, access to markets and the free movement of labor can also be resolved as soon as restrictions are lifted.

However, consistent with the literature, the largest problem suggested by our results was shown to be low household incomes. Low-income households do not have sufficient savings to bridge the loss of income for up to several months, or are unable to buy in large amounts, and are burdened by suddenly rising food prices. As a result, they cannot afford the same amount of vegetables, fruits, or animal proteins and consume less of these foods; this lack of demand is immediately apparent on the producer side. Producers thus have to deal not only with the direct consequences of government measures, such as the stagnation of labor flows and the lack of demand resulting from the closure of the catering sector, but also with the decline in consumption by low-income households.

Consequently, we conclude that the factor that most negatively affects food security during the COVID-19 pandemic is the same as the deepest structural problem of global food security: low income.

Q3. Are New Food Security Objectives Needed to Mitigate the Negative Effects of the Pandemic and Prepare for a Possible Future Pandemic?

As economic access has proven to be the strongest factor in food security vulnerability during the pandemic, we argue that there is no need for new global food security objectives, but there is a need for an even stronger emphasis on poverty reduction and raising the wages of low-income households so that policymakers understand that this is the first and most essential step in preparing for future crises, as the pandemic high-lighted that securing economic access through adequate wages not only increases overall food security in normal times but, in line with Béné's (2020) claim , is an essential element of household-level resilience in the event of a health, economic, or food crisis. By drawing lessons from the COVID-19 pandemic, it will be possible to prepare for temporary disruptions in a similar crisis situation, but there may also be unexpected and novel problems in a crisis, as is the case with COVID-19. It is not possible to prepare for these situations in a targeted way, but improving structural weaknesses, such as financial insecurity, would reduce the negative effects of a crisis on food security to a broader extent.

Although our sample is rather small and not representative, the numbers are indicative that, if we exclude articles that report new food security problems that could have been avoided by consumers having adequate wages and sufficient savings, only 11 of 51, 22% of the articles would remain in our sample. Last but not least, the structural adjustment of poverty and low wages could reduce the financial burden on governments in times of crises, as only a smaller proportion of the population would need food aid or other benefits, leaving more resources to address temporary problems and post-crisis recovery.

Author Contributions: Conceptualization, B.A.É. and A.J.; methodology, B.A.É.; software, B.A.É.; validation, A.J.; formal analysis, B.A.É.; investigation, B.A.É.; resources, A.J.; data curation, B.A.É.; writing—original draft preparation, B.A.É.; writing—review and editing, A.J.; visualization, B.A.É.; supervision, A.J.; project administration, A.J.; funding acquisition, A.J. All authors have read and agreed to the published version of the manuscript.

References

Adams, E. L., Caccavale, L. J., Smith, D., & Bean, M. K. (2020). Food insecurity, the home food environment, and parent feeding practices in the era of COVID-19. *Obesity*, *28*(11), 2056-2063. doi:10.1002/oby.22996.

Azra, M. N., Kasan, N. A., Othman, R., Noor, G. A. G. R., Mazelan, S., Jamari, Z. B., ... & Ikhwanuddin, M. (2021). Impact of COVID-19 on aquaculture sector in Malaysia: Findings from the first national survey. *Aquaculture Reports*, *19*, 100568. doi:10.1016/j.aqrep.2020.100568.

Béné, C. (2020). Resilience of local food systems and links to food security–A review of some important concepts in the context of COVID-19 and other shocks. *Food security*, *12*(4), 805-822. doi:10.1007/s12571-020-01076-1.

Bin Zarah, A., Enriquez-Marulanda, J., & Andrade, J. M. (2020). Relationship between dietary habits, food attitudes and food security status among adults living within the United States three months post-mandated quarantine: a cross-sectional study. *Nutrients*, *12*(11), 3468. doi:10.3390/nu12113468.

Boughton, D., Goeb, J., Lambrecht, I., Headey, D., Takeshima, H., Mahrt, K., ... & Diao, X. (2021). Impacts of COVID-19 on agricultural production and food systems in late transforming Southeast Asia: The case of Myanmar. *Agricultural Systems*, *188*, 103026. doi:10.1016/j.agsy.2020.103026.

Carroll, N., Sadowski, A., Laila, A., Hruska, V., Nixon, M., Ma, D. W., ... & Guelph Family Health Study. (2020). The impact of COVID-19 on health behavior, stress, financial and food security among middle to high income Canadian families with young children. *Nutrients*, *12*(8), 2352. doi:10.3390/nu12082352.

Ceballos, F., Kannan, S., & Kramer, B. (2020). Impacts of a national lockdown on smallholder farmers' income and food security: Empirical evidence from two states in India. *World Development*, *136*, 105069. doi:10.1016/j.worlddev.2020.105069.

Chee, M. J., Koziel Ly, N. K., Anisman, H., & Matheson, K. (2020). Piece of cake: Coping with COVID-19. *Nutrients*, *12*(12), 3803. doi:10.3390/nu12123803.

Clay, L. A., & Rogus, S. (2021). Impact of employment, essential work, and risk factors on food access during the COVID-19 pandemic in New York state. *International journal of environmental research and public health*, *18*(4), 1451. doi:10.3390/ijerph18041451.

Devereux, S., Béné, C., & Hoddinott, J. (2020). Conceptualising COVID-19's impacts on household food security. *Food security*, *12*(4), 769-772. doi:10.1007/s12571-020-01085-0.

Dou, Z., Stefanovski, D., Galligan, D., Lindem, M., Rozin, P., Chen, T., & Chao, A. M. (2021). Household food dynamics and food system resilience amid the COVID-19 pandemic: A cross-national comparison of China and the United States. *Frontiers in Sustainable Food Systems*, *4*, 577153. doi:10.3389/fsufs.2020.577153.

Elsahoryi, N., Al-Sayyed, H., Odeh, M., McGrattan, A., & Hammad, F. (2020). Effect of Covid-19 on food security: A cross-sectional survey. *Clinical nutrition ESPEN*, *40*, 171-178. doi:10.1016/j.clnesp.2020.09.026.

FAO (2009b). Declaration of the World Summit on Food Security. World Summit on Food Security. Rome, 16–18 November 2009. Available online: http://www.fao.org/fileadmin/templates/wsfs/Summit/Docs/Final_Declaration/WSFS09_Declaration.pdf (accessed on 25 March 2021).

FAO (2019). The State of Food Security and Nutrition in the World 2019. Available online: http://www.fao.org/publications/sofi/2019/en/ (accessed on 20 March 2021).

FAO (2020). The State of Food Security and Nutrition in the World 2020. Available online: http://www.fao.org/publications/sofi/en/ (accessed on 20 March 2021).

Fiorella, K. J., Bageant, E. R., Mojica, L., Obuya, J. A., Ochieng, J., Olela, P., ... & Okronipa, H. (2021). Small-scale fishing households facing COVID-19: The case of Lake Victoria, Kenya. *Fisheries Research*, *237*, 105856. doi:10.1016/j.fishres.2020.105856.

Gaitán-Rossi, P., Vilar-Compte, M., Teruel, G., & Pérez-Escamilla, R. (2021). Food insecurity measurement and prevalence estimates during the COVID-19 pandemic in a repeated cross-sectional survey in Mexico. *Public health nutrition*, *24*(3), 412-421, doi:10.1017/S1368980020004000.

Głąbska, D., Skolmowska, D., & Guzek, D. (2020). Population-based study of the changes in the food choice determinants of secondary school students: Polish adolescents' COVID-19 experience (place-19) study. *Nutrients*, *12*(9), 2640. doi:10.3390/nu12092640.

Gupta, A., Zhu, H., Doan, M. K., Michuda, A., & Majumder, B. (2021). Economic impacts of the COVID− 19 lockdown in a remittance-dependent region. *American Journal of Agricultural Economics*, *103*(2), 466-485. doi:10.1111/ajae.12178.

Hamadani, J. D., Hasan, M. I., Baldi, A. J., Hossain, S. J., Shiraji, S., Bhuiyan, M. S. A., ... & Pasricha, S. R. (2020). Immediate impact of stay-at-home orders to control COVID-19 transmission on socioeconomic conditions, food insecurity, mental health, and intimate partner violence in Bangladeshi women and their families: an interrupted time series. *The Lancet Global Health*, *8*(11), e1380-e1389. doi:10.1016/S2214-109X(20)30366-1.

Harris, J., Depenbusch, L., Pal, A. A., Nair, R. M., & Ramasamy, S. (2020). Food system disruption: initial livelihood and dietary effects of COVID-19 on vegetable producers in India. *Food security*, *12*(4), 841-851. doi:10.1007/s12571-020-01064-5.

Huss, M., Brander, M., Kassie, M., Ehlert, U., & Bernauer, T. (2021). Improved storage mitigates vulnerability to food-supply shocks in smallholder agriculture during the COVID-19 pandemic. *Global Food Security*, *28*, 100468, doi:10.1016/j.gfs.2020.100468.

Ibrahim, A. Z., & Othman, Z. (2020). COVID-19: Coping strategies among B40 households in Malaysia to achieve food security during movement control order (MCO). *European Journal of Molecular & Clinical Medicine*, *7*(6), 1513-1524.

IMF. World Economic Outlook (2020). A Long and Difficult Ascent. Available online: https://www.imf.org/en/Publications/WEO/Issues/2020/09/30/world-economic-outlook-october-2020 (accessed on 25. March 2021).

Jámbor, A., Czine, P., & Balogh, P. (2020). The impact of the coronavirus on agriculture: first evidence based on global newspapers. *Sustainability*, *12*(11), 4535. doi:10.3390/su12114535.

Janssen, M., Chang, B. P., Hristov, H., Pravst, I., Profeta, A., & Millard, J. (2021). Changes in food consumption during the COVID-19 pandemic: analysis of consumer survey data from the first lockdown period in Denmark, Germany, and Slovenia. *Frontiers in nutrition*, *8*, 635859. doi:10.3389/fnut.2021.635859.

Kansiime, M. K., Tambo, J. A., Mugambi, I., Bundi, M., Kara, A., & Owuor, C. (2021). COVID-19 implications on household income and food security in Kenya and

Uganda: Findings from a rapid assessment. *World development*, *137*, 105199. doi:10.1016/j.worlddev.2020.105199.

Kent, K., Murray, S., Penrose, B., Auckland, S., Visentin, D., Godrich, S., & Lester, E. (2020). Prevalence and socio-demographic predictors of food insecurity in Australia during the COVID-19 pandemic. *Nutrients*, *12*(9), 2682. doi:10.3390/nu12092682.

Kumaran, M., Geetha, R., Antony, J., Vasagam, K. K., Anand, P. R., Ravisankar, T., ... & Vijayan, K. K. (2021). Prospective impact of Corona virus disease (COVID-19) related lockdown on shrimp aquaculture sector in India–a sectoral assessment. *Aquaculture*, *531*, 735922. doi:10.1016/j.aquaculture.2020.735922.

Kundu, S., Al Banna, M. H., Sayeed, A., Sultana, M. S., Brazendale, K., Harris, J., ... & Khan, M. S. I. (2021). Determinants of household food security and dietary diversity during the COVID-19 pandemic in Bangladesh. *Public Health Nutrition*, *24*(5), 1079-1087. doi:10.1017/S1368980020005042, Accepted manuscript.

Laborde, D., Martin, W., Swinnen, J., & Vos, R. (2020). COVID-19 risks to global food security. *Science*, *369*(6503), 500-502. doi:10.1126/science.abc4765.

Larson, N., Slaughter-Acey, J., Alexander, T., Berge, J., Harnack, L., & Neumark-Sztainer, D. (2021). Emerging adults' intersecting experiences of food insecurity, unsafe neighbourhoods and discrimination during the coronavirus disease 2019 (COVID-19) outbreak. *Public Health Nutrition*, *24*(3), 519-530.doi:10.1017/S136898002000422X.

Lauren, B. N., Silver, E. R., Faye, A. S., Rogers, A. M., Woo-Baidal, J. A., Ozanne, E. M., & Hur, C. (2021). Predictors of households at risk for food insecurity in the United States during the COVID-19 pandemic. *Public health nutrition*, *24*(12), 3929-3936. doi:10.1017/S1368980021000355, Accepted manuscript

Litton, M. M., & Beavers, A. W. (2021). The relationship between food security status and fruit and vegetable intake during the COVID-19 pandemic. *Nutrients*, *13*(3), 712. doi:10.3390/nu13030712.

Marty, L., de Lauzon-Guillain, B., Labesse, M., & Nicklaus, S. (2021). Food choice motives and the nutritional quality of diet during the COVID-19 lockdown in France. *Appetite*, *157*, 105005. doi:10.1016/j.appet.2020.105005.

Mialki, K., House, L. A., Mathews, A. E., & Shelnutt, K. P. (2021). Covid-19 and college students: food security status before and after the onset of a pandemic. *Nutrients*, *13*(2), 628. doi:10.3390/nu13020628.

Middendorf, B. J., Faye, A., Middendorf, G., Stewart, Z. P., Jha, P. K., & Prasad, P. V. (2021). Smallholder farmer perceptions about the impact of COVID-19 on agriculture and livelihoods in Senegal. *Agricultural Systems*, *190*, 103108. doi:10.1016/j.agsy.2021.103108.

Molitor, F., & Doerr, C. (2021). Peer Reviewed: Very Low Food Security Among Low-Income Households With Children in California Before and Shortly After the Economic Downturn From COVID-19. *Preventing chronic disease*, *18*. 200517, doi:10.5888/PCD18.200517.

Naja, F., & Hamadeh, R. (2020). Nutrition amid the COVID-19 pandemic: a multi-level framework for action. *European journal of clinical nutrition*, *74*(8), 1117-1121., doi:10.1038/s41430-020-0634-3.

Nchanji, E. B., Lutomia, C. K., Chirwa, R., Templer, N., Rubyogo, J. C., & Onyango, P. (2021). Immediate impacts of COVID-19 pandemic on bean value chain in selected countries in sub-Saharan Africa. *Agricultural systems*, *188*, 103034. doi:10.1016/j.agsy.2020.103034.

Niles, M. T., Bertmann, F., Belarmino, E. H., Wentworth, T., Biehl, E., & Neff, R. (2020). The early food insecurity impacts of COVID-19. *Nutrients*, *12*(7), 2096. doi:10.3390/nu12072096.

Owens, M. R., Brito-Silva, F., Kirkland, T., Moore, C. E., Davis, K. E., Patterson, M. A., ... & Tucker, W. J. (2020). Prevalence and social determinants of food insecurity among college students during the COVID-19 pandemic. *Nutrients*, *12*(9), 2515. doi:10.3390/nu12092515.

Page, M.J.; McKenzie, J.E.; Bossuyt, P.M.; Boutron, I.; Hoffmann, T.C.; Mulrow, C.D.; Shamseer, L.; Tetzlaff, J.M.; Akl, E.A.; Brennan, S.E.; *et al*. (2021). The PRISMA 2020 Statement: An Updated Guideline for Reporting Systematic Reviews. *PLOS Med.* 18, e1003583, doi:10.1371/journal.pmed.1003583.

Pakravan-Charvadeh, M. R., Mohammadi-Nasrabadi, F., Gholamrezai, S., Vatanparast, H., Flora, C., & Nabavi-Pelesaraei, A. (2021). The short-term effects of COVID-19 outbreak on dietary diversity and food security status of Iranian households (A case

study in Tehran province). *Journal of cleaner production*, *281*, 124537. doi:10.1016/j.jclepro.2020.124537.

Parnham, J.C.; Laverty, A.A.; Majeed, A.; Vamos, E.P. Half of Children Entitled to Free School Meals Did Not Have Access to the Scheme during COVID-19 Lockdown in the UK. Public Health 2020, 187, 161–164, doi:10.1016/j.puhe.2020.08.019.

Patrick, S. W., Henkhaus, L. E., Zickafoose, J. S., Lovell, K., Halvorson, A., Loch, S., ... & Davis, M. M. (2020). Well-being of parents and children during the COVID-19 pandemic: a national survey. *Pediatrics*, *146*(4). doi:10.1542/peds.2020-0836.

Polsky, J. Y., & Gilmour, H. (2020). Food insecurity and mental health during the COVID-19 pandemic. *Health Rep*, *31*(12), 3-11. doi:10.25318/82-003-x202001200001-eng.

Quaife, M., Van Zandvoort, K., Gimma, A., Shah, K., McCreesh, N., Prem, K., ... & Austrian, K. (2020). The impact of COVID-19 control measures on social contacts and transmission in Kenyan informal settlements. *BMC Medicine*, *18*, 1-11. doi:10.1186/s12916-020-01779-4.

Rahman, S., Hossain, I., Mullick, A. R., & Khan, M. H. (2020). Food security and the coronavirus disease 2019 (COVID-19): a systemic review. *J. Med. Sci. Clin. Res*, *8*(5), 180-184. doi:10.18535/jmscr/v8i5.34.

Rocha, H. A., Sudfeld, C. R., Leite, Á. J., Rocha, S. G., Machado, M. M., Campos, J. S., ... & Correia, L. L. (2021). Coronavirus disease 2019, food security and maternal mental health in Ceará, Brazil: a repeated cross-sectional survey. *Public Health Nutrition*, *24*(7), 1836-1840. doi:10.1017/s1368980021000628.

Rodríguez-Pérez, C., Molina-Montes, E., Verardo, V., Artacho, R., García-Villanova, B., Guerra-Hernández, E. J., & Ruíz-López, M. D. (2020). Changes in dietary behaviours during the COVID-19 outbreak confinement in the Spanish COVIDiet study. *Nutrients*, *12*(6), 1730. doi:10.3390/nu12061730.

Russo, C., Simeone, M., Demartini, E., Marescotti, M. E., & Gaviglio, A. (2021). Psychological pressure and changes in food consumption: the effect of COVID-19 crisis. *Heliyon*, *7*(4). doi:10.1016/j.heliyon.2021.e06607.

Ruszczyk, H. A., Rahman, M. F., Bracken, L. J., & Sudha, S. (2021). Contextualizing the COVID-19 pandemic's impact on food security in two small cities in

Bangladesh. *Environment and Urbanization*, *33*(1), 239-254. doi:10.1177/0956247820965156.

Saxena, A., Amin, A., Mohan, S. B., & Mohan, P. (2020). Food insecurity in tribal high migration communities in Rajasthan, India. *Food and Nutrition Bulletin*, *41*(4), 513-518. doi:10.1177/0379572120967163.

Scacchi, A., Catozzi, D., Boietti, E., Bert, F., & Siliquini, R. (2021). COVID-19 lockdown and self-perceived changes of food choice, waste, impulse buying and their determinants in Italy: QuarantEat, a cross-sectional study. *Foods*, *10*(2), 306. doi:10.3390/foods10020306.

Sereenonchai, S., & Arunrat, N. (2021). Understanding food security behaviors during the COVID-19 pandemic in Thailand: a review. *Agronomy*, *11*(3), 497. doi:10.3390/agronomy11030497.

Shen, W., Long, L. M., Shih, C. H., & Ludy, M. J. (2020). A humanities-based explanation for the effects of emotional eating and perceived stress on food choice motives during the COVID-19 pandemic. *Nutrients*, *12*(9), 2712. doi:10.3390/nu12092712.

Shrestha, C., Acharya, S., Sharma, R., Khanal, R., Joshi, J., Ghimire, C., ... & Agrawal, A. (2020). Changes and compromises in health choices during COVID-19 lockdown in Kathmandu Valley: a descriptive cross-sectional study. *JNMA: Journal of the Nepal Medical Association*, *58*(232), 1046. doi:10.31729/jnma.5790.

Sidor, A., & Rzymski, P. (2020). Dietary choices and habits during COVID-19 lockdown: experience from Poland. *Nutrients*, *12*(6), 1657. doi:10.3390/nu12061657.

Snuggs, S., & McGregor, S. (2021). Food & meal decision making in lockdown: How and who has Covid-19 affected?. *Food quality and preference*, *89*, 104145. doi:10.1016/j.foodqual.2020.104145.

Steenbergen, D. J., Neihapi, P. T., Koran, D., Sami, A., Malverus, V., Ephraim, R., & Andrew, N. (2020). COVID-19 restrictions amidst cyclones and volcanoes: A rapid assessment of early impacts on livelihoods and food security in coastal communities in Vanuatu. *Marine policy*, *121*, 104199. doi:10.1016/j.marpol.2020.104199.

Vargas, R., Fonseca, C., Hareau, G., Ordinola, M., Pradel, W., Robiglio, V., & Suarez, V. (2021). Health crisis and quarantine measures in Peru: Effects on livelihoods of coffee and potato farmers. *Agricultural Systems*, *187*, 103033. doi:10.1016/j.agsy.2020.103033.

WHO (2020a). Mission summary: WHO Field Visit to Wuhan, China 20–21 January 2020. 22 January 2020 Available online: https://www.who.int/china/news/detail/22-01-2020-field-visit-wuhan-china-jan-2020 (accessed on 11 March 2021).

WHO (2020b). Director-General's Opening Remarks at the Mission Briefing on COVID-19—12 March 2020. Available online: https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020 (accessed on 11 March 2021).

Wolfson, J. A., & Leung, C. W. (2020). Food insecurity and COVID-19: disparities in early effects for US adults. *Nutrients*, *12*(6), 1648. doi:10.3390/nu12061648.

Workie, E., Mackolil, J., Nyika, J., & Ramadas, S. (2020). Deciphering the impact of COVID-19 pandemic on food security, agriculture, and livelihoods: A review of the evidence from developing countries. *Current Research in Environmental Sustainability*, *2*, 100014. doi:10.1016/j.crsust.2020.100014.

World Bank. Poverty and Hunger: Issues and Options for Food Security in Developing Countries. World Bank: Washington, DC, USA, 1986. Available online: http://documents1.worldbank.org/curated/en/166331467990005748/pdf/multi-page.pdf (ac-cessed on 20 March 2021).

Worldometers. COVID-19 Coronavirus Pandemic. Available online: https://www.worldometers.info/coronavirus/ (accessed on 25 March 2021).

4. Brief introduction of Publication 2

4.1. Bibliometrics

Éliás, Boglárka Anna (2024). Magyarország élelmezése válság idején. *Gazdálkodás*, *68*(2), 103–125, [Food security of Hungary in times of crisis] https://doi.org/10.53079/GAZDALKODAS.68.2.t.pp_103-125.

Ranking of journal in year of publishing:

Hungarian Academy of Science – IV. Section of Agricultural Sciences: A,

Hungarian Academy of Science – IX. Section of Economics and Law: C.

4.2. Targeted research question

Q1. Could a comprehensive, 3+1 dimensions analysis contribute to discovering new results regarding crisis-caused impacts and their interplays in the food system?

4.3. Research gap

Although FAO, GFSI provides an annual report on the state of food security in Hungary, these analyses take a bird's-eye view of individual countries. To develop a globally consistent method that allows for comparison and ranking among countries, they necessarily overlook specific local features. The last comprehensive food security analysis of Hungary was published in 2013 (Jankuné Kürthy *et al*., 2013); therefore, there is no empirical evidence on the assumed food security development in the second half of the 2010s, and there is no empirical evidence on the effects of the 2022–2023 food price crisis on food security in Hungary.

4.4. Hypotheses

H1. Despite the overall improvement in food security in Hungary between 2015 and 2020, significant differences in dietary quality persisted across households with different income levels.

H2. Food availability in Hungary remained stable even during the disruptions to food supply chains caused by the COVID-19 pandemic and the Russian-Ukrainian war.

H3. The food price surge in 2022–2023 induced changes in food purchasing patterns through deteriorating affordability.

H4. The change in consumption is not reflected in a reduction in total energy intake but rather in a decrease in the consumption of micronutrients and dietary fiber.

H5. The gap between the dietary quality of the lowest and highest income groups increased in 2022–2023.

4.5. Key findings

Gap-filling access and nutrition status analysis of Hungary between 2015–2020.

Physical access to food:

Small settlements have more grocery stores per capita, but they face issues like high prices and limited selection. There's a decline in small retail outlets and an increase in larger stores' average size, suggesting retail concentration. The concentration of larger stores in urban areas may limit access for those in smaller settlements, potentially raising food prices there due to reduced competition.

Economic access to food:

Hungarian households generally had low risk of food insecurity between 2015 and 2020, with an average food expenditure of 24.7% of total household expenditure. Certain groups, however, including active and inactive households in specific income quintiles, showed higher food expenditure shares, indicating greater vulnerability. From 2015 to 2020, food prices increased by 23.0, and net capita incomes increased by 60.7%. Despite some groups being more vulnerable (retired, inactive, low level of education), Hungary saw an overall increase in economic access to food.

Nutrition:

The most recent nutrient intake survey (OTÁP, 2019) highlights issues with the Hungarian diet, including high overweight and obesity rates, inadequate dietary fiber and vitamin intake, and excessive fat consumption.

H1. Despite the overall improvement in food security in Hungary between 2015 and 2020, significant differences in dietary quality persisted across households with different income levels. – Confirmed.

According to Spearman’s rank correlation coefficient, there is a very strong relationship between income level and the consumption of healthier foods like fruits (r_s=0.988), fish

(r_s=0.976), vegetables and potatoes (r_s=0.964), while consumption of cereals (r_s=0.673), fats (r_s=0.600) and sugar (r_s=0.406) is more evenly distributed across income groups between 2015 and 2020.

H2. Food availability in Hungary remained stable even during the disruptions to food supply chains caused by the COVID-19 pandemic and the Russian-Ukrainian war. – Confirmed.

The statistical analysis of the production of major cereals and meat between 2018 and 2022, along with the available daily nutrient volume per capita in 2022, suggests that food availability remained stable. Hungary continues to maintain food self-sufficiency for key cereals and meat products, with production levels consistently exceeding domestic consumption.

H3. The food price surge in 2022–2023 induced changes in food purchasing patterns through deteriorating affordability. – Confirmed.

A significant increase in food prices was noted between 2022 and 2023 (+58.6%), while incomes increased by 33.2%, challenging the previously positive trends in economic access. 71.7% of respondents reported changing their food shopping habits due to rising food prices. Only 6.3% of the respondents reported that there were only small shops in their area whose prices they could not afford or could barely afford, however, unexpectedly only one-third of them were rural residents, and half of them were from the capital, putting the findings of the questionnaire in tension with the implications of the previous literature and data.

H4. The change in consumption is not reflected in a reduction in total energy intake but rather in a decrease in the consumption of micronutrients and dietary fiber. – Rejected.

The household survey revealed that since the beginning of 2022, a significant portion, 34% of respondents reported buying less food associated with a *healthy diet* due to affordability issues. Price increases led to a reduction in the purchase of nutrient-rich foods like fruits, nuts, fish, and vegetables, particularly among lower-income respondents. However, 3.3% of the respondents cannot afford to buy a *sufficient amount* of food, while they could afford it prior to 2022. Therefore, the hypothesis cannot be confimred.

H5. The gap between the dietary quality of the lowest and highest income groups increased in 2022–2023. – Confirmed.

The survey results suggest that the gap in diet quality between low and high-income households has widened further with the food price increases in 2022–2023. Higher-income households (13–27% higher income than sample average) have been able to maintain or increase their consumption of high nutritional quality foods, while lower-income households (7–14% lower income than sample average) have had to reduce their consumption of these essential nutrient sources (fruits, vegetables, fishes, oil seeds and nuts).

Further implications regarding the food security status of Hungary:

Given that the average financial situation of the respondents is above the national average by 32.9%, it can unfortunately be concluded that food security in Hungary has been affected by the food price increase even more severely than the level presented in the analysis of the survey results. More than 3.3% of the respondents reported not being able to purchase a sufficient amount of food, which implicates severe insecurity, and this proportion is already above the previous data (<2.5%). From a research perspective, the vulnerable groups should be further explored through representative questionnaires or qualitative research methods. From a decision-making perspective, monitoring of the most vulnerable and food-insecure households should be introduced, since it is striking that there is no available data regarding them. Constant monitoring could support targeted policies that are required for the most vulnerable households to get through crises.

4.6. Author contributions

I conducted every phase of this research myself.

5. Complete text of Publication 2

Food Security of Hungary in times of crisis

(translation)

Summary of findings, conclusions, recommendations

Between 2015 and 2020, food prices increased by 23% and average annual net per capita income by 61%, while in 2022–2023, food prices increased by 59% and incomes by 33.2%. The rate of food inflation significantly outpacing income growth calls for a reassessment of Hungary's food situation. Following the conceptual framework of food security, the study examines food availability, food use, physical and economic access to food, and the stability of these factors. Public data (KSH, Nébih, EFSA, WHO, OTÁP) and data from an online non-representative (n=300) questionnaire survey were applied. The results show that availability and physical access are basically achieved in Hungary, with the Achilles heel of food security being the combined dimension of economic access and utilisation, i.e. the affordability of a quality diet. According to the 2019 OTAP survey, the consumption of important sources of vitamins, essential fatty acids and dietary fibre (vegetables, fruits, whole grains, dry pulses, fish, nuts, oilseeds) is below the dietary recommendations. An analysis of the relationship between food consumption and average income between 2015 and 2020 (Spearman's rank correlation) showed that households with higher incomes consumed more fruits (r_s =0.988), fishes (r_s =0.976), vegetables and potatoes (r_s =0.964) and meat (r_s =0.915), thus meeting the OTAP dietary recommendations better than households with lower income. Among respondents, the average monthly income of those who consumed less of these foods compared to the period before January 2022 was 3–14% lower than the sample average. Due to the answers, food price increase was the main reason of the change in diet. However, the average income of those who bought more of these foods exceeded the average income of the sample by 13–27 percent, suggesting that food inflation between 2022–2023, which outpaces income growth, will further increase the quality gap between the diets of low and high income households.

Keywords: food security, access, purchasing power, food supply, diet

Introduction

After the relatively peaceful and prosperous 2010s, the world, including Hungary, has been experiencing a series of crises since 2020. The Covid-19 pandemic, which hit Hungary in March 2020, and the sudden increase in demand resulting from restrictions and later their lifting and the economic recovery programs, have led to a rapid increase in the prices of raw materials and energy commodities. In the same period (second half of 2021 — first half of 2022), the combination of the surplus income flowing out ahead of the parliamentary elections and the weakening of the forint triggered a surge in inflation, further fuelled by the global energy and financial market effects of the Russian-Ukrainian war and the responses to that from the European Union and the United States. Due to the income surplus that emerged in 2021–2022, demand did not respond to the rise in consumer prices, remaining at persistently high levels throughout the year, and in addition, the retail loss from the introduction of fixed prices for certain products from 1 February 2022 was compensated by higher prices for non-fixed priced products (Jankuné Kürthy, 2022). The combination of these factors resulted in food price inflation at a rate not seen since the 1990s, 26.0 percent in 2022 and 25.9 percent in 2023 (KSH, 1.1.1.2.). And at the time of writing, a conflict in the Middle East casts a shadow over the global, including Hungarian, energy supply outlook. These crises could affect Hungary's food supply from several directions. Rising energy prices and the weakening of the forint could lead to higher prices for various imported inputs, which could affect the volume of agricultural production. The combination of rising food input prices, energy prices and the prices of imported commodities will push up the price of food for consumers, potentially jeopardizing households' economic access to food and quality diet. All these factors make it urgent to examine the food security situation in Hungary.

The concept of food safety is often confused with food security in Hungary. While the latter mainly inspect if a certain food product is safe to eat and if the ingredients are properly labelled, food security theory examines whether a defined group has access to sufficient quantities of food of adequate quality. Food safety is therefore a sub-issue of food security. Among many other definitions, the most widely used and perhaps the most comprehensive definition is the one set out in the Rome Declaration on Food Security, issued at the 1996 World Food Conference. According to the Declaration, food security is defined as food that is *available* in sufficient quantities for a given group of people, with *physical, economic* and *cultural access*, that is used in a manner appropriate to a

healthy and active life (*utilization*), and that is *stable* over time (FAO, 1996). In my opinion, the frequent confusion between the concepts of food security and food safety in Hungary — apart from the similar sounding — is due to the fact that, as an agricultural country, food security is taken for granted and therefore little attention is paid to this topic. In fact, in a global comparison, Hungary, as a high-income and net food-exporting economy, belongs to the group of countries with the most stable food security (Jámbor, 2017). In the Global Food Security Index (GFSI), compiled by the Economist Impact news agency and the agricultural giant Corteva Agriscience, Hungary has been ranked 34th for several years with a score of around 70–75, 10–12 points behind the first place and around 40 points ahead of the last place in a list of 113 countries. Both the GFSI country report and the *Food and Agriculture Organization of the United Nations (*FAO) review use the lowest value (≤ 2.5 percent) to estimate the proportion of undernourished people in Hungary, with both reports identifying obesity due to poor diet quality as the most problematic food phenomenon. FAO classifies as obese the 26.4 percent of the adult population and GFSI the 28.6 percent of the whole population (GFSI, 2022; FAO, 2023). However, these reports take a bird's eye view of individual countries and, in order to provide a globally applicable methodology that ensures comparability and ranking between countries, they must ignore local characteristics. The 2013 study by Jankuné Kürthy *et al*. — currently the most recent comprehensive analysis of food security in Hungary — provides a closer perspective and a more detailed explanation. In terms of availability, the study finds that, averaged over the years 2007–2009, self-sufficiency is particularly high in cereals (186%), oilseeds (214%), vegetables (131%), fruits (104%), pork (103%) and poultry (126%), although poultry production has declined significantly from 2002 to 2011. However, self-sufficiency in milk (95%), eggs (95%), animal fat (93%) and potatoes (86%) has been persistently absent, while self-sufficiency in sugar has plummeted, falling below 50% in 2010. In Hungary, food expenditure accounted for an average of 25.6% of household expenditures between 2002 and 2009, while food prices rose by 61.5% between 2000 and 2008. The pattern of consumption was determined by income level, as consumption was typically lower for products with higher income elasticity and higher for products with low-income elasticity compared to higher income levels in Germany and Austria. Energy intake (2550 kcal instead of 3480 kcal), protein intake (75 g instead of 89 g) and fat intake (80 g instead of 152 g) exceeded dietary recommendations. The average consumption of fruit and vegetables including potatoes

was 312 g instead of the recommended daily intake of 400 g. In addition to the comprehensive study by Jankuné Kürthy *et al*. (2013), there are of course a number of scientific works available that do not examine food security in its full complexity but provide important information and insights on certain dimensions of food security. The results of these studies are not presented in separated literature review chapter, but in the analysis according to their relevance to the particular food security dimension.

Objectives

The aim of the study is to assess the extent of how inflation and price increases in 2022-2023 affected food security in Hungary. Based on the lessons learned from past trends in factors affecting food security, I have made the following assumptions: 1) Food availability in Hungary remains stable; 2) The food price surge in 2022–2023 induced changes in food purchasing patterns through deteriorating affordability. 3.) The change in consumption is not reflected in a reduction in total energy intake but rather in a decrease in the consumption of micronutrients and dietary fiber. 4) The gap between the dietary quality of the lowest and highest income groups will increase in 2022–2023.

The study is strictly focused on food security, thus it does not seek to identify the causes of the price increase, but only to examine its effects or potential effects on food security. Nor is it intended to provide a global or regional picture of food security. These issues would require different approaches.

The study analyzes the dimensions of availability, access and utilization, based on available public data, literature and questionnaire survey results. The data on food consumption and expenditure collected and published by the Central Statistical Office are currently available until 2020, information on the exact time of the drastic food price increase is not available. Data for the period after 2020 is collected through an online questionnaire survey.

Material and method

The analysis applies data from the KSH (Hungarian Central Statistical Office) on production and consumption of wheat, maize, rice, poultry meat, pork, beef and veal; number of food retail enterprises; incomes, food expenditure and consumption by income deciles, household composition, age, education, activity, type of residence and by region. — I consider it accurate and transparent the cross-referencing of the numerous KSH data

tables by indicating the serial number of the table rather than the year of the last update of the table, and will therefore do so throughout the study. — In addition, data, analyses and statements from Eurostat, the National Food Chain Safety Office (hereinafter referred to as "Nébih"), the National Nutrition and Diet Status Surveys (hereinafter referred to as "OTÁP"), the Food Bank and the European Food Safety Authority (hereinafter referred to as "EFSA") are used in the study.

As I mentioned earlier, food expenditure and consumption data are currently public only until 2020, but a questionnaire survey is part of the analysis. The questionnaire was shared on the social web in Google form. The initial sharing locations were selected to cover as wide a socio-demographic spectrum of respondents as possible, and after the initial sharing, respondents could then re-share it in a snowball way on their own platforms or in online groups they visited. The questionnaire consisted of two parts. The first part asked for socio-demographic data and the average monthly income, total expenditure and food expenditure of the respondent's household, while the second part contained questions exploring changes in food purchasing habits and their causes between January 2022 and the time the questionnaire was completed. In designing the questionnaire, particular attention was paid to food security problems and threats previously identified in the literature and inferred from the analysis of public data. After cleaning, the publicly available data and the data collected through the questionnaire were analyzed using descriptive (distribution, mean) and mathematical (Spearman's rank correlation) statistical methods. I also applied qualitative methods to collect information. Since no data on the exact prevalence of undernourishment is available, I contacted the management of the Food Bank for a qualitative interview.

The questionnaire was publicly available in November 2023. The final sample size after cleaning of the 321 completed questionnaires received was 300. The survey is not representative, Table 10 shows how the socio-demographic data of the sample differs from the national data. The most striking differences are in the direction of average income, the highest education level of the highest income earner in the household and the type of municipality of residence, which suggest that the national food security situation is somewhat lower than the food security situation obtained from the questionnaire. Readers of this study are asked to keep this in mind when interpreting the results.

Table 10. Main sociodemographic data at national level and in the survey sample

	Sociodemographic characteristic	National	Sample deviation from the national value	Sample of questionnaire respondents n=300
Sex ratio in the adult population (%) (national data: 1st January 2023, KSH 22.1.1.3.)	Women	52,5	+7,8	60,3
	Men	47,5	-7,8	39,7
Proportion of age groups in the adult population (%) (national data: 1st January 2023, KSH 22.1.1.3.)	18–24 years old	9,0	-5,3	3,7
	25–54 years old	51,6	+3,4	55,0
	55–64 years old	14,5	-0,5	14,0
	Over 65 years	24,9	+2,4	27,3
Percentage of people living in a given type of settlement (%) (national data: Census 2022, population aged 20 and over)	Capital city	18,1	+19,9	38,0
	County center, county level city	20,8	-4,8	16,0
	Other city	32,0	-10,0	22,0
	Village	29,1	-5,1	24,0
Composition of households (persons) (national data: 2020, KSH 14.1.1.23.)	average number of household members	2,3	+0,3	2,6
	child/household	0,41	+0,1	0,5
	retired/household	0,5	+0,0	0,5
	earner/household	1,09	+0,3	1,4
	non-earner, non-pensioner adult/household	0,83	-0,6	0,3
Highest education of the person in the household with the highest income (%) (national data: 2022, KSH 20.1.1.6.)	no education	1,2	-0,9	0,3
	primary	17,7	-16,7	1,0
	intermediate, without baccalaureate	23,2	-18,9	4,3
	intermediate, with baccalaureate	33,2	-12,2	21,0
	Tertiary (university degree)	24,7	+48,6	69,3
	academic degree			4,0
Average monthly net income per capita in 2023 (HUF)		213 257*	+70 233	283 490

Source: Own compilation based on data referred in the table.

*Note: *Income data for 2023 are not yet available. Comparing the evolution of average net monthly earnings for full-time employees excluding benefits (KSH 20.2.1.52) and net per capita income (KSH 14.1.2.4) over the period 2016–2020, there is an average difference of 1.1 percent, so the evolution of average net earnings is a proxy for the evolution of net per capita income. Earnings data are currently available until October 2023. In 2019–2022, the monthly trend in*

national average earnings (base=previous month) for all four years shows a more pronounced increase from October to November (average +10.4% in 2019–2022), followed by a moderation of the increase from November to December (average +2.4% in 2019–2022). By applying this trend to the average earnings for October 2023, I obtain the estimated values for November-December 2023. Comparing the calculated average earnings for 2023 to 2022, I found an increase of 14.0%, which I then applied to the average net monthly income for 2022 (KSH 14.1.2.4: 187 067 HUF/month/person), to obtain the estimated average net monthly income of 213 257 HUF/month/person for 2023.

Results

Availability

In Hungary, the most important cereals for food consumption are wheat, maize and rice (KSH 19.1.1.21). The consumption share of the three crops are 74:23:3, calculated on average for 2018-2022. During the same period, farmers produced four times the domestic consumption of wheat and sixteen times of maize. — There are different approaches to measuring the level of self-sufficiency. As the focus of this study is exclusively on food security, the self-sufficiency rate is interpreted as the ratio of the quantity produced domestically to the quantity consumed for food purposes. — In the case of rice, self-sufficiency is not achieved as the climate in Hungary is not favourable for rice production, but rice is a popular staple for side dishes in Hungarian households. Between 2018 and 2022, domestic production covered less than one fifth of domestic consumption. As rice consumption accounts for only 3 percent of wheat-corn-rice consumption, it can be said that Hungary's food self-sufficiency in the major cereals is achieved. A similar picture emerges when looking at meat products. Poultry, pork and beef are distributed in a 49:45:6 ratio in Hungary's meat consumption (KSH 19.1.1.53; 19.1.1.47; 19.1.1.48). The poultry self-sufficiency level averaged 152% between 2004 and 2021, while the pork self-sufficiency level averaged 109%, but in 2018 and 2019 production undercame domestic consumption by nine and twelve tonnes respectively. Beef self-sufficiency averaged 101 percent from 2004 to 2021, i.e. the country produced slightly more than the population consumed. Self-sufficiency is therefore also basically achieved for meat products.

The link between self-sufficiency and food security is less strong at times when global food trade, food commodity production and food supply chains can function smoothly, as the consumed quantity of food can be easily complemented from external markets. For

this reason, there has been a debate in the 2010s on whether self-sufficiency is a proper food security determinant (Clapp, 2014). However, in the event of disruption in the food system — food trade, processing, etc. — the issue of self-sufficiency becomes important to ensure availability and economic access.

In addition to self-sufficiency, the amount of nutrients available per capita also provide information about availability. According to the KSH (19.1.1.65.), in Hungary, around daily 3000 kilocalories per capita food is available. Although in recent years the WHO (UN World Health Organization) and the FAO have emphasized that the desirable intake should be determined in line with energy expenditure, instead of a specific number, the previous FAO recommendation of 2550 kilocalories per day (Jankuné Kürthy *et al*., 2013) compared with the available 3000 kilocalories per day, confirming that sufficient food is available in Hungary. Based on the reviewed data, I conclude that 1) my assumption that food availability is not at risk in 2021–2023, is correct.

Physical and cultural access

In order to meet the food access needs of a country's population, economic, physical and cultural access must be met simultaneously (FAO, 1996). In Hungary, there are no religious or cultural prohibitions that affect the nutritional status of one gender or a particular group. Physical access is basically guaranteed in Hungary, but differences can be detected between different types of settlements. The ratio of grocery stores per 1,000 inhabitants is highest in the smallest settlements with less than 500 inhabitants (4.36 grocery stores per 1,000 inhabitants; national average: 2.32 grocery stores per 1,000 inhabitants), but in the absence of competition, these grocery stores often have very high prices, confusing opening hours or a narrow range of products (Szabó *et al*., 2019). The issue of concentration of food retailing should also be taken into account. Szenderák and Popp (2022) found that between 2015 and 2019, the number of small food and beverage retail outlets (1-4 employees) typically present in small settlements decreased from 7,603 to 6,624, i.e. of 12.9 percent. Statistical data show that between 2020 and 2022, the number of food and food-related mixed retail enterprises in Hungary decreased from 37 392 to 34 777 (KSH 2.1.1.2), while their average floor area increased from 126 to 139 square meters (KSH 2.1.1.1.3), which also suggests an increase in concentration and a potential decrease in the number of stores in the smallest settlements, usually employing 1-2 people and with a smaller floor area. Larger grocery stores, supermarkets and hypermarkets are usually located in larger municipalities, county and district centers,

therefore, access to food for households in small settlements who are less mobile for various reasons may be affected by the concentration of food retailing. Another consequence of concentration may be reduced price competition in small settlements, i.e. higher prices. This effect, however, affects the economic access dimension.

Based on one of the hypotheses of the study — that our food purchasing habits have changed compared to the period before 2022 — and the problems of physical accessibility identified in the literature, my questionnaire survey sought to understand the changes in the location of food purchases since 2022, and the experiences and coping strategies of households with access to only small grocery stores.

For the majority of respondents, 74.0%, there has been no change since 2022 in where they purchase food, 59.0% were already most likely to shop in supermarkets and hypermarkets before 2022 and still do so, and 15.0% still shop in small shops since 2022. 16.3 percent of respondents reported a change from buying most of their groceries in small shops before 2022 to buying most of their groceries in discount stores, supermarkets or hypermarkets. So, in just under two years, we have seen a 16.3 percent concentration on the consumer side, with the primary cause being the lower prices of larger stores, as 81.6 percent of the respondents who switched from small to large stores indicated that the reason for the changes in their food shopping habits was the increase in food prices, while this proportion is lower, 71.7 percent in the entire sample. In addition, although higher education and residence in the capital are more typical in this 16.3 percent of respondents than for the total sample, the number of earners per household is 17.4 percent lower, the number of pensioners per household is 48.9 percent higher and the average net per capita income is 6.9 percent lower for this group than for the total sample. Thus, the group of respondents who are switching from small grocery stores to supermarkets is considered to be more price sensitive compared to the overall sample, and a higher proportion of pensioners is typical in these households.

6.3% of respondents reported that there are only small shops near their home, with prices they can barely or not at all afford. The survey did not confirm the literature's claim that this phenomenon is most prevalent in the smallest villages. In fact, half of the respondents reporting this problem resides in the capital city and only 31.6% in villages, although the proportion of respondents in the capital was over-represented compared to the national distribution (Table 10). Furthermore, only 8.3 percent of all respondents

living in villages mentioned this difficulty. At the same time, 15.8 percent of respondents who indicated the problem of small, expensive shops reported that they purchase food away from their village in a cheaper store, while 84.2 percent did not mark this answer in the questionnaire. According to the survey, the latter group — i.e. those who have only small grocery stores near their homes, with prices they can barely or not at all afford, but who have no possibility to buy food at a lower price far from their homes — is the most vulnerable in terms of the physical-economic access dimension of food security.

Economic access

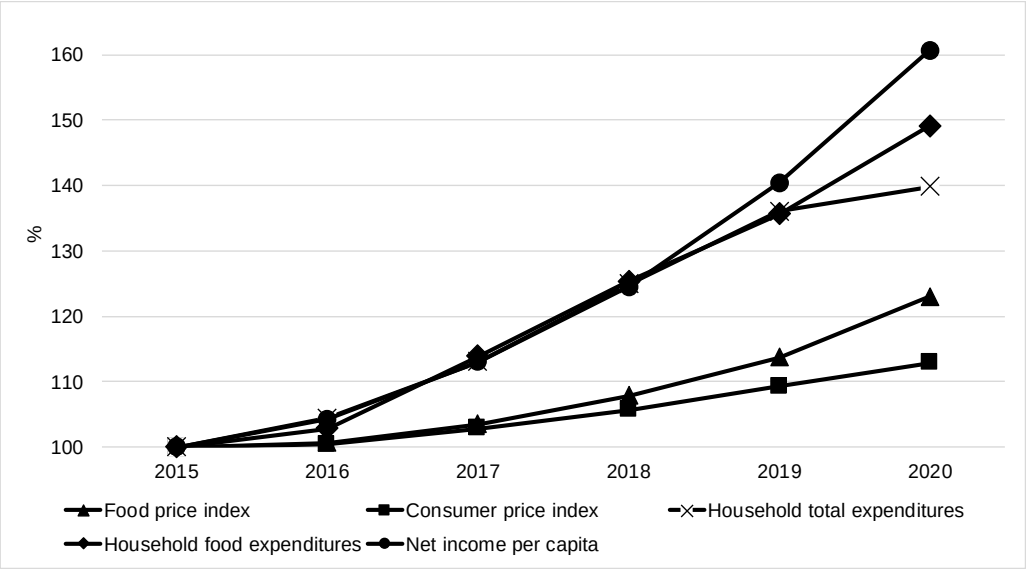
If there is sufficient food available for the group under study — an individual, a household, the population of a country, etc. — and there is no cultural barrier and physical access is ensured through established distribution systems, the next question to be examined is whether economic access is achieved, i.e. whether the group under study can afford to buy the food that is physically available. Economic access is the most vulnerable aspect of food insecurity worldwide. International agencies (IFPRI, 2022; FAO, 2023) and numerous studies (Akter and Basher, 2014; Ceballos *et al*., 2020, Éliás and Jámbor, 2021) have come to this conclusion year after year. The Food Expenditure Share *(FES*) is a well-established indicator for assessing economic access. When interpreting the results, it is important to take into account not only the share at the time of data collection, but also to consider real-life scenarios that could cause a negative change on the income or expenditure side, such as the inability to work of a household member to earn due to illness or other reasons, unexpected costs incurred in the event of breakdowns, etc., or a sudden increase in food prices. The higher the proportion of a household's expenditures that is spent on food, the more likely that in case of an unexpected necessary expenditure, the quality or even the quantity of food consumed will be reduced. Taking these factors into account, Smith and Subandoro (2007) developed their interpretation categories, which have now become the most widely accepted inference, used by many researchers, the World Food Programme, FAO, IFPRI, etc. Smith and Subandoro (2007)'s interpretation categories are: if the food expenditure ratio is higher than 75 percent, the risk of food insecurity is very high; between 65 and 75 percent, the risk is high; between 50 and 65 percent, the risk is medium; below 50 percent, the risk is low. In addition to Smith and Subandoro's (2007) methodology, it is also worthwhile to look at the share of basic expenditure (food, housing, household energy, transport) in total expenditure, given the role of the basic expenditure ratio in adjusting to food price increases.

In the FES framework, based on the number of children living in the household, activity (active, i.e. employed or unemployed/looking for work, retired, other inactive, i.e. not retired, not employed and not looking for work, students, homemakers, seasonal workers), type of settlement of residence, region, age of the highest earner in the household, highest educational attainment, and expenditure data by income quintiles and deciles (KSH 14.1.1.: 26; 31; 36; 41; 14.1.2.10), it can be concluded that the risk of food insecurity for Hungarian households was low between 2015 and 2020. On average, food expenditure accounted for 24.7 percent of total household expenditure, a smaller share than reported by Jankuné Kürthy *et al*. (2013) for 2002–2009 (25.6 percent).

Using the national average as a benchmark, we can identify relatively more vulnerable groups. The most significant deviations (≥30%) from the national average food expenditure share between 2015 and 2020 are found among active (30.1%) and inactive (excluding retired, 33.4%) households belonging to the first income quintile, and retired households in the 1st-3rd income quintiles (32.7%; 31.9%; 30.9%), and households in which the highest education level of the highest income earner is primary or no education (32.6%).

The share of basic expenditure (food, housing, household energy, transport) averaged 56.0 percent between 2015 and 2020, 63.6 and 62.2 percent for income deciles 1 and 2, and 54.1 and 50.3 percent for income deciles 9 and 10. At the same time, the share of basic expenditure decreased in all income deciles between 2015 and 2020. In contrast, the national food expenditure rate was 24.5 percent in 2015 and 26.1 percent in 2020, showing an increase that could even be interpreted as a deterioration in economic access. However, looking at the evolution of food prices, consumer prices and incomes, a positive picture emerges (Figure 6).

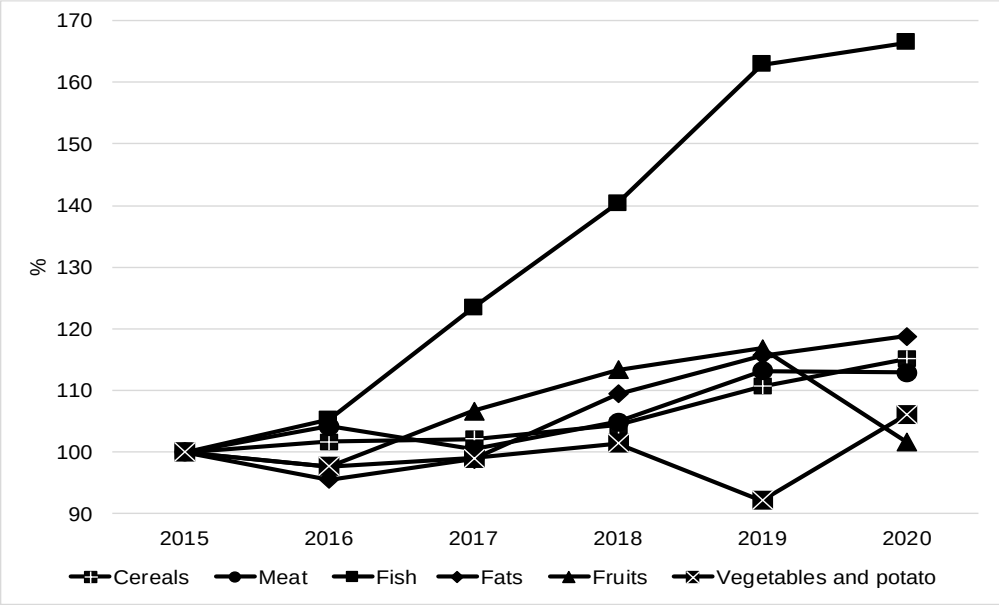
Figure 6. Trends in food and consumer prices, total expenditure and food expenditure and net income 2015–2020, base year = 2015 (percent)



Source: KSH

Food prices (KSH 1.1.1.2.) increased by 23.0% between 2015 and 2020, consumer prices by 12.8%, food expenditure by 49.1% and total expenditure by 39.8% (KSH 14.1.1.26.). This was accompanied by a 60.7 percent increase in average annual net per capita income (KSH 14.1.2.4) over the same period, more than twice as big increase as the increase in food prices. Households could therefore afford to buy more and/or more expensive food products during this period. This is also supported by consumption data (KSH 14.1.1.27), which show an increase in the annual per capita consumption of all food categories between 2015 and 2020, although this increase varied widely between food categories. From 2015 to 2020, consumption of cereals increased by 15.1 percent, meat by 12.9 percent, fish and canned fish by 66.4 percent, fats by 18.8 percent, fruit by 1.6 percent and vegetables and potatoes by 6.0 percent (Figure 7).

Figure 7. Trends in food consumption by major food groups 2015–2020, base year= 2015 (percent)



Source: Own compilation based on KSH data.

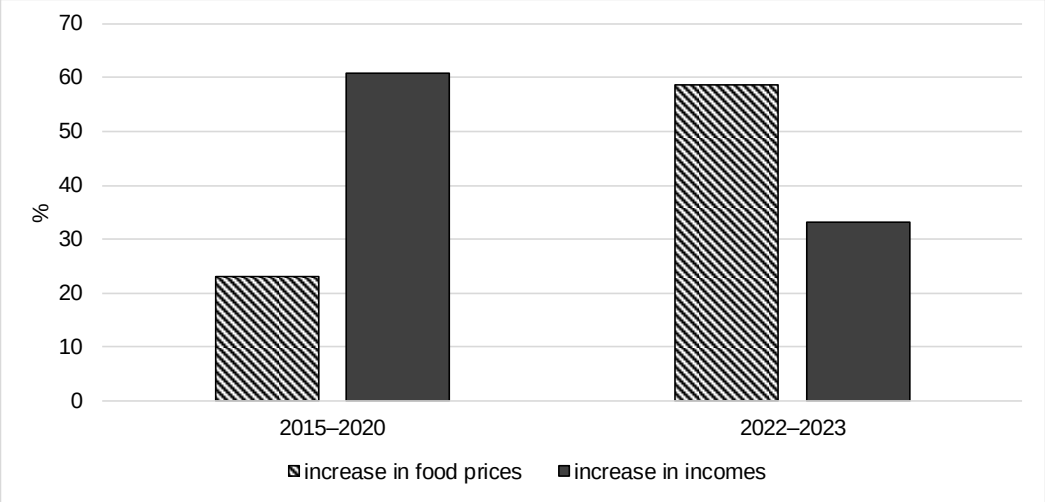
The 33% reduction in the number of farms between 2010 and 2020 (from 351 thousand to 234 thousand farms) may have contributed to a lesser extent to the increase in food expenditure. In other words, there was a reduction in the number of households which obtain certain types of food staples from their own crops rather than from the food market (KSH Agrárcenzus, 2020).

Consequently, comparing food expenditure rates, food prices, incomes and the amount of food consumed, economic access to food in Hungary has increased substantially between 2015 and 2020. Although there are groups with less stable economic access compared to the national average, a positive trend in incomes, food expenditure and consumption can also be observed between 2015 and 2020.

However, this period was followed by a dramatic price surge. Consumer prices (KSH 1.1.1.2.) increased by 41.5 percent between 2021 and 2023, while food prices rose by 65.1 percent. However, most of the price increases occurred in 2022–2023, with consumer prices rising by 34.7 percent and food prices by 58.6 percent in these two years. Average annual net per capita income (2021–2022: calculated according to the methodology presented in the Note to Table 10) increased by 44.8 percent in 2021–2023 and 33.2 percent in 2022–2023. Figure 8 illustrates the negative reversal in the pattern of

food price and income trends determining economic access, which is reflected in the comparison of the periods 2015–2020 and 2022–2023.

Figure 8. Food price and income growth in 2015–2020 and 2022–2023 (percent)



Source: Own calculation and compilation based on KSH data.

Food expenditure and consumption data are not yet available from 2021. In the questionnaire survey, respondents provided their average total monthly expenditure and the amount of food expenditure. The questionnaire included instructions, in line with the KSH methodology, on which expenditure to include in total expenditure and which expenditure to include in food expenditure, but compliance with this could not be verified when completed anonymously, so it is not appropriate to draw statistical conclusions by comparing the result (39%) of the survey with the calculated rate (26%) based on the 2020 KSH data, but instead it is worth examining the results of the questionnaire on their own. The average food expenditure rate among respondents was 39%. Food expenditure rates above this level were found for the groups of respondents aged 65 and over, those living in city but not in the capital, households with two children and households with a household leader with intermediate education, without baccalaureate. Households with a high food expenditure ratio tend to have a low share of per capita income within their sociodemographic category, but there is no explicitly strong relationship between the two variables (Table 11). The Pearson correlation coefficient (–0.483) between average monthly per capita income and food expenditure rate for different socio-demographic groups shows a negative relationship of medium strength, i.e. the higher the income, the lower the food expenditure rate, but this is not the case for the sample as a whole.

Table 11. Distribution of respondents' average monthly per capita income and food expenditure share by socio-demographic characteristics, n=300

Sociodemographic category	Sociodemographic characteristic	Distribution of net monthly income per capita by socio-demographic category (%)	Food expenditure as a percentage of total expenditure (%)
Sex	Women	48%	40%
	Men	52%	38%
Age	18-24 years old	23%	37%
	25-54 years old	27%	38%
	55-64 years old	27%	38%
	Over 65 years	22%	43%
Type of settlement of residence	Capital city	28%	39%
	County center, county level city	24%	42%
	Other city	23%	41%
	Village	25%	37%
Composition of households	households with at least one earning person and no children	31%	38%
	one-child households	18%	39%
	households with two children	16%	44%
	households with three or more children	13%	37%
	households consisting only of pensioners	22%	40%
Highest educational attainment of the person with the highest household income	no education	13%	57%
	primary	13%	61%
	intermediate, without baccalaureate	13%	41%
	intermediate, with baccalaureate	16%	37%
	Tertiary (university degree)	22%	39%
	academic degree	23%	40%

Source: Own compilation.

As the group of households in which the highest income earner had no education or the highest education was primary education was already considered to be a vulnerable group for economic access in the 2015–2020 period, it can be seen that these two groups have the highest food expenditure share among the respondents in 2023. In fact, for both groups, it exceeds the Smith and Subandoro (2007) threshold of 50 percent, thus, the survey shows that these households are food insecure not only relative to the national average, but also by international standards. — It should be noted, however, that the number of respondents with no education and with the highest primary education was low in the survey, and a survey specifically targeting these groups would be needed to draw a more accurate conclusion representing these groups.

There are no precise data on the prevalence of undernourishment in Hungary. The Food Bank (2023) reported that in the first half of 2023 it helped 248,000 people in need to access food in Hungary. As it presented in the introduction, according to international organizations, the prevalence of undernourishment in Hungary is 2.5 percent or lower. They estimate about the same number of people as the Food Bank reports. This suggests that the Food Bank has a broad coverage of households with food insecurity. On this basis, I consider that their experience may be relevant in clarifying the malnutrition picture. When I contacted the Food Bank management via telephone, I was informed that the charities working with them to distribute food are present throughout the country, but not with full coverage. Consequently, the number of people in need at a national level is higher than the 248,000 reported by the Food Bank, but it is not possible to get an accurate estimation. In addition, the 248,000 people does not mean 248,000 undernourished people, since the Food Bank and its partner organizations also provide food to families who are not undernourished, have access to food that meets their energy requirements, but have problems accessing certain food groups for a quality diet or other basic needs. The Food Bank's January 2023 impact assessment found that 43.3 percent of its 418 partner organizations experience the occurrence of food insecurity among the households they help, 8.9 percent see it as typical, and 34.4 percent see it as occurring but not typical. The phenomenon of weight loss due to food shortage is perceived as typical by 16.3 percent of the organizations, while 36.8 percent experience this phenomenon but do not consider it typical. — The ratio numbers therefore represent the responding organizations, not the proportion of undernourished people. — Also in this survey, 83 percent of food

distributing organizations reported that there has been a recent increase in demand for food donations.

In my questionnaire survey, 3.3 percent of respondents said they could not afford to buy the sufficient quantity of food, meaning they were at risk of malnutrition. The average income of these respondents is 51 percent lower than the average income of all respondents and 35 percent lower than the national average income estimated for 2023. Compared to the total survey sample, there is a higher proportion of women (+9.7%), of people over 65 years old (+12.7%), of those with intermediate education, without baccalaureate (+44.7%) and of those living in households with more children among the respondents cannot afford to buy enough food. At the same time, the share of those with university degree (-39.9%) and those aged 55–64 (-14.0%) is lower. No significant difference in the type of settlement of residence is found compared to the total respondents.

The questionnaire survey also asked respondents to answer questions about the reasons for changes in their food consumption habits between January 2022 and the time they completed the questionnaire. 71.7 percent of respondents cited the increase in food prices as a reason for making a change, 28.3 percent cited the price increase as the only reason, 30.3 percent also cited a change in health, lifestyle or taste, and 14.6 percent cited a change in household income in addition to the increase in prices. The average per capita income of respondents who cited price rises as a reason, alone or in combination with other factors, was 6.8% lower and the ratio of woman among the respondents was 6.2% higher than for all respondents, with all other socio-demographic indicators showing a minimal difference of 2.5% or less compared to the total sample. Thus, the change in the cost of food due to rising food prices is an experience shared by a wide range of respondents, irrespective of age, education or household composition.

Utilization — Diet

In the food security concept, utilization refers to food safety, access to reliable drinking water, the nutrient composition and utilization of the food consumed, and the extent of food wastage. Thus, we are essentially looking at food and food consumption in qualitative terms.

The strict food safety standards of the European Union are enforced at EU level by the European Food Safety Authority (*EFSA)* and in Hungary by the National Food Chain

Safety Office (Nébih). The responsibilities of these agencies include monitoring the entire food supply chain, restricting and controlling the use of agricultural inputs that pose a risk to health or the environment, checking the composition of food products on store shelves and ensuring that consumers are fully informed about the composition of food products — for example labelling of allergens on packaging. According to a summary by Nébih, an average of 78 food poisoning cases were reported each year between 2008 and 2019, with an average of 2163 people falling ill each year (Nébih, 2019). According to a survey by EFSA (2022), Hungarians trust Nébih's work and therefore have confidence in the food they eat. In Hungary, access to safe drinking water is 99–100 percent in 11 counties and the capital, 96–98 percent in one county, 90–95 percent in six counties, and 83–89 percent in one county (Bufa-Dőrr *et al*., 2021).

According to Eurostat data, in 2021 Hungary's annual household food waste per capita was 65 kilograms, 4 kilograms below the EU average (Eurostat, 2021). This amount refers to total food waste, so it includes unavoidable waste — parts of food not suitable for human consumption, such as fruit and vegetable peelings. According to the Nébih (2022) survey, the amount of avoidable waste decreased by 24% between 2016 and 2021, from 33.14 kg to 25.19 kg. The largest amounts of food waste in Hungary are meal waste (10.7 kg/person/year), fresh fruit and vegetables (4.5 kg/person/year) and bakery products (3.4 kg/person/year). This significant decrease is a cause for optimism. The results of the questionnaire survey are in line with the national trend presented by the Nébih, with 54% of respondents saying that their household wastes less food than before January 2022, and only one response to the contrary.

The most important source of information on the nutrient intake of the Hungarian population is the Nutrient Intake Survey (OTÁP). The most recent OTÁP data are from 2019. Based on the information collected, the National Institute of Pharmacy and Food Health (OGYÉI) concluded that overweight and obesity affect both sexes, including children, in high proportions. The intake of dietary fiber, i.e. wholegrain cereals, vegetables, fruits, dry pulses, nuts, oilseeds, does not reach the WHO and EFSA recommendations. The consumption of milk and dairy products is around 240 grams per day for adult women and 230 grams per day for adult men, below the level of half a liter of milk recommended by the SMARTPLATE (OKOSTÁNYÉR) and international recommendations, and it is decreasing, except for cheese. Adult fat intake exceeds the WHO 2018 recommendation (less than 30 percent of daily energy intake) for all age

groups and both sexes. Consumption of oilseeds, nuts, fish is low, and intakes of EPA + DHA polyunsaturated fatty acids are 150 mg per day for men and 160 mg per day for women, contrary to the EFSA recommendation of 250 mg. The intakes of vitamin C, vitamin B2 and vitamin A are insufficient for different age groups, and the intakes of vitamin D, folic acid, biotin, pantothenic acid and vitamin B12 are below the reference intakes for all age groups (OGYÉI, 2019).

The available domestic data are therefore consistent with the findings presented earlier by GFSI and FAO that the primary nutrition-related health risk in Hungary is not malnutrition but quality hunger, i.e. inadequate macro- and micronutrient intakes. Excessively high fat intake, combined with inadequate dietary fiber and vitamin intake, increases the risk of obesity and various chronic diseases. The causal analysis of quality hunger brings us back to the issue of economic access, and more specifically economic access to quality food. In fact, Jankuné Kürthy *et al*. (2013), analyzing food security in Hungary between 2002 and 2011, already found a correlation between quality hunger and income status, in line with the general global experiences.

Economic access to a quality diet

Based on the currently available consumption data, it is possible to review the period 2015–2020. It can be assumed that the trends in Hungary between 2015 and 2020 are consistent with the data for Hungary before 2011 and with the global trend, i.e. there is a strong correlation between quality of nutrition and income status. This hypothesis is tested by analyzing the relationship between per capita net monthly income per income decile (KSH 14.8.1.5) and food consumption (KSH 14.1.1.27) for the period 2015–2020. To clarify the relationship between income and food consumption for the period 2015–2020, Spearman's rank correlation coefficient is applied.

Table 12. Relationship between average monthly net per capita income by income decile and per capita consumption of major food groups, 2015–2020

Food Groups	Spearman rank correlation coefficient	Explanation
Fruits	r_s =0.988	very strong relationship
Fish, canned fish	r_s =0.976	
Vegetables and potatoes	r_s =0.964	
Meat products	r_s =0.915	

Cereals	r_s =0.673	moderately strong relationship
Fatty acids	r_s =0.600	
Sugar	r_s =0.406	weak relationship

Source: Own calculation and compilation based on KSH data.
Methodological note: Calculated using Spearman rank correlation based on Schober et al., 2018.

The results presented in Table 12 show that there is a very strong statistical relationship between income level and consumption of certain foods. The higher a person's income, the more fruit, fish, vegetables and potatoes, and meat they consume. Cereals and fats are consumed more overall by people in higher income groups, but these foods are also consumed in large quantities by people with lower incomes. The correlation is weakest for sugar consumption, but it is true to some extent that those with higher incomes are higher sugar consumers.

At the product level, the positive relationship with net income is strongest for the consumption of butter, butter cream; fruit juices, wines, carbonated soft drinks; melons; other fruit and canned fish, i.e. these products are consumed in higher quantities by higher income earners. There is a moderately strong negative relationship between income and consumption of animal fat and a strong negative relationship between income and consumption of bread, i.e. those with lower income consume more bread and also tend to consume more animal fat.

In nutrient terms, I hypothesize that there is a correlation between the quality of the diet recommended by the OGYÉI (2019) and income status. Higher income earners consume more micronutrient-rich fruits and vegetables and fish rich in polyunsaturated fatty acids, while lower income earners have a higher proportion of macronutrient-rich but micronutrient-poor cereals and animal fats in their diet. The combined recommended minimum daily consumption of fruit and vegetables of 400 grams is reached only by those in the top two income deciles, with those in income deciles 1 to 3 not even eating 300 grams of fruit and vegetables per day, although even the consumption of potatoes is included in the consumption of vegetables in the KSH statistics (14.1.1.27). The distribution of the diets of the two extreme income deciles by food major groups is shown in Figures 9 and 10.

Figure 9. Average food consumption of the first income decile, 2015–2020

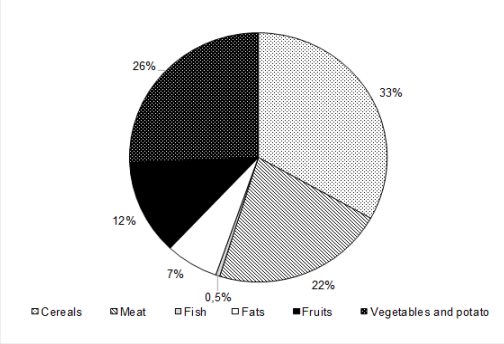
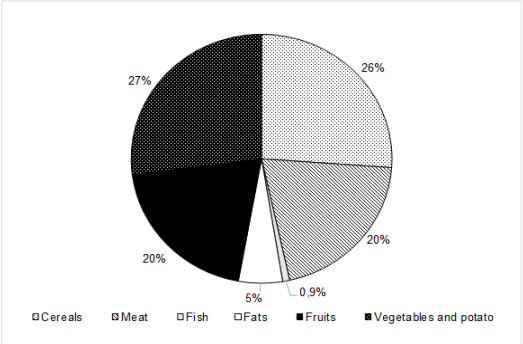


Figure 10. Average food consumption of the tenth income decile, 2015–2020



Source (Figure 9–10): own calculation and compilation based on KSH data

Economic access to a quality diet is therefore unlikely to have been fully achieved in Hungary in the period 2015–2020. The fact that higher income households have a higher quality diet suggests that lower income households have a lower quality diet, mainly because of their lower income. — Of course, income level can be related to a number of other factors, such as place of residence, education, which can also influence food choices, so it is clearly a complex interdependence, of which income is only one, but probably the most significant, factor. — This raises the question of how the diet of Hungarian households has evolved since the beginning of 2022, with food prices rising above the pace of income increase.

According to the results of the questionnaire survey, 34% of respondents felt that it was true that they could currently afford to buy less food related to a healthy diet compared to before January 2022, 32% could not afford to buy the food they considered to be of the best quality and 18% felt that they could not afford to follow the diet they considered to be healthy compared to before 2022. When asked about purchasing special foods for food allergies, 14 percent of respondents said it is not a financial concern for their household, while 9 percent say it is a concern. 27 percent of respondents have given up certain favorite food brands in 2022–2023.

Respondents also indicated the changes in their household's food purchasing habits for specific food groups since January 2022 and the reasons for these changes (Table 13). Only 16% of the respondents have not change their food purchasing and consuming habits, 84% reported a wide range of changes. Overall, it is true that the average income of respondents who bought less of each food group is lower than the average income of the whole sample, and higher for those who bought more. There is also a positive change

in diet. 53% of respondents buy fewer snacks, 43% fewer sugary drinks and 33% fewer alcoholic drinks. These respondents also cite the rise in food prices as the main cause of the change, but their average income differs only slightly (between –4 and +4 percent) from that of all respondents.

Table 13. Most frequent changes in food purchasing habits since January 2022 (occurrence above 10 percent), reasons for changes, income and food expenditure characteristics of respondent groups, n=300

Answers *From January 2022...*	Number of respondents (number)	Percentage of respondents in the total sample (%)	Deviation of average income of respondents from average income of the total sample (%)	Respondents' average food expenditure as a percentage of total expenditure (%)	The two most frequently cited reasons for change (price increase, change in taste, diet or health, %)
buying fewer snacks	160	53%	–4%	38%	food price increases (87%) lifestyle changes (36%)
buying less food	137	46%	–9%	40%	food price increases (96%) lifestyle changes (44%)
buying fewer sugary drinks	130	43%	4%	38%	rising food prices (86%) lifestyle changes (39%)
buying less meat	123	41%	–3%	39%	food price increases (89%) lifestyle changes (39%)
buying less bread	114	38%	3%	38%	food price increases (90%) lifestyle changes (38%)
buying less dairy products	109	36%	–14%	38%	food price increases (92%) health change (35%)
buying fewer alcoholic drinks	100	33%	–1%	39%	food price increase (87%) health change (34%) lifestyle change (34%)
buying fewer nuts, oilseeds	94	31%	–8%	38%	food price increase (96%) health change (30%)
buying less fruit	92	31%	–10%	38%	food price increase (96%) health change (30%) lifestyle change (30%)
I buy less fish	81	27%	–7%	38%	rising food prices (94%) lifestyle changes (36%)
buying fewer vegetables	70	23%	–14%	38%	food price increases (99%) health change (29%)

buying more vegetables	49	16%	13%	37%	lifestyle changes (69%) food price increases (65%)
buying more fruit	35	12%	27%	39%	rising food prices (69%) lifestyle changes (66%)

Source: Own compilation.

A worrying result in the light of the previous dietary picture — but consistent with my preliminary assumption — is that 31% of respondents said they buy less fruit and nuts and oilseeds, 27% buy less fish and 23% less vegetables, mainly because of rising food prices. When looking at average income, these respondent groups appear to have the lowest average incomes compared to sample average, while the average income of respondents who buy more fruit, nuts, oilseeds, fish and vegetables is 13–27 percent higher than the average income of the sample as a whole. It is also of concern that the average income of these respondent groups is only below average among those who completed the questionnaire, but exceeds the estimated national average income in 2023 (see Table 10) by 15–25 percent, suggesting that at the national level, there is a higher proportion of people who currently buy and consume less of these important micronutrient sources compared to the period before January 2022. This implies that as a result of the food price increases in 2022–2023, the quality gap between the diets of low- and high-income households will widen further.

My hypothesis 2) is confirmed by the questionnaire survey, as the majority of the responding households have experienced a change in food purchasing and thus consumption in 2022–2023 compared to the previous period. However, hypothesis 3) was partly disproved by the questionnaire survey, as there is evidence of a change not only in quality but also in quantity, with 46% of respondents buying less food overall. It is true, however, that the most widespread problem is the reduction in the quantity of physiologically important food groups consumed. My hypothesis (4) is fully supported by the questionnaire survey, with higher income earners still increasing the amount of food purchased for a quality diet in 2022–2023, while lower income earners reduced it, so the gap has widened further.

Conclusions — Stability

Hungary is self-sufficient in basic food commodities of crop and animal origin and food is available in quantities exceeding the energy requirements of the population. There are no indications that a negative change in this respect is expected in the short to medium term. In the long term, adaptation to climate change and changes in European and global food markets will determine the future of self-sufficiency and food availability.

In physical access, the process of concentration of food retailing may cause problems for less mobile households due to a reduction in the number of small local shops. Alternatively, a combined problem of physical and economic access arises when only grocery stores are available near less mobile low-income households, where prices are difficult or impossible for the households to afford, thus putting them at risk of malnutrition. In my survey, 5.3 percent of respondents fall into this vulnerable group. 75.2 percent of respondents most often buy their food from discount stores and supermarkets, and 16.3 percent used to buy mainly from small grocery stores before the 2022-2023 price hikes. So the food price crisis is adding to the already existing concentration of retailers.

The positive trend in economic access presented by Jankuné Kürthy *et al*. (2013) for the post-millennium period continued in the 2010s, with the food expenditure share remaining low, with a 23.0 percent increase in food prices coupled with a 60.7 percent increase in incomes between 2015 and 2020. Economic access was lower than the national average for households of those in the lowest income quintile, retirees in income quintiles 1-3, and heads of households with no or only primary school education.

Households in low-income deciles also saw consumption increase in all food groups between 2015 and 2020, but they were more affected by quality hunger, as they consumed less micronutrient-rich foods — below the recommended intake — compared to higher-income households. There is a clear correlation between income status and diet quality. Thereafter, between 2021 and 2023, prices and incomes followed a downward trend. In 2022–2023, food prices increased by 58.6 percent, while incomes increased by only 33.2 percent. For respondents living in households with a head of household without education or with primary school education, the food expenditure share rose above the 50 percent level considered vulnerable by even international standards, although the number of respondents was low. 71.7 percent of respondents to the questionnaire indicated that there

had been a change — qualitative and/or quantitative — in their food consumption compared to the period before January 2022 due to the rise in food prices. 18 percent of respondents cannot afford to follow the diet they consider healthy, 32 percent cannot afford to buy the food they consider best quality and 3.3 percent cannot afford to buy enough food compared to period before January 2022. Households that consumed less fruit, nuts and oilseeds, fish and vegetables since January 2022 were from lower income households, while those that purchased more of these rich micronutrient sources tended to have incomes above the sample average. The gap in dietary quality between the poorer and better off will therefore widen further in the wake of the food price crisis 2022-2023.

There are also positive changes in food handling and consumption among some groups of respondents. 54% of respondents have wasted less food, 53% have consumed fewer snacks, 43% have consumed fewer sugary drinks and 33% have consumed fewer alcoholic drinks since January 2022.

The overall picture shows that the stability that characterized Hungary's food security in the previous two decades has been broken, with food security deteriorating as a result of the food price crisis of 2022–2023. The number of households who cannot afford to buy sufficient quantities and/or quality of food has increased. Given that the financial situation of the respondents to the questionnaire is above the national average, it can unfortunately be concluded that food security in Hungary has been affected by the food price hikes even more severely than the level presented in this research. This should be further explored through representative questionnaire or qualitative research methods among vulnerable groups and the collection of food consumption diaries. Regaining food security stability depends on the evolution of food prices and incomes of low-income households.

References

Akter, S., and Basher, S. A. (2014) The impacts of food price and income shocks on household food security and economic well-being: evidence from rural Bangladesh. *Global Environmental Change*, *25*(1), 150-162. https://doi.org/10.1016/j.gloenvcha.2014.02.003

Bufa-Dőrr, Zs., Málnási, T., Sebestyén, Á., Vargha, M. and Vecsey, A. (2021). Report - Drinking Water Quality in Hungary, 2020. National Centre for Public Health. https://www.nnk.gov.hu/attachments/article/726/Ivovizminoseg_2020.pdf

Ceballos, F., Kannan, S., and Kramer, B. (2020). Impacts of a national lockdown on smallholder farmers' income and food security: empirical evidence from two states in India. *World Development, 136*, 105069. https://doi.org/10.1016/j.worlddev.2020.105069

Clapp, J. (2014) Food security and food sovereignty: getting past the binary. *Dialogues in Human Geography, 4*(2), 206-211.

Food Bank (2023). Reports: our results https://www.elelmiszerbank.hu/hu/eredmenyeink.html; A quarter more food saved this year https://www.elelmiszerbank.hu/hu/hirek/hireink/negyedevel_tobb_elelmiszert_mentettunk_iden.html

Éliás, B. A., and Jámbor, A. (2021). Food security and COVID-19: a systematic review of the first-year experience. *Sustainability, 13*(9), 5294.

European Food Safety Authority (2022). Food safety in the EU. Eurobarometer 97.2 special edition. https://www.efsa.europa.eu/sites/default/files/corporate_publications/files/eurobarometer22/country-factsheets/eb972_factsheet_hu_hu.pdf

Eurostat (2021). Food waste and food waste prevention by NACE Rev. 2 activity https://ec.europa.eu/eurostat/databrowser/view/env_wasfw/default/table?lang=en

FAO (1996). Rome Declaration on World Food Security and World Food Summit Plan of Action. World Food Summit 13-17 November 1996. Rome. http://www.fao.org/3/w3613e/w3613e00.htm

FAO (2023). The State of Food Security and Nutrition in the World 2023. https://www.fao.org/3/cc3017en/cc3017en.pdf

Global Food Security Index 2022. https://impact.economist.com/sustainability/project/food-security-index/explore-countries/hungary

IFPRI (2022). 2022 annual Report https://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/136727/filename/136938.pdf

Jámbor, A. (2017). *Global issues of agricultural competitiveness and food security*. Eco-Sensus Nonprofit Ltd., Szekszárd.

Jankuné Kürthy, Gy., Kőnig, G., Mizik, T. and Szabó, M. (2013). Közép-Kelet Európa Élelmezésbiztonsága. In Kiss, J. (2013). *Az élelmezésbiztonság világgazdasági dimenziói.* MTA Közgazdaság- és Regionális Tudományi Kutatóközpont, Világgazdasági Intézet. OTKA Kutatási Jelentések, pp. 145–216. [Food security of Central and Eastern Europe. In: *Food security in global context.]*

Jankuné Kürthy, Gy. ed. (2022). *Relationships between production costs and price developments in some major food product chains*. Institute of Agricultural Economics [manuscript]

KSH 1.1.1.2 Consumer price index by main consumption groups, the pensioner consumer price index and core inflation [previous year = 100.0%]. https://www.ksh.hu/stadat_files/ara/hu/ara0002.html

KSH 14.1.1.23. Number of households, characteristics of persons living in the household, their income-earning activities, income deciles. https://www.ksh.hu/stadat_files/jov/hu/jov0022.html

KSH 14.1.1.26. Annual expenditure per capita by COICOP population groups and income deciles [HUF/person/year]. https://www.ksh.hu/stadat_files/jov/hu/jov0025.html

KSH 14.1.1.27. Annual per capita food consumption by income deciles [kilograms]. https://www.ksh.hu/stadat_files/jov/hu/jov0026.html

KSH 14.1.1.31. Breakdown of annual expenditure per capita by COICOP grouping, age group of reference person, educational attainment and age composition of household members [HUF/person/year]. https://www.ksh.hu/stadat_files/jov/hu/jov0030.html

KSH 14.1.1.36. Breakdown of annual per capita expenditure by COICOP grouping in households with children, households without children and single-person households [HUF/person/year]. https://www.ksh.hu/stadat_files/jov/hu/jov0035.html

KSH 14.1.1.41. Breakdown of annual per capita expenditure of active, pensioner and other inactive households by COICOP grouping, income quintiles [HUF/person/year]. https://www.ksh.hu/stadat_files/jov/hu/jov0040.html

KSH 14.1.2.10. Breakdown of annual expenditure per capita by COICOP grouping, region and type of settlement [HUF/person/year]. https://www.ksh.hu/stadat_files/jov/hu/jov0050.html

KSH 14.1.2.4 Gross and net per capita income by region and type of settlement [HUF/person/year]. https://www.ksh.hu/stadat_files/jov/hu/jov0045.html

KSH 14.8.1.5 Gross and net per capita income by income deciles [HUF/person/year]. https://www.ksh.hu/stadat_files/jov/hu/jov0005.html

KSH 19.1.1.21. Production and use of major arable crops. https://www.ksh.hu/stadat_files/mez/hu/mez0021.htmll

KSH 19.1.1.47. Pig meat balance sheet. https://www.ksh.hu/stadat_files/mez/hu/mez0048.html

KSH 19.1.1.48. Beef and veal balance sheet. https://www.ksh.hu/stadat_files/mez/hu/mez0049.html

KSH 19.1.1.53. Poultry meat balance. https://www.ksh.hu/stadat_files/mez/hu/mez0054.html

KSH 19.1.1.65. Daily amount of nutrients per capita in kilocalories. https://www.ksh.hu/stadat_files/mez/hu/mez0066.html

KSH 2.1.1.2 Number of retail outlets by type of outlet, 31 December https://www.ksh.hu/stadat_files/bel/hu/bel0002.html

KSH 2.1.1.3. Total and average floor area of retail stores by type of store, 31 December https://www.ksh.hu/stadat_files/bel/hu/bel0003.html

KSH 20.1.1.6 Population by highest level of education, by sex (thousands). https://www.ksh.hu/stadat_files/mun/hu/mun0006.html

KSH 20.2.1.52. Average net earnings of full-time employees excluding benefits by industry, monthly, cumulated monthly and quarterly. https://www.ksh.hu/stadat_files/mun/hu/mun0202.html

KSH 22.1.1.3 Population by age and sex, 1 January https://www.ksh.hu/stadat_files/nep/hu/nep0003.html

KSH Agrárcenzus (2020). Preliminary data. https://www.ksh.hu/docs/hun/xftp/ac2020/elozetes_adatok/index.html#/cover

Nébih (2019). Nébih Food and Feed Safety Directorate, Catering and Public Catering Supervision Unit Summary. https://portal.nebih.gov.hu/documents/10182/1487366/honlapra_%C3%89M+report%C3%A9s+2019.pdf/1fe72e40-049a-964c-a838-5c0d34ae70d9?t=1594899201668

Nébih (2022). Our food waste has been cut by a quarter. https://portal.nebih.gov.hu/-/negyedevel-csokkent-az-elelmiszerpazarlasunk

Census 2022 Database. https://nepszamlalas2022.ksh.hu/adatbazis/#/table/WBS001

OGYÉI: OTÁP 2019 - Evaluation presentations. https://ogyei.gov.hu/otap2019/

Schober, P., Boer, C., and Schwarte, L. A. (2018). correlation coefficients: appropriate use and interpretation. *Anesthesia & Analgesia,* 126(5), 1763-1768.

Smith, L. C., and Subandoro, A. (2007) *Measuring food security using household expenditure surveys (Vol. 3*) Intl Food Policy Res Inst.

Szabó, P., Kabai, G., Fekete, K. (2019). The main characteristics of retail food supply in Hungary and the supply problems and opportunities of small villages in the 21st century. *Tér-Gazdaság-Ember, 7*(2-3), 205-229.

Szenderák, J., and Popp, J. (2022). Sectoral concentration along the food chain in Hungary. Gazdálkodás, *66*(2), 99-116.

Appendix — Survey questions

Food prices and our experience
In our research, we examine the impact of food price inflation on Hungarian households. The questionnaire is completely anonymous and no information about the respondent's identity is given to us through the filling-in system. Please do not provide any identifiable information (name, phone number, etc.) when filling in the questionnaire. The questionnaire will first ask questions about you and your household's composition, income and expenditure, and then about changes in your household's food purchasing habits since January 2022. To fill in the questionnaire , you must be 18 years of age or over in Hungary. Please complete the questionnaire only once.
Have you filled in this questionnaire before?
Yes
No
I. Information about you and your household
Your gender
Women
Men
Your age
Under 25 years old
25-54 years old
55-64 years old
Over 65 years old
Type of municipality where you live
Capital city
County center, county level city
Other city
Village
Number of adults living in your household
Number of children under 18 living in your household, minors
Number of persons in your household who are gainfully employed
Number of pensioners living in your household
Number of adults in your household NOT in gainful employment and NOT retired

Highest level of education of the highest earner in your household
no education
primary
intermediate, without baccalaureate
intermediate, with baccalaureate
Tertiary (university degree)
academic degree
Your household's net income for the month, including the net earned income of all earners, net income from business, social benefits (pensions, unemployment benefits, child allowances, etc.), i.e. all the income that the household can earn during the month.
Total average monthly expenditure for your household, including food, housing, medicine, mortgage repayments, clothing, transport, entertainment, etc. Please select from the drop-down list.
The average monthly food expenditure of your household, including the monthly amount spent on food and non-alcoholic beverages, NOT including the amount spent on alcoholic beverages, food supplements, medicines, restaurants or catering.
II. Changes in food purchasing habits
In the second part of our questionnaire, we want to assess whether your household has been forced to make changes to its food purchasing and consumption habits in the last two years due to particularly high food price increases, so the following questions are about food purchasing changes that have occurred since January 2022. Please tick the statements that are true for your household price! You can tick more than one statement. (If the size of your household has increased or decreased in the last two years and you buy more or less food overall because of this, but the amount of food you buy is the same for each person in the household, please do not tick this box.)
Compared to the period before 2022...
I buy less food.
I buy more groceries.
I buy fewer vegetables.
I buy more vegetables.
I buy less fruit.
I buy more fruit.
I buy less meat.
I buy more meat.
I buy less fish, canned fish.

I buy more fish, canned fish.
buy fewer dairy products (milk, cheese, yoghurt, cottage cheese, milk-based desserts, etc.).
I buy more dairy products (milk, cheese, yoghurt, cottage cheese, milk-based desserts, etc.).
I buy less bread and pastries.
I buy more breads and pastries.
I buy fewer nuts and oilseeds.
I buy more nuts, oil seeds.
I buy fewer snacks.
I buy more snacks.
buy fewer sugary drinks.
I buy more sugary drinks.
buy fewer alcoholic drinks.
I buy more alcoholic drinks.
pay more attention to promotions and discounts.
I've given up some of my favourite food brands.
Neither of these statements are true, there have been other changes in my household's food buying habits since January 2022.
Neither of these statements are true, because there has been no change in my household's food purchasing habits since January 2022.
Please select the statement(s) that best reflect the reality of the situation! You can mark more than one claim.
The reason for the change in my household's food purchasing habits is...
the rise in food prices.
health change.
changes in taste.
a change in my household income.
lifestyle change.
My household's food buying habits have not changed.
Please tick the statements that are true for your household! You can tick more than one statement.
To buy enough food, I don't have to give up other expenses.
To buy enough food, I have to give up other expenses.
I cannot afford to buy enough food.
I can't afford to follow a diet that I consider healthy.

I can afford health-conscious food only in smaller quantities than before 2022.
I can't afford to buy the food I consider of the best quality.
My household member(s) have food allergies/sensitivities, but I have NO problem buying the right foods financially.
My household member(s) have food allergies/sensitivities and I have trouble affording to buy the appropriate food.
Since January 2022, less food is wasted in my household.
Since January 2022, my household has been wasting more food.
None of these statements are true.
Please tick the statements that are true for your household about where to buy food. You can tick more than one statement.
Even before 2022, I shopped in small grocery stores most of the time, and I still do.
Before 2022, I used to shop at smaller grocery stores most of the time, but lately I mostly shop at discount stores, supermarkets or hypermarkets.
Even before 2022, I shopped in discount stores, supermarkets and hypermarkets most of the time, and have done so ever since.
There are only small grocery store(s) near where I live, and I can barely afford their prices, if at all.
I buy food far from home at better prices than local shops.

6. Brief introduction of Publication 3

6.1. Bibliometrics

Jámbor, Attila and Éliás, Boglárka Anna (2024). Determinants of Food Security: A Comprehensive Analysis Across East, South, and Southeast Asia. *Journal of Sustainability Research*, *6*(2):e240030; https://doi.org/10.20900/jsr20240030.

Ranking of journal in year of publishing: SJR Q2.

6.2. Targeted research question

Q2. Can well-established statistical methods—commonly used to identify food security determinants—be effectively applied to assess the deterministic effect of crises on food security?

6.3. Research gaps

In addition to the research gap which formed Q2, – i.e., there are several studies applying panel data approach with a large number of observations to find deterministic factors of food security, but to our best knowledge, there are no studies that would use this approach to assess the deterministic level of crisis on food security –, we have not found studies that would examine food security determinants considering East, Southeast, and South Asia, which regions together account for half of the world's population and present a very diverse picture in terms of both food security and economic indicators, with a number of countries in these regions particularly exposed to extreme weather events, several food price crises in recent decades, and a number of geopolitical hot spots.

6.4. Hypotheses

H6. Higher performance of the agriculture sector decreases food insecurity.

H7. The growth of average economic size foster food security.

H8. Open economic activities positively influence food security.

H9. Higher changes in average temperature are against food security.

H10. Crises situations cause food security to decrease.

6.5. Key findings

Due to the results of our GLS random effects regression model (357 observations from 17 countries between 2001 and 2021; independent variable: Prevalence of Undernourishment, *PoU*), population size (+), economic growth (+), the value of agricultural production (–), agricultural employment (+), the cereal imports dependency ratio (–/+), and the number of deaths in battle were statistically significant (+), while foreign direct investment, exchange rate, annual temperature change, dummy of refugees, economic crisis, and food price surge dummy variables were not.

H6. Higher performance of the agriculture sector decreases food insecurity – Confirmed.

Our analysis also supports the theory that agriculture plays a pivotal role in food security, as evidenced by the influence of agricultural employment and production value on PoU, emphasizing the importance of efficient and profitable agricultural sectors. This observation is consistent with the notion that in developed nations with advanced agricultural technologies and various social factors, agricultural employment tends to be low, whereas the opposite is true in less developed countries.

H7. The growth of average economic size foster food security – Partially confirmed.

In line with previous research (Applanaidu and Baharudin, 2014; Kovljenič and Raletič-Jotanovič, 2020; Aiyedogbon *et al*., 2022), we found a positive relationship between population size and PoU, though the impact was less significant than in other studies, due to outliers such as China, Japan, and Mongolia, underscoring the demographic challenges to food security.

However, our hypothesis cannot be completely accepted as our results question several long-held beliefs on the relationship between GDP-growth and food security status. Contrary to the expected negative relationship, we discovered a positive link between GDP and undernourishment, indicating that economic expansion is not a sole predictor of food security, a finding that deviates from common belief and calls for further scrutiny.

H8. Open economic activities positively influence food security. – Rejected.

Similarly, the impact of open economy factors such as the cereal import dependency ratio and foreign direct investment (FDI) on PoU revealed unexpected patterns. The lack of a consistent negative effect of high cereal import dependency on food security challenges the idea that dependence on food imports is inherently harmful. Additionally, the minimal

influence of FDI on PoU disputes the notion that FDI is a straightforward solution to enhancing food security through economic growth and agricultural innovation.

H9. Higher changes in average temperature are against food security. – Rejected.

Another surprising discovery was the insignificance of temperature change on food security, suggesting that climate change's expected adverse effects on agriculture and food supply might be offset by other variables, such as adaptive strategies or economic progress in the regions studied.

H10. Crises situations cause food security to decrease. – Partially confirmed.

The “deaths in battle” dummy variable showed a significant impact on the food security of the countries in the three examined regions. However, other crisis-related dummies (“refugees”, food price boom, economic crises) had no significant impact on food security in model. This indicates that while geopolitical and societal stability are essential, their direct influence on undernourishment is more complex than assumed, pointing to the necessity for a deeper exploration of resilience mechanisms.

It's important to note that PoU is a measurement of extreme food insecurity. The lack of significant findings for crisis variables suggests that future research could benefit from examining more nuanced indicators like dietary diversity, although such data is scarce in the regions of interest; thus, different geographical scope might be needed for that research.

6.6. Author contributions

A. J. and B.A.E. designed the study, B.A.E. collected and analyzed the data, A. J. ran the regression model, B.A.E. and A. J. analyzed the results. Both authors contributed to the writing of each chapters in the paper.

7. Complete text of Publication 3

Determinants of Food Security: A Comprehensive Analysis Across East, South, and Southeast Asia

Abstract

The role of food security has continuously been increasing during the recent decades and especially due to recent crises. This study investigates the determinants of food security in East Asia, South Asia, and Southeast Asia — regions that are critical to global food security due to their substantial population and agricultural output. Utilising a dataset spanning from 2001 to 2021 and employing a random effects regression model, this paper examines the influence of economic growth, agricultural performance, open economic activities, climate change, and crisis situations on food security. The study covers 357 observations from 17 countries within the selected regions. Results suggest that the relationship between economic growth and food security is not straightforward across the regions. While agricultural performance generally supports food security, the impact of open economic activities and external shocks like conflicts and climate change vary. Notably, recent global crises have had nuanced effects on food security, while the prevalence of undernourishment steadily decreased despite of the crisis events. The study highlights the complexity of achieving food security in Asia and the need for sustainable region-specific policies addressing both structural and transitory challenges. Policymakers need to consider a broader range of factors, related to sustainability, to effectively combat hunger and undernutrition.

Keywords: undernourishment, food security, determinants, Asia, crises

JEL classifications: Q18.

Introduction

Ensuring food security, defined as consistent access to an adequate quantity (availability) and quality (utilisation) of food over time (stability) (FAO, 1996), is fundamental for maintaining social stability and economic prosperity. Consequently, food

security holds significant importance in both national and international political agendas. Several of the United Nations' 17 Sustainable Development Goals (SDGs) are intertwined with food security, with SDG2, "Zero Hunger", explicitly addressing this concern. Following the formulation of the SDGs at the United Nations Sustainable Development Summit on 25 September 2015, there was room for optimism about achieving substantial progress in SDG2. From 2002 to 2017, the trend in the global number of undernourished people was declining, however, in 2018 and 2019, there was a modest increase (+2.6% and +4.4%). In the subsequent years, 2020 and 2021, the increase was more pronounced at 14.5% and 5.3%, followed by a slight 0.5% decrease in 2022, bringing the global number of undernourished to 735.1 million — a regression to the 2006 level (FAOSTAT).

UN Food and Agriculture Organization (FAO) projections indicate an expected increase to 590.3 million undernourished people by 2030. This suggests that during the Sustainable Development Framework period (2015–2030), rather than achieving the targeted decrease, the number of undernourished people may increase by 0.24%. Even if the share of undernourished people in the population (prevalence of undernourishment, PoU) is likely to be smaller in 2030 than in 2015 due to expected population growth, this outcome would still fall short of the targets set by SDG2.

The pre-COVID-19 FAO projection in 2019 foresaw a 19.9% decrease in the global number of undernourished people. By contrast, a more modest decline of 3.6% was projected for 2021, reflecting the aftermath of the COVID-19 peak and preceding the conflict in Ukraine. The most recent scenario from 2022 expects a slight 0.24% increase in the number of undernourished people globally between 2015 and 2030 (FAO, 2023).

According to the FAO classification, chronic food insecurity arises from structural weaknesses, such as low income, with enduring effects. On the other hand, transitory food insecurity results from sudden shocks like conflicts and weather extremes, and its effects are temporary (FAO and EC, 2008). In the three FAO projections mentioned above, the annual change in the number of undernourished is projected to remain relatively consistent from 2025 onward. Consequently, the factors hindering food security due to recent crises may not significantly impact the long-term food security process. However, if the pace of food security development merely returns to pre-COVID-19 levels, the surplus of 120 million people who fell into undernourishment between 2020 and 2022 will persist compared to the pre-crisis scenario (FAO, 2023). Consequently, the distinction between chronic and transitory food security becomes blurred.

The relationship between non-food-security crises and their impact on food security is often challenging to determine due to multicausality and mutual reinforcement between outcomes of certain non-food-security crises and their direct and indirect effects on food security. The Global Report on Food Crises (GRFC) presents analyses of countries experiencing food security crises in specific years. From 2018 to 2023, the primary drivers of food crises were crises of conflict, weather extremes, and economic shocks nature (Food Security Information Network, 2018–2023).

Until 2019, conflict and weather extremes stood out as the two most significant causes of food crises in the countries examined in the GRFC reports (Food Security Information Network, 2018–2023). However, from 2020 onward, conflict remains the driver resulting in the biggest food crises in terms of number of affected people, while economic shocks drag the most countries into food crisis and weather extremes became a relatively less significant factor. While the extent or frequency of natural disasters has not decreased, economic problems have reached a level where they surpass the food security-related effects of weather conditions (Food Security Information Network, 2018–2023).

The lesson extracted from the (Food Security Information Network, 2018–2023) and (FAO, 2023) annual reports is that global crises, such as COVID-19, the war in Ukraine, or even pre-existing issues like the 2007–2008 food price crisis, do not solely explain deep food security crises. Food security is most jeopardised when the pre-existing structural weaknesses of local food and economic systems intersect with the direct or indirect effects of local security, climate, or economy-related crises, and/or the direct or indirect effects of a global crisis on market prices, supply chains, national currencies etc.

In this paper, we assess the determinants of food security in three major regions of Asia: East Asia (encompassing China with Taiwan, Hong Kong SAR, and Macao SAR; Mongolia; North Korea (DPRK); South Korea (ROK); and Japan), South Asia (comprising Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka), and Southeast Asia (including Brunei, Cambodia, Indonesia, Laos, Malaysia, Myanmar, Philippines, Singapore, Thailand, Timor-Leste, and Vietnam). These three regions are highly populous, collectively representing more than half of the global population, and thus, they play a significant role in global food consumption and production. Furthermore, in economic and food security terms, the countries within these regions exhibit substantial variations. The presence of conflicts and extreme weather

conditions in certain parts of these regions makes it possible to account for local crises of this nature.

The paper contributes to the existing literature in three ways. First, it gives an update on the latest trends of food security in three Asian regions. Second, it identifies the determinants of food security, especially considering those related to recent crises. Third, it provides better understanding of food security dynamics to policy makers.

The paper is structured as follows. Chapter 2 (Literature Review) provides a brief review of the literature so far, followed by a description of the methods used. Chapter 4 (The Food Security Landscape Of South And East Asia And Its Determinants) shows some descriptive patterns of regional food security, followed by the presentation and discussion of our regression results. Chapter 6 (Conclusions) concludes.

Literature review

The application of panel data analysis to identify food security determinants is not unprecedented. Demeke *et al*. (2011) sought to identify food security determinants using panel data from Ethiopian rural households and employed a fixed-effects regression model. Their findings indicated that factors such as rainfall variability, household size, participation in local savings groups, and livestock ownership had a positive impact on the food security of the involved households.

Subramanyam *et al*. (2011) found an inverse association between economic growth and food insecurity in India using fixed and random effects logistic models. In Kenya, Mutisya *et al*. (2016) discovered that higher levels of education reduced the risk of severe food insecurity through the application of a random effects generalised ordered probit model. Dithmer and Abdulai (2017) examined the impact of trade openness and economic growth on dietary energy consumption and dietary diversity analysing data from 151 countries between 1980 and 2007. Their linear dynamic panel data model demonstrated a positive and significant impact of the independent variables on dietary outcomes. Affoh *et al*. (2022) analyzed panel data from 25 sub-Saharan African countries between 1985 and 2018 to assess the relationship between precipitation, temperature, CO2 emissions, and the availability, access, and utilisation dimensions of food security. Their findings revealed that rainfall positively affected all three dimensions, temperature negatively

impacted availability and access but had no effect on utilisation, while CO2 emissions positively influenced both availability and access but did not affect utilisation.

Population growth also appears to be a determinant of food security according to the literature, often demonstrating an inverse relationship. In the analysis of former Yugoslav countries, Kovljenič and Raletič-Jotanovič (2020) found that a 2.85% growth in population resulted in a 1% increase in the prevalence of undernourishment. Additionally, according to Applanaidu and Baharudin (2014), a sudden change in population has a negative but temporary impact on food security. Aiyedogbon *et al*. (2022) found that population growth is significantly but variably associated with agricultural output and consequently, food security over time.

The relationship between economic growth and food security is far from as evident as one might think. Aziz *et al*. (2021), in their examination of South Asia, found that a 1% GDP growth reduced the number of undernourished people by 0.005%. Warr (2014) also found an inverse association between GDP per capita and undernourishment; however, in the case of Asia, the result was not statistically significant. According to Applanaidu and Baharudin (2014), a shock in GDP growth results in a decline in food security, but this effect is not immediate; instead, it is strongest 2 years after the economic shock. In contrast, Ramessur and Bundhun (2022) found that in parallel with the growth of GDP per capita, the level of food security declined in the Maldives. The study by Holleman and Conti (2020) also detected this phenomenon and concluded that in the case of countries with high income inequality, the positive effect of economic growth on food security cannot prevail. Instead, there is a simultaneous increase in GDP and undernourishment in these countries.

On the whole, various studies have concentrated on different factors behind food security so far but the number of studies taking into account different determinants at the same time are limited — a gap which paper aims to fill in.

Data and methods

The aim of this paper is to identify the various determinants of food security in Asia. Based on the above literature, the following hypotheses are tested:

H1: The growth of average economic size foster food security.

The difference in resources can be measured in various ways—we use two proxies here: population and GDP, suggesting that increasing population challenges food security. While keeping in mind the above introduced ambiguous results of the literature on the association between GDP growth and food security level, we still assume that in case of the three examined regions, higher GDP levels guarantees higher food security levels. Population is measured in million people, while GDP is measured in million USD—population size is expected to be positively related to prevalence of undernourishment, while GDP is thought to be negatively related.

H2: Open economic activities positively influence food security.

Open economic activities and liberal trade relations are generally thought to increase economic prosperity and hence food security. Three proxies are used here to capture these effects: FDI (Foreign direct investment) inflows (measured in million USD), exchange rates (local currency/USD) and the dependency on cereal imports (in percentage). Higher FDI rates assume higher capital for food infrastructures and technologies, higher employment and household incomes, thereby a negative relationship with prevalence of undernourishment, unlike weak exchange rates, where a positive relationship is assumed. Cereal import dependency, in our understanding, fosters undernourishment, so again a positive association with PoU is expected.

H3: Higher performance of the agriculture sector decreases food insecurity.

It seems to be evident that higher performance of the agriculture sector guarantees food security. Three proxies are used to capture these impacts: share of agricultural employment in total employment, gross production value of agriculture and producer prices of agricultural products. Higher agricultural employment rates and production values are expected to be negatively related to prevalence of undernourishment, while higher producer prices are expected to foster undernourishment through decreasing food access.

H4: Higher changes in average temperature are against food security.

Agriculture and the climate are strongly linked together. Climate change impacts, measured in temperature changes, assume lower yields, higher variability and lower reliability of agricultural production and thereby increased prevalence of undernourishment.

H5: Crises situations cause food security to decrease.

Previous years have shown several crises situations, impact of which on food security are also about to be tested. We have introduced five dummy variables to capture the effects of crises situations: refugees, deaths in battles, price booms, crises in time and delayed crises in time. The first two represent the years of fatal casualties on the battlefield within the country's territory and the years when the number of refugees hosted by the country equalled at least 0.01% of the country's population. The crisis dummy variable identifies the years of the 2007–2008 food price crisis (extremely affecting Southeast Asia) and the years of the COVID-19 pandemic (2020–2021).

By examining food price trends in East, South, and Southeast Asia, we can explore deviations from the global average. Notably, during 2019–2020, food prices in the three examined regions increased significantly, unlike the global trend. While globally, prices continued to rise amid the ongoing COVID-19 crisis, prices in East, South, and Southeast Asia decreased remarkably in 2021 (FAOSTAT) (See below Figure 11). Hence, a fourth dummy variable was introduced, representing the years of significant food price increase in the three regions. The distinction between these two dummy variables aims to understand whether price increases or more complex crises have a more influential impact on food security. The last dummy variable is the "delayed crises" variable, based on the findings of Applanaidu and Baharudin (2014) about delayed food security effects of economic downfalls and based on our assumption that households are more likely to cut expenditures on other items before reducing spending on food. Thus, during economic crises or food price spikes, the consequences, such as people falling into undernourishment, may not appear immediately. The "delayed crises" dummy variable marks the years of global crises plus one. All crises dummy variables are expected to have a significant positive relationship with prevalence of undernourishment.

The paper applies a random effects regression model to identify the determinants of food security in Asia between 2000 and 2021, based on a dataset containing 357 observations. The following model is applied and tested:

$$POU_{it} = \alpha_0 + \alpha_1 POP_{it} + \alpha_2 GDP_{it} + \alpha_3 FDI_{it} + \alpha_4 EXCH_{it} + \alpha_5 CIDR_{it} + \alpha_6 AGREMP_{it} + \alpha_7 GPVAGRI_{it} + \alpha_8 PPRICEAGRI_{it} + \alpha_9 TEMPCHANGE_{it} + \alpha_{10} REFUGEE_{it} + \alpha_{11} DEATHS_{it} + \alpha_{12} PRICEBOOM_i + \alpha_{13} CRISES_i + \alpha_{14} DELAYEDCRISES_i + v_{ij} + \varepsilon_{ij} \quad (1)$$

where *i* stands for a particular country, while *t* stands for time.

Table 14 presents an overview of the description of variables and the associated hypotheses.

Table 14. Description of variables used

Variable name	Variable description	Unit of measurement	Data source	Expected sign on POU
POU	Prevalence of undernourishment	%	FAOSTAT	N/A
POP	Total population of the country	1000 people	FAOSTAT	+
GDP	GDP (annual value)	Million $, 2015 prices	FAOSTAT	-
FDI	FDI-inflow	Million $, 2015 prices	FAOSTAT	-
EXCH	Exchange rate of local currency to USD	Local currency/$	FAOSTAT	+
CIDR	Cereals import dependency ratio	%	FAOSTAT	+
AGREMP	Share of agricultural employment in total employment	%	FAOSTAT	-
GPVAGRI	Gross production value of agriculture	1000 $, 2014-2016	FAOSTAT	-
PPRICEAGRI	Producer prices of agricultural products	%, 2014-2016 =100%	FAOSTAT	+
TEMP-CHANGE	Temperature change on land	Celsius	FAOSTAT	+
REFUGEE	Dummy: refugees 1= share of refugees in the host country's population bigger or equal to 0.01% 0= share of refugees in the host country's population smaller than 0.01%	Binary	World Bank	+
DEATHS	Dummy: fatalities in battle 1= fatal casualties happened on battlefield on the territory of the country 0= no fatal outcomes of battle on the territory of the country	Binary	Uppsala Conflict Data Program	+
PRICEBOOM	Dummy: price boom in East, South, Southeast Asia 1= the years of remarkable food price increases in the three regions: 2007, 2008, 2011, 2014, 2019, 2020 0=rest of the years	Binary	-	+
CRISES	Dummy: crises 1= years of the food price crisis in 2007, 2008, years of COVID19 in 2020, 2021 0= rest of the years	Binary	-	+

DELAYED-CRISES	Dummy: delayed crises 1= dummy-crises+1 year 0= rest of the years	Binary	-	+

Source: Own composition.

In estimating the determinants of prevalence of undernourishment, we use the generalised least square (GLS) random effects model. Standard regression and panel unit root tests were applied before estimations and we have not found any multicollinearity, heteroskedasticity or unit roots.

The research focuses on countries in East, South, and Southeast Asia. For China, mainland China, Taiwan, Hong Kong SAR, and Macao SAR were considered separately. Due to a lack of data, 10 countries were excluded. The final panel includes the following countries: Bangladesh, Cambodia, China—Hong Kong SAR, mainland China, India, Indonesia, Japan, Laos, Malaysia, Mongolia, Nepal, Pakistan, Philippines, South Korea, Sri Lanka, Thailand, and Vietnam. The observed period spans from 2001 to 2021, with data retrieved from FAOSTAT, World Bank Data Bank, and the Uppsala Conflict Data Program.

We employ two different approaches in running regressions in line with Bakucs *et al*. (2018). First, for more robust data, we run GLS random effects regression in STATA18, involving all 17 countries with available data from the three regions without any differentiation between them ("three regions" regression with 357 observations). Second, for more regionally specific results, we run GLS random effects regressions for each of the three regions, including only the countries belonging to the respective region.

The food security landscape of South and East Asia and its determinants

The food security landscape across the countries of the discussed three regions is notably diverse. On the Global Food Security Index ranking list, countries from these regions exhibit high scores (Japan, China, Singapore) as well as low scores (Pakistan, Laos, Bangladesh, Sri Lanka). On a regional level, the protein, fat, and overall food supply per capita are above the global average in East Asia and below it in South and Southeast Asia (Table 15). Compared to 2015, there has been a 5.0% and 5.2% increase in food supply in South and Southeast Asia, and a 9.9% and 8.3% increase in protein

supply, respectively. The meat and fish consumption in Asia is anticipated to grow by 73% until 2050, based on 2017 figures, with Southeast Asia expected to contribute the most substantial increase (McCarron *et al.,* 2018).

Table 15. Food, protein and fat supply per capita in East, South and Southeast Asia and in the World, 2021

Supply	World	East Asia	South Asia	Southeast Asia
Food supply (kcal/capita/day)	2936	3238	2546	2819
Protein supply quantity (g/capita/day)	85	109	67	68
Fat supply quantity (g/capita/day)	86	92	59	65

Source: Based on FAOSTAT data.

In alignment with the presented supply data, the prevalence of undernourishment in East Asia is generally low, notwithstanding higher values in countries such as Mongolia, Macao SAR, or Taiwan. Notably, mainland China, the most populous entity in the region, boasts the lowest FAO-given value (<2.5%), influencing the overall prevalence for the entire region. Southeast Asia has demonstrated improvement from 2015 to 2021, with the prevalence of undernourishment decreasing from 7.5% to 5.3% during this period. Conversely, South Asia stands out as one of the most food-insecure regions globally, with a 16.9% prevalence of undernourishment in 2021, marking a 2.5% increase from 2015. By region, the PoU decreased in East Asia from 9.6 to 3.7 from 2001 to 2021, while from 19.1 to 11.4 in South Asia and from 19.00 to 4.8 in Southeast Asia.

As to the determinants of food security, the combined population of the three regions accounted for 54.4% of the global population in 2023, showing a growing trend. East Asia had 1.65 billion people, South Asia had 2.0 billion, and Southeast Asia was home to 682 million individuals (Population Reference Bureau, 2023). The urban population consistently grew in all three regions over the last few decades. In 2021, 66% of East Asia's population, 51% of Southeast Asia's population, and 37% of South Asia's population lived in urban areas. Aligned with the declining share of rural residents, the proportion of agricultural employment in total employment has also diminished since the

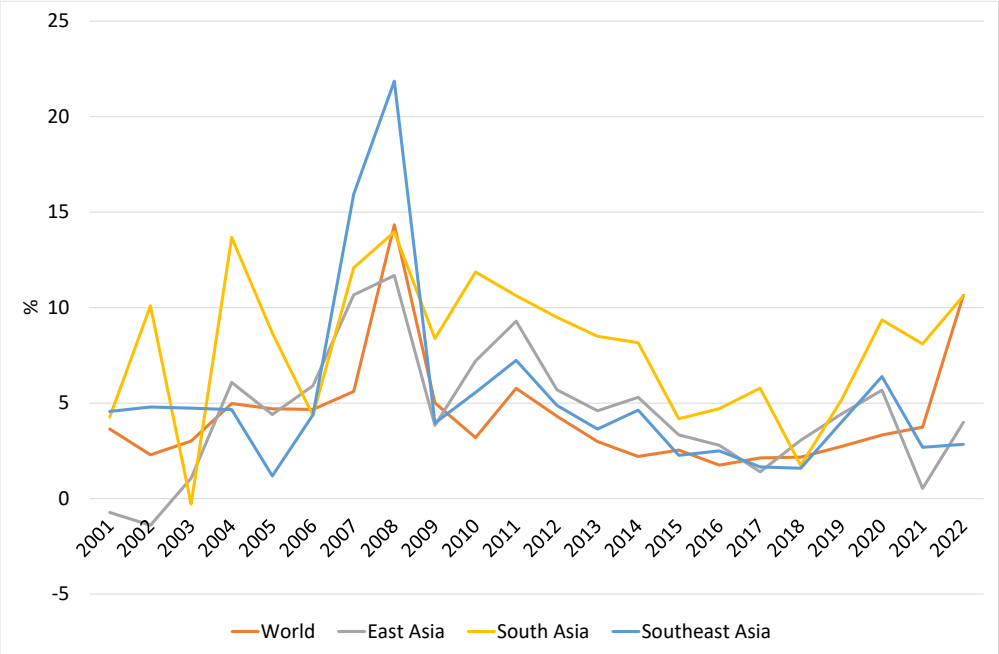
millennium, reaching 22.2% in East Asia, 29.2% in Southeast Asia, and 41.5% in South Asia in 2021 (Population Reference Bureau, 2023).

East, South and Southeast Asia contributed 33.7% to the global GDP in 2021, though not evenly distributed. East Asia alone produced 26.0% of the global GDP and accounted for 77.0% of the combined GDP of the three discussed regions in 2021 (FAOSTAT). Within these regions, there is a diverse economic landscape, featuring high-income countries like Japan, South Korea, or Singapore, upper-middle-income countries such as China, Thailand, Indonesia, lower-middle-income countries like Mongolia, India, or the Philippines, and low-income countries including Afghanistan and North Korea. In 2021, the GDP per capita of East Asia was $15,200, which was 24.9% more than the global average of $12,200. In Southeast Asia, the GDP per capita was less than half of the global value, standing at $4945.8, while in South Asia, it was less than 20% at $2157.8 (FAOSTAT).

The populations of low-income and lower-middle-income economies are often the most vulnerable to economic crises, which impact household incomes and/or food prices (Headey and Martin, 2016; Amolegbe *et al.,* 2021). Between 2001 and 2022, the three regions experienced several food price shocks, with the 2007–2008 crisis being the most severe (Figure 11).

The East Asia region, with the purchasing power of its high-income countries and the economic potential of China, attracted 23.3% of global foreign direct investment in 2021. Meanwhile, 10.8% of the global FDI flowed into the emerging economies of Southeast Asia. However, South Asia, with its weaker purchasing power and security issues, could only attract 0.4% of FDI inflow from around the world. The East Asian region is a significant investor as well, accounting for 29.1% of foreign direct investment worldwide. Notably, Japan (10.8% of global FDI outflow in 2021) and Mainland China (9.2%) were the biggest investors from East Asia (FAOSTAT).

Figure 11. Average monthly change in food prices in East Asia, South Asia, Southeast Asia and the world, 2001–2022, percentage



Source: FAOSTAT data.

Feeding half of the world's population with only 23.1% of the world's agricultural land poses a remarkable challenge for the agri-food production systems in the three regions analyzed (FAOSTAT). According to FAO data from 2022, 45.2% of global cereal production (with rice accounting for 89% of the global production), 49.4% of oil crops production, 38.6% of meat production (where pork production has the highest global share at 53.6%), 37.7% of dairy production, and 60.3% of egg production occurred in these regions. Within the three regions, East Asia dominates in cereals, roots and tubers, vegetables, fruits, meat, and egg production. The majority of oilseeds production takes place in Southeast Asia, and South Asia leads in milk production (Table 16). The combined gross agricultural production value of the three regions was $2311.6 billion in 2021 (FAOSTAT), with 63.1% belonging to East Asia, 24.0% to South Asia, and 12.9% to Southeast Asia.

Table 16. Production quantities, regional and global shares of East Asia, South Asia and Southeast Asia in the major food commodities, in 2022

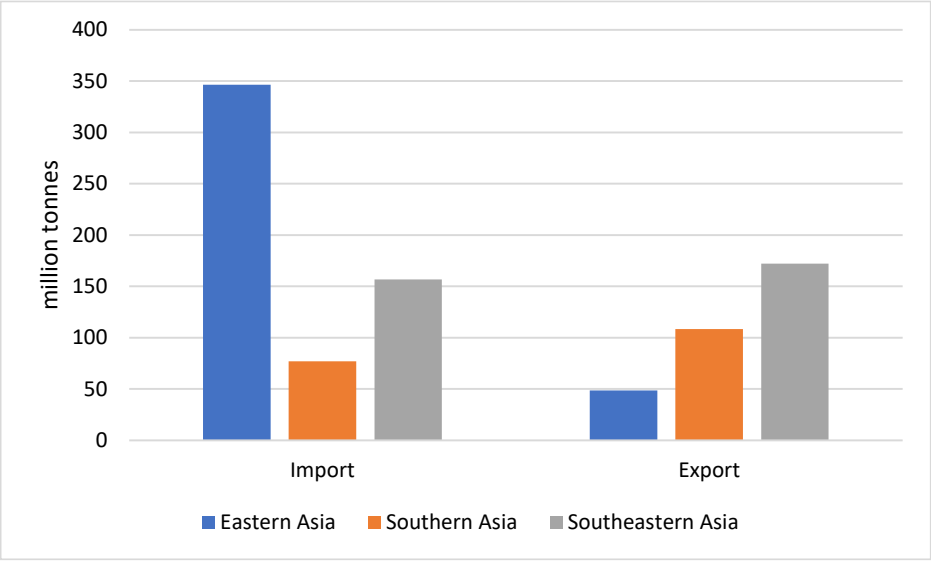
Food commodities	East Asia	South Asia	Southeast Asia	Total
Cereals				
Quantity (million tonnes)	657.02	485.03	239.80	1381.86
Global share (%)	21.5%	15.9%	7.8%	45.2%
Share of the 3 regions (%)	47.5%	35.1%	17.4%	100.0%
Oil crops				
Quantity (million tonnes)	79.67	74.01	411.38	565.05
Global share (%)	7.0%	6.5%	36.0%	49.4%
Share of the 3 regions (%)	14.1%	13.1%	72.8%	100.0%
Roots and tubers				
Quantity (million tonnes)	154.94	87.43	94.50	336.86
Global share (%)	17.1%	9.6%	10.4%	37.1%
Share of the 3 regions (%)	46.0%	26.0%	28.1%	100.0%
Vegetables				
Quantity (million tonnes)	641.41	165.59	49.39	856.40
Global share (%)	54.7%	14.1%	4.2%	73.0%
Share of the 3 regions (%)	74.9%	19.3%	5.8%	100.0%
Fruits				
Quantity (million tonnes)	270.78	133.38	70.48	474.65
Global share (%)	29.0%	14.3%	7.6%	50.9%
Share of the 3 regions (%)	57.0%	28.1%	14.8%	100.0%
Meat				
Quantity (million tonnes)	102.45	17.68	19.15	139.28
Global share (%)	28.4%	4.9%	5.3%	38.6%
Share of the 3 regions (%)	73.6%	12.7%	13.8%	100.0%
Eggs				
Quantity (million tonnes)	37.94	8.59	9.61	56.14
Global share (%)	40.7%	9.2%	10.3%	60.3%
Share of the 3 regions (%)	67.6%	15.3%	17.1%	100.0%
Milk				
Quantity (million tonnes)	51.06	294.94	5.01	351.02

Global share (%)	5.5%	31.7%	0.5%	37.7%
Share of the 3 regions (%)	14.5%	84.0%	1.4%	100.0%

Source: FAOSTAT data.

The three regions are not self-sufficient in the production of most staple food categories; therefore, agri-food trade plays a crucial role in ensuring their food supply. In 2022, 27.2% of the food trade volume within the three regions was internal, while 72.8% involved global trade with countries outside of these regions. In East Asia, 87.7% of the region's foreign food trade consists of imports, with China (mainland) accounting for 66.1% and Japan for 15.7% of regional agri-food imports. Both China and Japan are significant global players in terms of the value of food imports. In South Asia, agri-food exports surpass import volumes by 31.4 million tonnes, constituting a 17% surplus. India, as the main producer in the region, contributed to 78.6% of South Asia's total exports. In Southeast Asia, major agri-food exporters in 2022 were Thailand (29.3%), Indonesia (29.2%), Malaysia (25.4%), and Vietnam (22.0%) (Figure 12). In terms of value, the combined agricultural imports of the three examined regions accounted for 27.0% of global imports in 2021, while their exports constituted 11.4% of global exports (FAOSTAT).

Figure 12. Agri-food foreign trade volume of East Asia, South Asia, Southeast Asia (excluding the trade between these three regions), in 2022, million tonnes



Source: FAOSTAT data.

Security concerns are also prevalent in these regions, determining food security levels. These concerns include tense relationships between North and South Korea, Mainland China and Taiwan, India and Pakistan, territorial disputes in the East China Sea, the South China Sea, and the Ambalat Block, the China-India border dispute, the presence of the Abu Sayyaf Group militants in South Philippines, and piracy posing a threat to maritime trade (Ariadno, 2021). Approximately one million Rohingya refugees have been living in the Cox Bazar's region of Bangladesh since fleeing Myanmar in 2017. The Taliban takeover in August 2021, following the American withdrawal, resulted in a record refugee outflow from Afghanistan, while skirmishes in the bordering regions between Pakistan and Afghanistan have persisted for decades.

In addition to security concerns, weather extremes have doubled worldwide since the 1990s, and droughts and floods have become more frequent in these regions (Food Security Information Network, 2019). The Global Climate Risk Index from Germanwatch is calculated by the multiplication of differently weighted rankings of a certain country in terms of fatalities, fatalities per 100 thousand inhabitants, losses (USD), and losses per GDP due to weather extremes like droughts, floods, storms, heatwaves, etc. A higher index score indicates a smaller risk. According to the last calculation in 2019, the countries in the three regions most exposed to climate-related risks (having the lowest scores in order) were Japan, Afghanistan, India, Nepal, Bangladesh, Indonesia, Pakistan, Myanmar, and Mongolia. The average score was 55.5 in East Asia, 44.8 in South Asia, and 72.2 in Southeast Asia (Eckstein *et al.,* 2021).

The characteristics outlined above, spanning the economy, food production, trade, and supply, highlight significant food security-related structural weaknesses in all three discussed regions. In South Asia, both food availability (supply) and economic access (GDP per capita) face deficiencies. In Southeast Asia, availability and access are notably below the world average, although this region is experiencing dynamic development in terms of both economy and food security. While food security in East Asia is generally stable, countries like Mongolia or North Korea encounter challenges in economic access and availability. Additionally, even the most developed countries in the region are net food importers, relying on international food supply chains, with economic access heavily influenced by world market prices.

The determinants of food security – Regression results and discussion

As to the determinants of food security, our results suggest a diverse picture (Table 17). In terms of average economic size, both population and GDP seem to be significantly and positively related to prevalence of undernourishment, suggesting that countries with more people and bigger economies tend to be less food secure. While the influence of population size on food security aligns with the literature, it appears to be less influential in the examined regions compared to findings such as Kovljenić and Raletič-Jotanovič (2021). They found that a 2.85% growth in population resulted in a 1% increase in PoU in the countries of the former Yugoslavia, whereas in East, South, and Southeast Asia, a larger 3.5%–4.0% (156.7 million people) population increase results in a 1% growth in undernourishment.

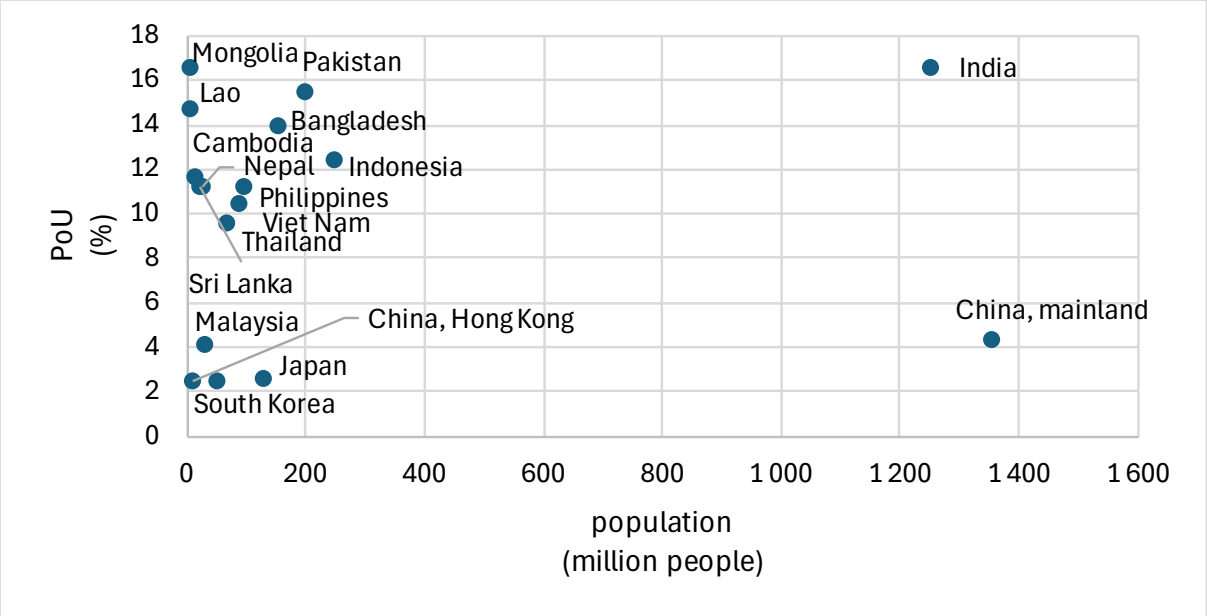
Table 17. Determinants of prevalence of undernourishment in South, Southeast and East Asia, 2001–2021

Variable	Coefficient	Standard error	p-value
POP	6.38e-06	2.51e-06	0.0110
GDP	1.30e-06	2.63e-07	0.0000
FDI	0.0001	0.0001	0.3370
EXCH	-0.0002	0.0001	0.0210
CIDR	0.1631	0.0208	0.0000
AGREMP	0.5115	0.0299	0.0000
GPVAGRI	-1.85e-08	5.46e-09	0.0010
PPRICEAGRI	-0.0385	0.0067	0.0000
TEMPCHANGE	-0.4822	0.4034	0.2320
REFUGEE	-1.1873	0.8057	0.1410
DEATHS	2.1596	0.5899	0.0000
PRICEBOOM	-0.3885	0.3751	0.3000
CRISES	0.5382	0.4912	0.2730
DELAYED-CRISES	-0.1359	0.4751	0.7750
Constant	-8.8278	1.9235	0.0000
Observations	357		
R^2	0.5846		

Source: Own compilation.

Figure 13 demonstrates the relationship between population and prevalence of undernourishment in the discussed countries from 2001 to 2021 average values, showing why undernourishment is not as sensitive to changes in population in the chosen three regions. Examples include instances where a large population is paired with a high PoU value like in India, Pakistan, Bangladesh and Indonesia. Conversely, there are cases of countries with small populations having lower PoU values, like South Korea and Hong Kong. However, notable exceptions exist: China, the country with the largest population, and Japan, the sixth most populous country, exhibit low PoU values. On the other hand, Mongolia, with the smallest population, has the highest percentage of undernourished people on the 2001–2021 average. It is striking that the three exceptional countries are all from East Asia.

Figure 13. Relationship between population and prevalence of undernourishment in South and East Asia, 2001–2021 averages



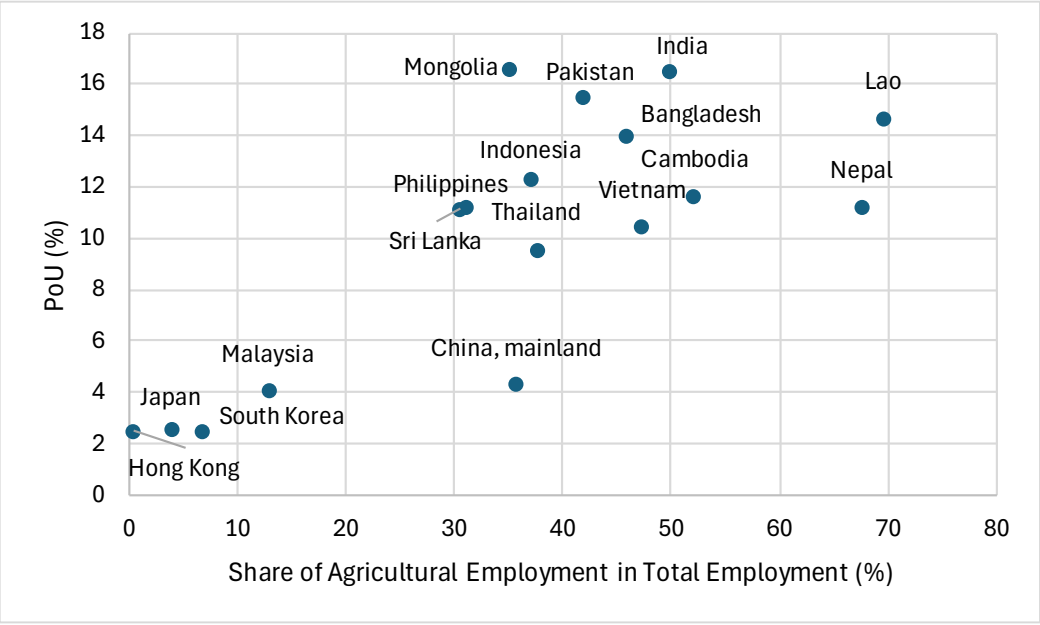
Source: Own compilation based on FAOSTAT data.

As to open economy related determinants, FDI inflows were found to be positively but not significantly related to the prevalence of undernourishment in South and East Asia between 2001 and 2021. However, exchange rate and cereal import dependency ratio were both significantly related to PoU, though with different signs (exchange rate negatively, cereal import dependency positively affected PoU).

Note that the national currency of Mainland China, South Korea and Thailand became stronger compared to USD between 2001 and 2021, while the exchange rate of Japan, Hong Kong and the Philippines stagnated (in the rest of the countries, the exchange rate became higher, their national currency lost value to USD). Exchange rate related results, however, should be taken with caution as they may reflect the effects of the overall economic development over the examined twenty years which in most of the analyzed countries was executed with weakening national currencies.

Regarding agriculture sector related determinants, results suggest an ambiguous picture. Higher shares of agricultural employment seem to be significantly and positively related to the prevalence of undernourishment, while higher agricultural production values and producer prices significantly decrease prevalence of undernourishment. The first argument is also evident from Figure 14, drawing a scatter plot on agricultural employment share in total employment and PoU. Although a linear and positive relationship is observable, note that the scatter plot illustrates the average values between 2001 and 2021, which does not reflect changes over time. As to the value of agricultural production, a statistically significant and negative relationship holds, suggesting that higher production value decreases the prevalence of undernourishment, as expected.

Figure 14. Share of agricultural employment in total employment and prevalence of undernourishment in the examined countries, 2001–2021 average



Source: Own compilation based on FAOSTAT data.

The producer price of agricultural products also appears to be a relevant determinant of food security in the region. We found an inverse relationship between prevalence of undernourishment and producer prices — if producer prices increase, undernourishment decreases. To understand the reason behind this inverse relationship, one need to look at the agricultural employment data — while globally the share of employment in agriculture in total employment is 26.58% (FAOSTAT), in Southeast Asia this value is 29.16, in South Asia it is 41.5 percent and in East Asia, it is 22.15% (FAOSTAT). Consequently, the rural population employed in agriculture can achieve higher incomes from higher producer prices, thus, they can improve their economic access to food.

As another determinant of food security, temperature change appears to be a statistically not significant determinant for food security in the region, though an inverse relationship was found — we assume a similar reasoning than we had about interpreting exchange rate results (being parallel in time with economic development).

Last but not least, the crises related dummy variables which we created based on the conclusions of the literature were in general not found to be statistically significant, except for the deaths in battle dummy variable on the territory of the given country. Not surprisingly, there is positive relationship between prevalence of undernourishment and deaths in battle, as expected.

The “per region” analysis helps us to better understand regional patterns of food security determinants (Table 18). In the case of East Asia, for instance, population growth has a significantly positive impact on food security, not like in South and Southeast Asia (though the impact was found to be very small). The entities omitted in this region due to a lack of data are North Korea (25.97 million people in 2021) and China, Taiwan (23.86 million people) with relatively similar population sizes. Taiwan has a very low, 3.0% PoU rate, while in North Korea, the estimated share of undernourished people is very high, 45.5%. Therefore, we can assume that in terms of the effects of population size on food security, these two entities are cancelling each other out, so the inclusion of them into the regression would not change the regional result significantly. The South Asian and Southeast Asian results are in line with the literature.

Table 18. Determinants of prevalence of undernourishment in East, South and South-East Asia, by region, 2001–2021

Variable	East Asia	South Asia	South-East Asia
POP	-0.0001***	0.0001**	0.0001***
GDP	9.69e-07***	9.07e-06**	4.95e-06
FDI	-0.0001*	-0.0001	0.0001
EXCH	-0.0017***	-0.0173	-0.0002***
CIDR	0.1734***	-01912*	0.1018***
AGREMP	0.8308***	-0.0413	0.3740***
GPVAGRI	1.01e-08**	-1.15e-07**	-1.49-07**
PPRICEAGRI	0.0082	-0.0590***	-1.49e-07**
TEMPCHANGE	-0.3548	-2.0257**	-1.7891**
REFUGEE	0.4531	-3.4871	-0.3320
DEATHS	-0.3014	3.1817***	1.6811
PRICEBOOM	-0.1977	-1.2261*	-0.5631
CRISES	0.4232	1.2059	0.3667
DELAYED-CRISES	-0.4045	-0.2769	-0.1962
Constant	-14.2277***	25.4189***	-0.2008
Observations	105	105	147
R^2	0.9736	0.7125	0.8219

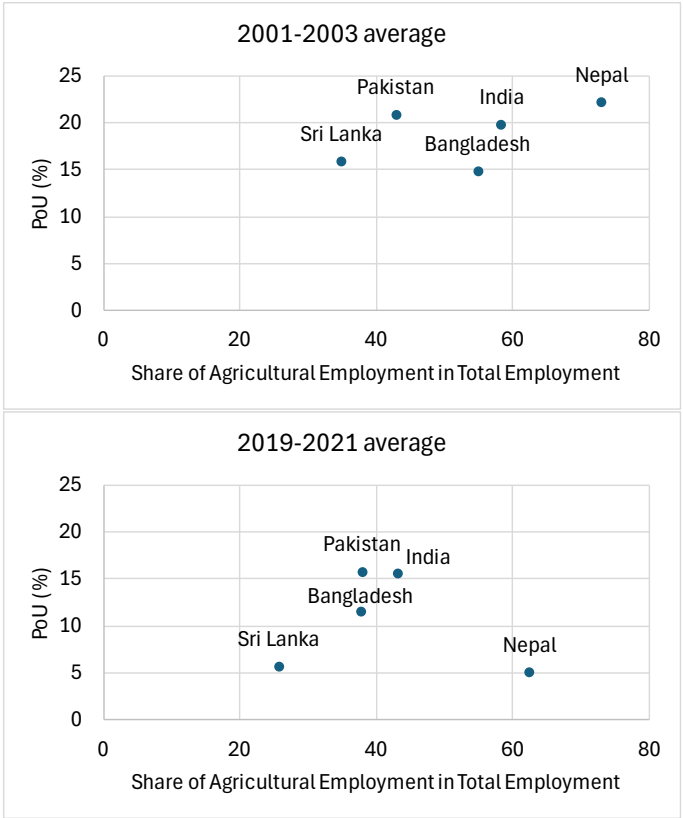
Note: * stands for 10% significance, ** stands for 5% significance, *** stands for 1% significance.

However, economic size does not exhibit a statistically significant relationship with food security in Southeast Asia and found to have little impact on food security in all subregions analyzed. The positive relationship with undernourishment supports the above presented similar findings of the literature (Holleman and Conti, 2020; Ramessur and Bundhun, 2022).

As to open economy related variables, FDI inflow was still found to be insignificantly related to PoU, though signs were changed, compared to the whole sample. The role of exchange rate was the same as the whole sample by region, though cereal import dependency was interestingly found to be negatively related to PoU in South Asia in the period analyzed.

In Table 17, agricultural employment turned out to be a significant determinant of food security for the three regions together, and also for East and Southeast Asia, but not for South Asia (Table 18). The magnitude of the impact is relatively strong. The reason behind the case of South Asia, we can look at average respective values of 2001–2003 and 2019–2021 (Figure 15). Nepal had the highest agricultural employment share among the examined South Asian countries in the time of 2001–2003 and 2019–2021, however, in terms of PoU, Nepal turned from the last to the first in the last two decades with recently having the lowest prevalence of undernourishment in the region. Furthermore, while Bangladesh had the largest decrease in agricultural employment share (−31.8%) comparing the two chosen period, in prevalence of undernourishment, Bangladesh had the smallest change (−22.5%). The GLS random effect regression model considered these changes over time, therefore agricultural employment share turned out to be statistically not significant.

Figure 15. Share of agricultural employment in total employment and prevalence of undernourishment in the examined South Asian countries, 2001–2003 and 2019–2021 average



Source: Own compilation based on FAOSTAT data.

As to agricultural production value, a small but significantly positive relationship with PoU was found in East Asia, while negative impacts were identified in South and Southeast Asia. Agri-food prices and temperature change were not found to have significant impacts on food security in East Asia. Last but not least, the only highly significant dummy variable was found to be deaths in conflicts in South Asia.

With all these results, we can reject our first hypotheses as GDP were not found to be significantly and negatively related to prevalence of undernourishment, and population size just had a minor impact—it seems that relationship between economic size and food security does not hold for these regions. Our second hypothesis also needs to be rejected as clear signs between open economy and food security could not be found.

Our third hypothesis related to agricultural sector related determinants can just partly be rejected as not all variables showed the expected signs. Our fourth hypothesis should be definitely rejected as relationship between temperature and prevalence of undernourishment was found to be negative in nature. Our fifth hypothesis can also not be accepted due to lack of significant relationships among the dummy variables identified and food security.

Conclusions

In conclusion, our comprehensive study on the determinants of food security in South, Southeast, and East Asia over the period 2001–2021 provides both expected and unexpected insights into the complex interplay of economic, demographic, agricultural, and external factors influencing the prevalence of undernourishment (PoU). Consistent with existing literature, the positive relationship between population size and PoU, albeit with a less pronounced effect — due to such exceptional countries as China, Japan and Mongolia — than reported in some studies, reaffirms the demographic pressures on food security. Similarly, the significance of agricultural employment and the value of agricultural production in influencing PoU align with established theories positing agriculture as a critical determinant of food security, highlighting the crucial role of productive and remunerative agricultural sectors, and reflecting on the fact that in food secure developed countries — due to technologically developed agriculture and other social factors — agricultural employment rate is usually low, while in less developed countries the other way round.

Unexpectedly, however, our findings challenge several established assumptions. The relationship between GDP and PoU was anticipated to be negative, based on the presumption that larger economies would have better resources to ensure food security. Contrary to this expectation, our analysis indicates a positive relationship, suggesting that economic growth alone does not guarantee improved food security, a deviation from the literature that warrants further investigation.

The nuanced effects of open-economy variables, such as cereal import dependency ratio and foreign direct investment, on PoU also present an unexpected picture. The anticipated negative impact of high cereal import dependency on food security (i.e., positive on PoU) was not universally observed, challenging the notion that reliance on food imports is inherently detrimental to food security. Furthermore, the insignificance of foreign direct investment (FDI) in relation to PoU contradicts the optimistic view of FDI as a catalyst for improving food security through economic development and agricultural modernization.

Another intriguing aspect is the non-significant impact of temperature change on food security, which diverges from the expected negative outcomes of climate change on agricultural productivity and food availability. This finding suggests that other factors, possibly adaptive measures or economic development, may mitigate the impact of temperature changes in the studied regions.

Finally, the lack of significant relationships among the crisis-related dummy variables (except for the deaths in battle) and food security stands out as unexpected. This suggests that while geopolitical and social stability is crucial, its direct impact on food security may not be as straightforward as previously thought, indicating the need for a deeper understanding of the resilience mechanisms at play. However, we have to note here, that PoU is a quite radical food security indicator, measuring severe food insecurity. The insignificance of the crisis-related variables shows a direction for further research with a more nuanced food security indicator such as dietary diversity. However, dietary diversity data is very scarce in the selected region, therefore this future research request a different geographical scope.

In sum, our study reaffirms some established narratives on food security determinants while challenging others, offering new insights that enrich the discourse on food security in South, Southeast and East Asia. The unexpected findings, in particular, highlight the

complexity of food security dynamics and the need for nuanced, region-specific approaches to understand and address the challenges of undernourishment.

Data availability

All data generated from the study are available in the manuscript.

Author contributions

Attila Jambor and Boglarka Anna Elias designed the study, Elias collected and analyzed the data, Jambor ran the regression model, Elias and Jambor analyzed the results. Both authors contributed to the writing of each chapters in the paper.

Conflicts of interest

The authors declare that there is no conflict of interest.

References

Affoh, R., Zheng, H., Dangui, K., & Dissani, B. M. (2022). The impact of climate variability and change on food security in sub-Saharan Africa: Perspective from panel data analysis. *Sustainability*, *14*(2), 759. doi.org/10.3390/su14020759

Aiyedogbon J. O., Anyanwu S. O., Isa G. H., Petrushenko Y. M., Zhuravka O. S. (2022). Population growth and food security: Evidence from Nigeria. *Probl Perspect Manage*, 20(2):402-10. doi.org/10.21511/ppm.20(2).2022.33

Amolegbe K. B., Upton J, Bageant E, Blom S. (2021). Food price volatility and household food security: Evidence from Nigeria. *Food Policy,* 102:102061. doi.org/10.1016/j.foodpol.2021.102061

Applanaidu S. D., Baharudin A. H. (2014). An econometric analysis of food security and related macroeconomic variables in Malaysia: A vector autoregressive approach (VAR). *UMK Proced*. 2014; 1:93-102. doi.org/10.1016/j.umkpro.2014.07.012

Ariadno M. K. (2021). Maritime Security in South East Asia: Indonesian Perspective. *Indones J Int Law* 7(5):88-102. doi.org/10.17304/ijil.vol7.1.229

Aziz N, He J, Raza A, Sui H, Yue W. (2021). Elucidating the macroeconomic determinants of undernourishment in South Asian countries: Building the framework for action. *Front Public Health*. 2021; 9:696789. doi.org/10.3389/fpubh.2021.696789

Bakucs Z, Fertő I, Varga Á, Benedek Z. (2018). Impact of European Union development subsidies on Hungarian regions. *Eur Plan Stud.,* 26(6):1121-36. doi.org/10.1080/09654313.2018.1437394

Demeke A. B., Keil A, Zeller M. (2011). Using panel data to estimate the effect of rainfall shocks on smallholders food security and vulnerability in rural Ethiopia. *Climatic Change*, 108(1–2):185-206. doi.org/10.1007/s10584-010-9994-3

Dithmer J, Abdulai A. (2017). Does trade openness contribute to food security? A dynamic panel analysis. *Food Policy,* 69:218-30. doi.org/10.1016/j.foodpol.2017.04.008

Eckstein D, Künzel V, Schäfer L. (2021). The global climate risk index 2021. Bonn (Germany): Germanwatch; 2021.

FAO – European Commission (2008). An Introduction to the Basic Concepts of Food Security, EC - FAO Food Security Programme: 2008,1. https://www.fao.org/3/al936e/al936e.pdf. Accessed 2024

FAO (2023). The State of Food Security and Nutrition in the World 2023: Urbanization, agrifood systems transformation and healthy diets across the rural-urban continuum. Available from: https://doi.org/10.4060/cc3017en. Accessed 2024 Jun 12.

FAO (1996). World Food Summit 13–17 November 1996. Available from: http://www.fao.org/3/w3613e/w3613e00.htm. Accessed 2024 Jun 12.

FAOSTAT. Statistical Database. Available from: https://www.fao.org/faostat/en/#home. Accessed 2024 Jan 20.

Food Security Information Network (2018). Global Report on Food Crises 2018. Available from: https://www.fao.org/fileadmin/user_upload/fsin/docs/global_report/2018/GRFC_2018_Full_report_EN.pdf. Accessed 2024 Feb 11.

Food Security Information Network (2019). Global Report on Food Crises 2019. Available from: https://www.fsinplatform.org/report/global-report-food-crisis-2019/. Accessed 2024 Feb 11.

Food Security Information Network (2020). Global Report on Food Crises 2020. Available from: https://www.fsinplatform.org/sites/default/files/resources/files/GRFC%20ONLINE%20FINAL%202020.pdf. Accessed 2024 Feb 11.

Food Security Information Network (2021). Global Report on Food Crises 2021. Available from: https://docs.wfp.org/api/documents/WFP-0000127343/download/?_ga=2.208631515.813678707.1717073951-67621395.1710625693. Accessed 2024 Feb 11.

Food Security Information Network (2022). Global Report on Food Crises 2022. Available from: https://docs.wfp.org/api/documents/WFP-0000138913/download/?_ga=2.208631515.813678707.1717073951-67621395.1710625693. Accessed 2024 Feb 11.

Food Security Information Network (2023). Global Report on Food Crises 2023. Available from: https://www.fsinplatform.org/sites/default/files/resources/files/GRFC2023-compressed.pdf. Accessed 2024 Feb 11.

Headey D. D. and Martin W. J. (2016). The impact of food prices on poverty and food security. *Annu Rev Resour Econ,* 8:329-51. doi.org/10.1146/annurev-resource-100815-095303

Holleman C, Conti, V. (2020). Role of income inequality in shaping outcomes on individual food insecurity: Background paper for the state of food security and nutrition in the World 2019. Rome (Italy): FAO; 2020.

Kovljenić M, Raletić-Jotanović S. (2021). Food security issues in the former Yugoslav countries. *Outlook Agr.,* 50 (1):46-54. doi.org/10.1177/0030727020930039

McCarron B., Tan S., Giunti A. (2018). Charting Asia's Protein Journey. Singapore (Singapore): Asia Research and Engagement; 2018.

Mutisya M., Ngware M. W., Kabiru C. W., Kandala N. B. (2016). The effect of education on household food security in two informal urban settlements in Kenya: a longitudinal analysis. *Food Secur.* 8:743-56. doi.org/10.1007/s12571-016-0589-3

Population Reference Bureau (2023). World Population Data Sheet, 2023, https://2023-wpds.prb.org/. Accessed 2024 March 10

Ramessur T. S. and Bundhun S. (2022). Responsiveness of food security to macroeconomic variables: the cases of Maldives, Mauritius and Seychelles. *Small States Territ*., 5(2):293-312.

Subramanyam M. A., Kawachi I., Berkman L. F., Subramanian S. V. (2011). Is economic growth associated with reduction in child undernutrition in India? *PLoS Med.*, 8(3):e1000424. doi.org/10.1371/journal.pmed.1000424

Uppsala Conflict Data Program. Available from: https://ucdp.uu.se/downloads/. Accessed 2024 Feb 10.

Warr P. (2014). Food insecurity and its determinants. *Australian Journal of Agricultural and Resource Economics*, 58(4):519-37. doi.org/10.1111/1467-8489.12073

World Bank Data. Available from: https://databank.worldbank.org/home.aspx. Accessed 2024 Feb 28.

8. Summary and conclusions

8.1. Reflection on the research questions

Q1. Could a comprehensive, 3+1 dimensions analysis contribute to discovering new results regarding crisis-caused impacts and their interplays in the food system?

Publication 1 investigated the effects of the supply chain and economic crises triggered by lockdowns, travel bans, and transportation restrictions following the COVID-19 outbreak, using a systematic literature review at a global scale. The selected articles reported empirical findings on both the consumer side (access and utilization) and the supply side (availability) of the food system. The analysis of physical access to food during the pandemic revealed significant causal relationships among the physical access, availability, economic access, and utilization/nutrition dimensions. Physical access to food was hindered in two primary ways during this period. First, consumers autonomously chose to limit food purchases due to fear of infection. Second, political measures, such as curfew and movement restrictions, further restricted access. The decline in food purchases led to temporary food shortages in certain households, reducing their nutritional status. Simultaneously, decreased food demand resulted in lower sales prices for agricultural commodities, which caused income losses for rural agricultural households. This, in turn, reduced their ability to purchase food from markets, a critical factor in mitigating the impacts of crises on food security for rural population, as noted by Vlassenroot and Raesmaekers (2004) and Wineman *et al*. (2017). Additionally, movement and border restrictions caused temporary income losses for agricultural workers and led to shortages of labor and other inputs for agricultural production. These findings underscore the importance of considering the entire food system when implementing restrictions to address future crises. Decision-makers must account for the interconnected impacts on food access, availability, and utilization to minimize disruptions and enhance resilience.

Publication 2 examined the impact on food security of the food price crisis in Hungary, which was the result of COVID-19 and the Russian-Ukrainian war, as well as domestic economic and political dynamics. To answer the research question, I examined all 3+1

food security dimensions pre-crisis and amid crisis, applying both secondary national data and primary household survey data. The simultaneous examination of the 3+1 dimensions made it possible to detect an interplay between physical access, economic access, and utilization dimensions. I discovered an effect of food price surge, where food consumers seeking better offers tend to shift from smaller local stores to larger supermarkets, hypermarkets, and discount stores, thereby enhancing market concentration, and potentially contributing to further price increases. Those who are not able to regularly visit larger, cheaper stores far from their home turned out to be the most vulnerable, as they had to decrease the diversity of their diet and, in some cases, even the amount of energy they intake.

Consequently, the answer to the first research question (Q1) is yes, a comprehensive, 3+1-dimension analysis can contribute to new results by discovering interplays of crisis impacts between different food security dimensions.

Q2. Can well-established statistical methods – commonly used to identify food security determinants – be effectively applied to assess the deterministic effect of crises on food security? In Publication 3, we searched for determinants of undernourishment at a super-regional level (East, South, and Southeast Asia), with a relatively high number of observations through a logistic regression model, in which we used dummy variables representing different types of crises: years when the share of refugees in the host country's population was higher or equal to 0.01%; years when fatal casualties happened on the battlefield on the territory of the country; the years of remarkable food price increases in the three regions: 2007, 2008, 2011, 2014, 2019, 2020; years of the food price crisis in 2007, 2008, years of COVID-19 in 2020, 2021; years of food crisis + 1.

Aside from battlefield deaths, crisis-related factors have not significantly affected food security. This suggests that, although geopolitical and societal stability are crucial, their direct impact on undernourishment is more intricate than previously assumed, highlighting the need to explore resilience mechanisms further. It is important to remember that the PoU (Prevalence of Undernourishment) reflects extreme food insecurity, and the absence of significant results for crisis variables indicates that future studies may need to focus on more sensitive indicators, such as dietary diversity. The conclusion that in East, South, and Southeast Asia, PoU is no longer a reliable indicator

to examine changes in food security indicates a positive development in regard to the food security status of these three regions; however, this poses difficulty for further panel data analysis since data for more nuanced indicators are rarely available for longer periods.

Table 19. Summary of results

Research Part I.	
Research question/Subquestion/Hypothesis	***Conclusion***
Q1. Could a comprehensive, 3+1 dimensions analysis contribute to discovering new results regarding crisis-caused impacts and their interplays in the food system?	Yes, it can. The research published in Publications 1 and 2 proved that a 3+1 dimension approach can reveal otherwise neglected interplays and causalities between food security dimensions and between the components of the food system.
Publication 1: a systematic literature review limited to the COVID-19 pandemic crisis-related effects on food security, without geographical limitation.	
SQ1. What segments of food security have been affected by the COVID-19 lockdown and pandemic?	All 3+1 dimensions have been affected, but primarily the economic access dimension.
SQ2. Are the COVID-19-related food security problems temporary and "crisis specific" or are they rooted in structural weaknesses?	Most of the impacts are temporary, however the biggest problem proved to be income loss combined with previous low income.
SQ3. Are new food security objectives needed to mitigate the negative effects of the pandemic and prepare for a possible future pandemic?	The most important objective remains poverty reduction to build resilience against food security crises.
Publication 2: a national-level statistical analysis of the impact of the food price surge in Hungary 2022–2023 on food security.	
H1. Despite the overall improvement in food security in Hungary between 2015 and 2020, significant differences in dietary quality persisted across households with different income levels.	Confirmed.
H2. Food availability in Hungary remained stable even during the disruptions to food supply chains caused by the COVID-19 pandemic and the Russian-Ukrainian war.	Confirmed.
H3. The food price surge in 2022–2023 induced changes in food purchasing patterns through deteriorating affordability.	Confirmed.

H4. The change in consumption is not reflected in a reduction in total energy intake but rather in a decrease in the consumption of micronutrients and dietary fiber.	Rejected.
H5. The gap between the dietary quality of the lowest and highest income groups increased in 2022–2023.	Confirmed.
Research Part II.	
Q2. Can well-established statistical methods — commonly used to identify food security determinants — be effectively applied to assess the deterministic effect of crises on food security?	Research Part II (presented in Publication 3) failed to fully assess the deterministic effects of all crisis variables. However, I suggest that this limitation arose not from the chosen method (random effects regression model) but rather from the selection of the independent variable (PoU).
Publication 3: applying a panel data logistic regression model to detect food security determinants and the deterministic feature of crisis events on food security in East, South, and Southeast Asia between 2001 and 2021.	
H6. Higher performance of the agriculture sector decreases food insecurity.	Confirmed.
H7. The growth of average economic size fosters food security.	Partially confirmed.
H8. Open economic activities positively influence food security.	Rejected.
H9. Higher changes in average temperature are against food security.	Rejected.
H10. Crisis situations cause food security to decrease.	Partially confirmed.

Source: Own compilation.

8.2. Contribution to the existing literature

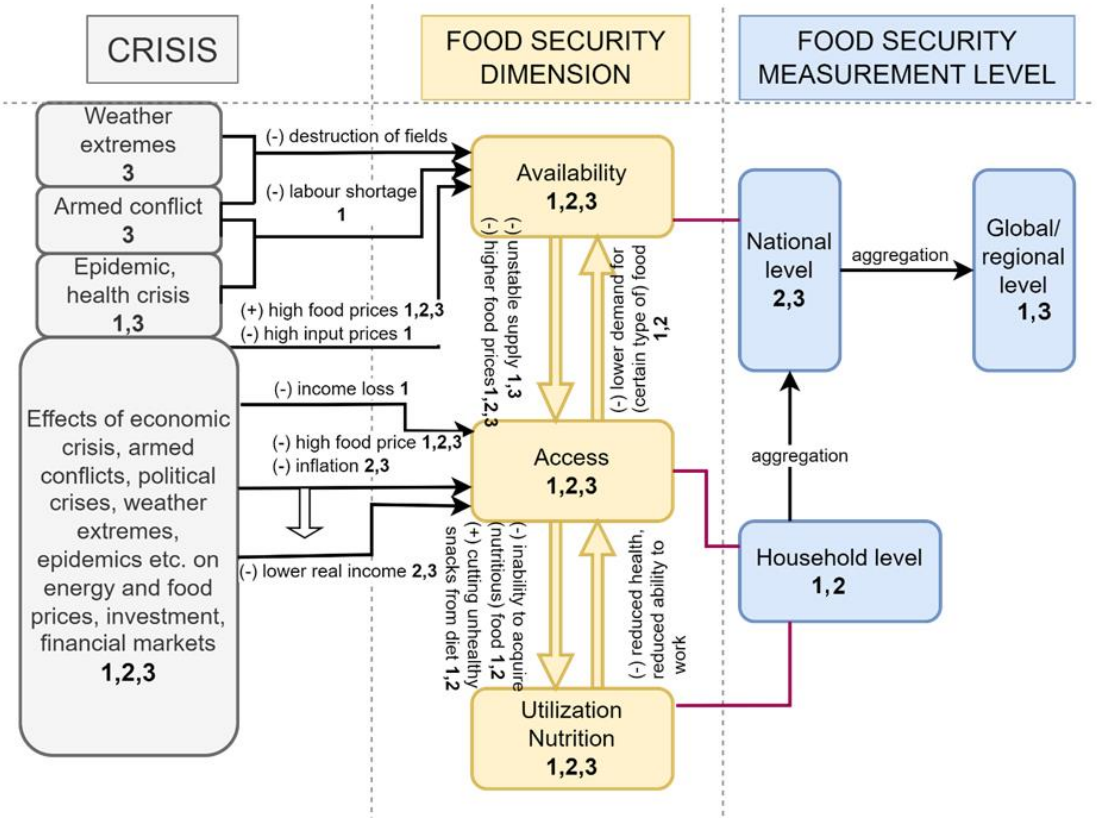
Besides answering the research questions and adding new conceptual and methodological approaches to the research on the crisis-impacts on food security, each research phase produced several results, which contribute to the literature on a wide range due to the diversity in methodology and approaches. Number of results:

a.) conclusions based on the qualitative analysis of the systematic literature review: 21;
b.) statistical results based on primary data: 128;
c.) statistical results based on secondary data: 183.

Figure 16 highlights how the results from my three publications contribute to various segments of the conceptual framework for the research subject.

Figure 16. Contributions to the conceptual framework by publications.

(Publication 1 = 1; Publication 2 = 2; Publication 3 = 3)



Source: Own compilation.

Many of these findings align with previous research; however, several of them challenge the existing literature or highlight unresolved research gaps:

Although mental distress during crisis events as a cause of negative dietary shifts has received some attention lately (Bakaloudi *et al.,* 2022; Shamir-Stein *et al.,* 2024), during my review of the theoretical and empirical literature, I have not encountered studies that would express that the psychological well-being of the food consumers is not only affecting their own nutrient intake but has an impact on the whole food system. As I presented above by answering my first research question (Q1), in Publication 1, we concluded that anxiety caused disruption in physical access, which means lower food demand which affects the producer, transportation, and retail components of the food system. Therefore, in the future, it is important to consider the psychological well-being of individuals when planning communication strategies for crisis management, since the

mental distress of food consumers impacts the whole food system and has economic consequences.

After an 11-year hiatus, Publication 2 completed a comprehensive food security overview of Hungary, including an analysis of income, consumption, and nutrient intake for the period 2015–2020 and a household survey and analysis for the food price crisis of 2022–2023. The latter also filled a void in the literature, as previous publications of these surveys took place during the COVID-19 crisis when households encountered different difficulties compared to the 2022–2023 food price surge.

The unexpected findings in Publication 2 were that the proportion of people unable to buy enough food was higher than international malnutrition rates for Hungary and that the phenomenon of only small and expensive grocery stores being available near the household is significant among urban and even capital city residents, not just in small villages as I had assumed relying on previous literature and national statistical data.

According to the previous findings of the literature, food retail concentration leads to higher prices, thus endangering food security (Aalto-Setälä, 2002; Hovhannisyan *et al*., 2019). However, it has not been pointed out before that in case of a food price crisis, the consumers' coping strategy – shifting from smaller nearby grocery shops to discount stores and supermarkets for current lower prices – can enhance further retail concentration, thus prolonging the ongoing crisis (Publication 2). Political decision-makers might consider this phenomenon in their crisis-management strategy.

In Publication 3, several unexpected results emerged. It confirmed the literature that agricultural development and smaller populations predict stronger food security. However, despite the findings of Subramanyam *et al*. (2011), Applanaidu and Baharudin (2014), Warr (2014), and Aziz *et al*. (2021), we found a negative relationship between economic growth and food security. The weak influence of import dependency of cereals, the insignificance of FDI, and temperature change are unexpected results as well and contribute to the prevailing theories in the literature as valid exceptions.

Another surprising result was that despite the South Asian region – one of the most food insecure regions in the world – was included in the research, PoU did not prove to be a sufficiently sensitive independent variable to statistically confirm the impact of crises on the food security of the region. This suggests that the food security of the South Asian region has improved significantly over the past two decades, highlighting the need for more sensitive indicators to track changes in the region's food security status.

8.3. Limitations and further research directions

The main challenge in the research was the lack, incompleteness, or poor quality of available data. This issue was especially prevalent in Publication 3. Therefore, my results should be interpreted only within the methodological limitations.

Furthermore, we must consider that the impact of crisis events and the responses of various actors to them give rise to complex phenomena, each possessing unique characteristics. Thus, the aim of my research was not to produce universal, one-size-fits-all statistical results, but rather to explore the relationship between crisis and food security from different perspectives, demonstrate its complexity, and highlight some specific recurring patterns, the knowledge of which may contribute to the development of a more resilient food system.

My research examined the regional, national, and household levels. I also plan to further extend this research to the individual level, aiming to gain deeper insights into the nuanced impacts of crises on personal food security and coping strategies. This would be a direct continuation of the research of Publication 2, i.e., conducting qualitative interviews with individuals from the most vulnerable groups identified in Publication 2.

The results of Publication 3 also left questions unanswered. Finding food security indicators more sensitive than PoU to statistically disclose the relationship between crisis and food security is a future challenge to be addressed. Furthermore, the unexpected result of the negative relationship between economic growth and food security calls for a new model including – in line with the suggestion of Holleman and Conti (2020) and Ramessur and Bundhun (2022) – income inequality indicators.

9. References

Aalto-Setälä, V. (2002). The effect of concentration and market power on food prices: evidence from Finland. *Journal of Retailing*, *78*(3), 207-216. doi.org/10.1016/s0022-4359(02)00073-8

Adams, E. L., Caccavale, L. J., Smith, D., & Bean, M. K. (2020). Food insecurity, the home food environment, and parent feeding practices in the era of COVID-19. *Obesity*, *28*(11), 2056-2063. doi:10.1002/oby.22996.

Affoh, R., Zheng, H., Dangui, K., & Dissani, B. M. (2022). The impact of climate variability and change on food security in sub-Saharan Africa: Perspective from panel data analysis. *Sustainability*, *14*(2), 759. doi.org/10.3390/su14020759

Aiyedogbon J. O., Anyanwu S. O., Isa G. H., Petrushenko Y. M., Zhuravka O. S. (2022). Population growth and food security: Evidence from Nigeria. *Probl Perspect Manage*, 20(2):402-10. doi.org/10.21511/ppm.20(2).2022.33

Akter, S., and Basher, S. A. (2014) The impacts of food price and income shocks on household food security and economic well-being: evidence from rural Bangladesh. *Global Environmental Change, 25*(1), 150-162. https://doi.org/10.1016/j.gloenvcha.2014.02.003

Al-Dahash, H., Thayaparan, M., and Kulatunga, U. (2016). Understanding the terminologies: Disaster, crisis and emergency. In *Proceedings of the 32nd annual ARCOM conference, ARCOM* 2016 (pp. 1191-1200).

Amolegbe K. B., Upton J, Bageant E, Blom S. (2021). Food price volatility and household food security: Evidence from Nigeria. *Food Policy,* 102:102061. doi.org/10.1016/j.foodpol.2021.102061

Applanaidu, S. D., and Baharudin, A. H. (2014). An econometric analysis of food security and related macroeconomic variables in Malaysia: A vector autoregressive approach (VAR). *UMK Procedia*, *1*, 93-102. doi.org/10.1016/j.umkpro.2014.07.012

Ariadno M. K. (2021). Maritime Security in South East Asia: Indonesian Perspective. *Indones J Int Law* 7(5):88-102. doi.org/10.17304/ijil.vol7.1.229

Aziz, N., He, J., Raza, A., Sui, H., and Yue, W. (2021). Elucidating the macroeconomic determinants of undernourishment in South Asian countries: Building the

framework for action. *Frontiers in Public Health*, *9*, 696789. doi.org/10.3389/fpubh.2021.696789

Azra, M. N., Kasan, N. A., Othman, R., Noor, G. A. G. R., Mazelan, S., Jamari, Z. B., ... & Ikhwanuddin, M. (2021). Impact of COVID-19 on aquaculture sector in Malaysia: Findings from the first national survey. *Aquaculture Reports*, *19*, 100568. doi:10.1016/j.aqrep.2020.100568.

Bakaloudi, D. R., Jeyakumar, D. T., Jayawardena, R., & Chourdakis, M. (2022). The impact of COVID-19 lockdown on snacking habits, fast-food and alcohol consumption: A systematic review of the evidence. *Clinical Nutrition*, *41*(12), 3038-3045. doi.org/10.1016/j.clnu.2021.04.020

Bakucs Z, Fertő I, Varga Á, Benedek Z. (2018). Impact of European Union development subsidies on Hungarian regions. *Eur Plan Stud.,* 26(6):1121-36. doi.org/10.1080/09654313.2018.1437394

Ben Hassen, T., and El Bilali, H. (2022). Impacts of the Russia-Ukraine war on global food security: towards more sustainable and resilient food systems?. *Foods*, 11(15), 2301. doi.org/10.3390/foods11152301

Béné, C. (2020). Resilience of local food systems and links to food security–A review of some important concepts in the context of COVID-19 and other shocks. *Food security*, *12*(4), 805-822. doi:10.1007/s12571-020-01076-1.

Bin Zarah, A., Enriquez-Marulanda, J., & Andrade, J. M. (2020). Relationship between dietary habits, food attitudes and food security status among adults living within the United States three months post-mandated quarantine: a cross-sectional study. *Nutrients*, *12*(11), 3468. doi:10.3390/nu12113468.

Blažková, I., Svatošová, V., Chmelíková, G., Tamáš, V., Svobodová, E., Grega, L., ... and Dobošová, Ľ. (2023). The effects of COVID-19 crisis on small family farms: empirical evidence from Visegrad countries. Agricultural Economics – Czech Republic, 69(9), 366-374. doi.org/10.17221/217/2023-agricecon

Boin, A., Hart, P. T., and Kuipers, S. (2018). The crisis approach. Handbook of disaster research, 23-38.

Boughton, D., Goeb, J., Lambrecht, I., Headey, D., Takeshima, H., Mahrt, K., ... & Diao, X. (2021). Impacts of COVID-19 on agricultural production and food systems in

late transforming Southeast Asia: The case of Myanmar. *Agricultural Systems*, *188*, 103026. doi:10.1016/j.agsy.2020.103026.

Bufa-Dőrr, Zs., Málnási, T., Sebestyén, Á., Vargha, M. and Vecsey, A. (2021). Report - Drinking Water Quality in Hungary, 2020. National Centre for Public Health. https://www.nnk.gov.hu/attachments/article/726/Ivovizminoseg_2020.pdf

Carroll, N., Sadowski, A., Laila, A., Hruska, V., Nixon, M., Ma, D. W., ... & Guelph Family Health Study. (2020). The impact of COVID-19 on health behavior, stress, financial and food security among middle to high income Canadian families with young children. *Nutrients*, *12*(8), 2352. doi:10.3390/nu12082352.

Ceballos, F., Kannan, S., & Kramer, B. (2020). Impacts of a national lockdown on smallholder farmers' income and food security: Empirical evidence from two states in India. *World Development*, *136*, 105069. doi:10.1016/j.worlddev.2020.105069.

Census 2022 Database. https://nepszamlalas2022.ksh.hu/adatbazis/#/table/WBS001

Chee, M. J., Koziel Ly, N. K., Anisman, H., & Matheson, K. (2020). Piece of cake: Coping with COVID-19. *Nutrients*, *12*(12), 3803. doi:10.3390/nu12123803.

Christian, B., and Griffiths, T. (2016). Algorithms to live by: The computer science of human decisions. Macmillan.

Clapp, J. (2014) Food security and food sovereignty: getting past the binary. *Dialogues in Human Geography, 4*(2), 206-211.

Clay, L. A., & Rogus, S. (2021). Impact of employment, essential work, and risk factors on food access during the COVID-19 pandemic in New York state. *International journal of environmental research and public health*, *18*(4), 1451. doi:10.3390/ijerph18041451.

da Silva, M. E., Lopes, S. O., Araújo, S. P., Priore, S. E., Alfenas, R. D. C. G., and Hermsdorff, H. H. M. (2020). Association between food insecurity and cardiometabolic risk in adults and the elderly: A systematic review. *Journal of Global Health,* 10(2). doi.org/10.7189/jogh.10.020402

Darling, J. R. (1994). Crisis management in international business: Keys to effective decision-making. *Leadership and Organization Development Journal*, 15(8), 3-8.

Das, S., Rasul, M. G., Hossain, M. S., Khan, A. R., Alam, M. A., Ahmed, T., and Clemens, J. D. (2020). Acute food insecurity and short-term coping strategies of urban and rural households of Bangladesh during the lockdown period of COVID-19 pandemic of 2020: report of a cross-sectional survey. *BMJ open*, 10(12), e043365.

Davies, H., and Walters, M. (1998). Do all crises have to become disasters? Risk and risk mitigation. *Property Management,* 16(1), 5-9. doi.org/10.1108/02637479810202883

de Waal, A. (1991). Counter-Insurgency and Famine in Tigray and its Borderlands, 1980-84. In Evil days: Thirty years of war and famine in Ethiopia (Vol. 3169, No. 69). Human Rights Watch.

Demeke A. B., Keil A, Zeller M. (2011). Using panel data to estimate the effect of rainfall shocks on smallholders food security and vulnerability in rural Ethiopia. *Climatic Change*, 108(1–2):185-206. doi.org/10.1007/s10584-010-9994-3

Devereux, S., Béné, C., & Hoddinott, J. (2020). Conceptualising COVID-19's impacts on household food security. *Food security*, *12*(4), 769-772. doi:10.1007/s12571-020-01085-0.

Dithmer J, Abdulai A. (2017). Does trade openness contribute to food security? A dynamic panel analysis. *Food Policy,* 69:218-30. doi.org/10.1016/j.foodpol.2017.04.008

Dou, Z., Stefanovski, D., Galligan, D., Lindem, M., Rozin, P., Chen, T., & Chao, A. M. (2021). Household food dynamics and food system resilience amid the COVID-19 pandemic: A cross-national comparison of China and the United States. *Frontiers in Sustainable Food Systems*, *4*, 577153. doi:10.3389/fsufs.2020.577153.

Eckstein D, Künzel V, Schäfer L. The global climate risk index 2021. Bonn (Germany): Germanwatch; 2021.

Élelmiszerbank (2023). Beszámolók: Eredményeink https://www.elelmiszerbank.hu/hu/eredmenyeink.html; Negyedével több élelmiszert mentettünk idén https://www.elelmiszerbank.hu/hu/hirek/hireink/negyedevel_tobb_elelmiszert_mentettunk_iden.html

Éliás, B. A. (2024). Magyarország élelmezése válság idején. *Gazdálkodás*, 68(2), 103–125; https://doi.org/10.53079/GAZDALKODAS.68.2.t.pp_103-125. [Food security of Hungary in times of crisis]

Éliás, B. A., and Jámbor, A. (2021). Food security and COVID-19: a systematic review of the first-year experience. *Sustainability*, 13(9), 5294; https://doi.org/10.3390/su13095294.

Elsahoryi, N., Al-Sayyed, H., Odeh, M., McGrattan, A., & Hammad, F. (2020). Effect of Covid-19 on food security: A cross-sectional survey. *Clinical nutrition ESPEN*, *40*, 171-178. doi:10.1016/j.clnesp.2020.09.026.

European Food Safety Authority (2022). Food safety in the EU. Eurobarometer 97.2 special edition. https://www.efsa.europa.eu/sites/default/files/corporate_publications/files/eurobarometer22/country-factsheets/eb972_factsheet_hu_hu.pdf

Eurostat (2021). Food waste and food waste prevention by NACE Rev. 2 activity https://ec.europa.eu/eurostat/databrowser/view/env_wasfw/default/table?lang=en

FAO – European Commission (2008). An Introduction to the Basic Concepts of Food Security, EC - FAO Food Security Programme: 1. https://www.fao.org/3/al936e/al936e.pdf

FAO (1991). The State of Food and Agriculture 1990, Rome, ISBN 925102989x

FAO (1992a). The State of Food and Agriculture 1991, Rome, ISBN 9251030928

FAO (1992b). The State of Food and Agriculture 1992, Rome, ISBN 9251032262

FAO (1993). The State of Food and Agriculture 1993, Rome, ISBN 9251033609

FAO (1994). The State of Food and Agriculture 1994, Rome, Series number 00814539

FAO (1995). The State of Food and Agriculture 1995, Rome, Series number 1995

FAO (1996a). Rome Declaration on World Food Security and World Food Summit Plan of Action. World Food Summit 13-17 November 1996. Rome. http://www.fao.org/3/w3613e/w3613e00.htm

FAO (1996b). The State of Food and Agriculture 1996, Rome, Series number 00814539

FAO (1997). The State of Food and Agriculture 1997, Rome, Series number 00814539

FAO (1998). The State of Food and Agriculture 1998, Rome, Series number 00814539

FAO (1999). The State of Food Insecurity in the World 1999, Rome, ISBN 9251043280

FAO (2000). The State of Food Insecurity in the World 2000, Rome, ISBN 9251044791

FAO (2001). The State of Food Insecurity in the World 2001, Rome, ISBN 925104628X

FAO (2002). The State of Food Insecurity in the World 2002, Rome, ISBN 9251048150

FAO (2003a). Trade Reforms and Food Security. Conceptualizing the linkages. Rome. https://www.fao.org/3/y4671e/y4671e.pdf

FAO (2003b). The State of Food Insecurity in the World 2003, Rome, ISBN 9251049866

FAO (2004). The State of Food Insecurity in the World 2004, Rome, ISBN 925105178X

FAO (2005). The State of Food Insecurity in the World 2005, Rome, ISBN 9251053847

FAO (2006). The State of Food Insecurity in the World 2006, Rome, ISBN 9251055807

FAO (2007). The State of Food and Agriculture 2007, Rome, ISBN 97892510575

FAO (2008) The State of Food Insecurity in the World 2008, Rome, ISBN 9789251060490

FAO (2009b). Declaration of the World Summit on Food Security. World Summit on Food Security. Rome, 16–18 November 2009. Available online: http://www.fao.org/fileadmin/templates/wsfs/Summit/Docs/Final_Declaration/WSFS09_Declaration.pdf (accessed on 25 March 2021).

FAO (2009a). The State of Food Insecurity in the World 2009, Rome, ISBN 9789251062883

FAO (2010). The State of Food Insecurity in the World 2010, Rome, ISBN 9789251066102

FAO (2011). The State of Food Insecurity in the World 2011, Rome, ISBN 9789251069271

FAO (2012). The State of Food Insecurity in the World 2012, Rome, ISBN 9789251073162

FAO (2013). The State of Food Insecurity in the World 2013, Rome, ISBN 9789251079164

FAO (2014). The State of Food Insecurity in the World 2014, Rome, ISBN 97892510 85431

FAO (2015). The State of Food Insecurity in the World 2015, Rome, ISBN 97892510 87855

FAO (2016). The State of Food and Agriculture 2016, Rome, ISBN 9789251093740

FAO Agricultural Development Economics Division (2018). Sustainable food systems. Concept and framework. http://www.fao.org/3/ca2079en/CA2079EN.pdf

FAO Asia and Pacific Commission on Agricultural Statistics (2014). Revision of the methodology for the estimation of the Prevalence of Undernourishment, APCAS 21th Session, 18-21 February 2014, Vientiane, Lao PDR:3

FAO, IFAD, UNICEF, WFP, WHO (2017). The State of Food Security and Nutrition in the World 2017, Rome, ISBN 9789251098882

FAO, IFAD, UNICEF, WFP, WHO (2018). The State of Food Security and Nutrition in the World 2018, Rome, ISBN 978-9251305713

FAO, IFAD, UNICEF, WFP, WHO (2019). The State of Food Security and Nutrition in the World 2019, Rome, ISBN 9789251315705

FAO, IFAD, UNICEF, WFP, WHO (2020). The State of Food Security and Nutrition in the World 2020, Rome, ISBN 9789251329016

FAO, IFAD, UNICEF, WFP, WHO (2021). The State of Food Security and Nutrition in the World 2021, Rome, ISBN 9789251343258

FAO, IFAD, UNICEF, WFP, WHO (2022). The State of Food Security and Nutrition in the World 2022, Rome, ISBN 9789251364994

FAO, IFAD, UNICEF, WFP, WHO (2023). The State of Food Security and Nutrition in the World 2023, Rome, ISBN 9789251372265

FAOSTAT. Statistical Database. Available from: https://www.fao.org/faostat/en/#home. Accessed 2024 Jan 20.

Fiorella, K. J., Bageant, E. R., Mojica, L., Obuya, J. A., Ochieng, J., Olela, P., ... & Okronipa, H. (2021). Small-scale fishing households facing COVID-19: The case of Lake Victoria, Kenya. *Fisheries Research*, *237*, 105856. doi:10.1016/j.fishres.2020.105856.

Food Security Information Network (2018). Global Report on Food Crises 2018. Available from: https://www.fao.org/fileadmin/user_upload/fsin/docs/global_report/2018/GRFC_2018_Full_report_EN.pdf. Accessed 2024 Feb 11.

Food Security Information Network (2019). Global Report on Food Crises 2019. Available from: https://www.fsinplatform.org/report/global-report-food-crisis-2019/. Accessed 2024 Feb 11.

Food Security Information Network (2020). Global Report on Food Crises 2020. Available from: https://www.fsinplatform.org/sites/default/files/resources/files/GRFC%20ONLINE%20FINAL%202020.pdf. Accessed 2024 Feb 11.

Food Security Information Network (2021). Global Report on Food Crises 2021. Available from: https://docs.wfp.org/api/documents/WFP-0000127343/download/?_ga=2.208631515.813678707.1717073951-67621395.1710625693. Accessed 2024 Feb 11.

Food Security Information Network (2022). Global Report on Food Crises 2022. Available from: https://docs.wfp.org/api/documents/WFP-0000138913/download/?_ga=2.208631515.813678707.1717073951-67621395.1710625693. Accessed 2024 Feb 11.

Food Security Information Network (2023). Global Report on Food Crises 2023. Available from: https://www.fsinplatform.org/sites/default/files/resources/files/GRFC2023-compressed.pdf. Accessed 2024 Feb 11.

Gaitán-Rossi, P., Vilar-Compte, M., Teruel, G., & Pérez-Escamilla, R. (2021). Food insecurity measurement and prevalence estimates during the COVID-19 pandemic in a repeated cross-sectional survey in Mexico. *Public health nutrition*, *24*(3), 412-421, doi:10.1017/S1368980020004000.

Gassara, G., and Chen, J. (2021). Household food insecurity, dietary diversity, and stunting in Sub-Saharan Africa: a systematic review. *Nutrients*, 13(12), 4401.

Gill, P., Stewart, K., Treasure, E., and Chadwick, B. (2008). Methods of data collection in qualitative research: interviews and focus groups. *British Dental Journal*, 204(6), 291-295.

Głąbska, D., Skolmowska, D., & Guzek, D. (2020). Population-based study of the changes in the food choice determinants of secondary school students: Polish adolescents' COVID-19 experience (place-19) study. *Nutrients*, *12*(9), 2640. doi:10.3390/nu12092640.

Global Food Security Index. Country Report: Hungary 2022. The Economist Impact. https://impact.economist.com/sustainability/project/food-security-index/reports/Economist_Impact_GFSI_2022_Hungary_country_report_Sep_2022.pdf

Gupta, A., Zhu, H., Doan, M. K., Michuda, A., & Majumder, B. (2021). Economic impacts of the COVID− 19 lockdown in a remittance-dependent region. *American Journal of Agricultural Economics*, *103*(2), 466-485. doi:10.1111/ajae.12178.

Hamadani, J. D., Hasan, M. I., Baldi, A. J., Hossain, S. J., Shiraji, S., Bhuiyan, M. S. A., ... & Pasricha, S. R. (2020). Immediate impact of stay-at-home orders to control COVID-19 transmission on socioeconomic conditions, food insecurity, mental health, and intimate partner violence in Bangladeshi women and their families: an interrupted time series. *The Lancet Global Health*, *8*(11), e1380-e1389. doi:10.1016/S2214-109X(20)30366-1.

Harris, J., Depenbusch, L., Pal, A. A., Nair, R. M., & Ramasamy, S. (2020). Food system disruption: initial livelihood and dietary effects of COVID-19 on vegetable producers in India. *Food security*, *12*(4), 841-851. doi:10.1007/s12571-020-01064-5.

Headey D. D. and Martin W. J. (2016). The impact of food prices on poverty and food security. *Annu Rev Resour Econ,* 8:329-51. doi.org/10.1146/annurev-resource-100815-095303

Holleman C, and Conti, V. (2020). Role of income inequality in shaping outcomes on individual food insecurity: Background paper for the state of food security and nutrition in the World 2019. Rome (Italy): FAO; 2020.

Holling, C. S. (1986). The resilience of terrestrial ecosystems: local surprise and global change. *Sustainable development of the biosphere*, 14, 292-317.

Holling, C. S. (2001). Understanding the complexity of economic, ecological, and social systems. *Ecosystems*, 4, 390-405.

Hovhannisyan, V., Cho, C., and Bozic, M. (2019). The relationship between price and retail concentration: Evidence from the US food industry. *European Review of Agricultural Economics*, *46*(2), 319-345.

Hungarian Central Statistical Office: Data table: Nr. 14.1.1.27. Annual food consumption volume per capita by income deciles [kilogram] https://www.ksh.hu/stadat_files/jov/en/jov0026.html

Hungarian Central Statistical Office: Data table: Nr. 14.8.1.5. Gross and net income per capita by income deciles [HUF/person/year] https://www.ksh.hu/stadat_files/jov/en/jov0005.html

Huss, M., Brander, M., Kassie, M., Ehlert, U., & Bernauer, T. (2021). Improved storage mitigates vulnerability to food-supply shocks in smallholder agriculture during the

COVID-19 pandemic. *Global Food Security*, *28*, 100468, doi:10.1016/j.gfs.2020.100468.

Ibrahim, A. Z., & Othman, Z. (2020). COVID-19: Coping strategies among B40 households in Malaysia to achieve food security during movement control order (MCO). *European Journal of Molecular & Clinical Medicine*, *7*(6), 1513-1524.

Ibrahim, M. S., Fakharu'l-razi, A., and Aini, M. S. (2003). A review of disaster and crisis. *Disaster Prevention and Management,* 12(1), 24-32.

IFPRI (2022). 2022 annual Report https://ebrary.ifpri.org/utils/getfile/collection/p15738coll2/id/136727/filename/136938.pdf

IMF. World Economic Outlook (2020). A Long and Difficult Ascent. Available online: https://www.imf.org/en/Publications/WEO/Issues/2020/09/30/world-economic-outlook-october-2020 (accessed on 25. March 2021).

Jámbor, A. (2017). *Global issues of agricultural competitiveness and food security*. Eco-Sensus Nonprofit Ltd., Szekszárd.

Jambor, A., and Elias, B. A. (2024). Determinants of Food Security: A Comprehensive Analysis Across East, South, and Southeast Asia. *Journal of Sustainability Research*, 6(2):e240030; https://doi.org/10.20900/jsr20240030.

Jámbor, A., Czine, P., & Balogh, P. (2020). The impact of the coronavirus on agriculture: first evidence based on global newspapers. *Sustainability*, *12*(11), 4535. doi:10.3390/su12114535.

Jankuné Kürthy, Gy. ed. (2022). *Relationships between production costs and price developments in some major food product chains*. Institute of Agricultural Economics [manuscript]

Jankuné Kürthy, Gy., Kőnig, G., Mizik, T. and Szabó, M. (2013). In Kiss, J. (Ed.) *The global economic dimensions of food security* (pp. 145-216.). Institute for the World Economy, Centre for Economic and Regional Research, Hungarian Academy of Sciences, OTKA Research Reports.

Janssen, M., Chang, B. P., Hristov, H., Pravst, I., Profeta, A., & Millard, J. (2021). Changes in food consumption during the COVID-19 pandemic: analysis of consumer survey data from the first lockdown period in Denmark, Germany, and Slovenia. *Frontiers in nutrition*, *8*, 635859. doi:10.3389/fnut.2021.635859.

Kansiime, M. K., Tambo, J. A., Mugambi, I., Bundi, M., Kara, A., & Owuor, C. (2021). COVID-19 implications on household income and food security in Kenya and Uganda: Findings from a rapid assessment. *World development*, *137*, 105199. doi:10.1016/j.worlddev.2020.105199.

Kassy, W. C., Ndu, A. C., Okeke, C. C., and Aniwada, E. C. (2021). Food security status and factors affecting household food security in Enugu State, Nigeria. *Journal of Health Care for the Poor and Underserved*, 32(1), 565-581.

Kent, K., Murray, S., Penrose, B., Auckland, S., Visentin, D., Godrich, S., & Lester, E. (2020). Prevalence and socio-demographic predictors of food insecurity in Australia during the COVID-19 pandemic. *Nutrients*, *12*(9), 2682. doi:10.3390/nu12092682.

Kovljenić M, Raletić-Jotanović S. (2021). Food security issues in the former Yugoslav countries. *Outlook Agr.,* 50 (1):46-54. doi.org/10.1177/0030727020930039

KSH 1.1.1.2 Consumer price index by main consumption groups, the pensioner consumer price index and core inflation [previous year = 100.0%]. https://www.ksh.hu/stadat_files/ara/hu/ara0002.html

KSH 14.1.1.23. Number of households, characteristics of persons living in the household, their income-earning activities, income deciles. https://www.ksh.hu/stadat_files/jov/hu/jov0022.html

KSH 14.1.1.26. Annual expenditure per capita by COICOP population groups and income deciles [HUF/person/year]. https://www.ksh.hu/stadat_files/jov/hu/jov0025.html

KSH 14.1.1.27. Annual per capita food consumption by income deciles [kilograms]. https://www.ksh.hu/stadat_files/jov/hu/jov0026.html

KSH 14.1.1.31. Breakdown of annual expenditure per capita by COICOP grouping, age group of reference person, educational attainment and age composition of household members [HUF/person/year]. https://www.ksh.hu/stadat_files/jov/hu/jov0030.html

KSH 14.1.1.36. Breakdown of annual per capita expenditure by COICOP grouping in households with children, households without children and single-person households [HUF/person/year]. https://www.ksh.hu/stadat_files/jov/hu/jov0035.html

KSH 14.1.1.41. Breakdown of annual per capita expenditure of active, pensioner and other inactive households by COICOP grouping, income quintiles [HUF/person/year]. https://www.ksh.hu/stadat_files/jov/hu/jov0040.html

KSH 14.1.2.10. Breakdown of annual expenditure per capita by COICOP grouping, region and type of settlement [HUF/person/year]. https://www.ksh.hu/stadat_files/jov/hu/jov0050.html

KSH 14.1.2.4 Gross and net per capita income by region and type of settlement [HUF/person/year]. https://www.ksh.hu/stadat_files/jov/hu/jov0045.html

KSH 14.8.1.5 Gross and net per capita income by income deciles [HUF/person/year]. https://www.ksh.hu/stadat_files/jov/hu/jov0005.html

KSH 19.1.1.21. Production and use of major arable crops. https://www.ksh.hu/stadat_files/mez/hu/mez0021.htmll

KSH 19.1.1.47. Pig meat balance sheet. https://www.ksh.hu/stadat_files/mez/hu/mez0048.html

KSH 19.1.1.48. Beef and veal balance sheet. https://www.ksh.hu/stadat_files/mez/hu/mez0049.html

KSH 19.1.1.53. Poultry meat balance. https://www.ksh.hu/stadat_files/mez/hu/mez0054.html

KSH 19.1.1.65. Daily amount of nutrients per capita in kilocalories. https://www.ksh.hu/stadat_files/mez/hu/mez0066.html

KSH 2.1.1.2 Number of retail outlets by type of outlet, 31 December https://www.ksh.hu/stadat_files/bel/hu/bel0002.html

KSH 2.1.1.3. Total and average floor area of retail stores by type of store, 31 December https://www.ksh.hu/stadat_files/bel/hu/bel0003.html

KSH 20.1.1.6 Population by highest level of education, by sex (thousands). https://www.ksh.hu/stadat_files/mun/hu/mun0006.html

KSH 20.2.1.52. Average net earnings of full-time employees excluding benefits by industry, monthly, cumulated monthly and quarterly. https://www.ksh.hu/stadat_files/mun/hu/mun0202.html

KSH 22.1.1.3 Population by age and sex, 1 January https://www.ksh.hu/stadat_files/nep/hu/nep0003.html

KSH Agrárcenzus (2020). Preliminary data. https://www.ksh.hu/docs/hun/xftp/ac2020/elozetes_adatok/index.html#/cover

Kumaran, M., Geetha, R., Antony, J., Vasagam, K. K., Anand, P. R., Ravisankar, T., ... & Vijayan, K. K. (2021). Prospective impact of Corona virus disease (COVID-19) related lockdown on shrimp aquaculture sector in India–a sectoral assessment. *Aquaculture*, *531*, 735922. doi:10.1016/j.aquaculture.2020.735922.

Kundu, S., Al Banna, M. H., Sayeed, A., Sultana, M. S., Brazendale, K., Harris, J., ... & Khan, M. S. I. (2021). Determinants of household food security and dietary diversity during the COVID-19 pandemic in Bangladesh. *Public Health Nutrition*, *24*(5), 1079-1087. doi:10.1017/S1368980020005042, Accepted manuscript.

Laborde, D.; Martin, W.; Swinnen, J.; Vos, R. (2020). COVID-19 Risks to Global Food Security. *Science*, 369, 500–502, doi:10.1126/science.abc4765.

Larson, N., Slaughter-Acey, J., Alexander, T., Berge, J., Harnack, L., & Neumark-Sztainer, D. (2021). Emerging adults' intersecting experiences of food insecurity, unsafe neighbourhoods and discrimination during the coronavirus disease 2019 (COVID-19) outbreak. *Public Health Nutrition*, *24*(3), 519-530.doi:10.1017/S136898002000422X.

Lauren, B. N., Silver, E. R., Faye, A. S., Rogers, A. M., Woo-Baidal, J. A., Ozanne, E. M., & Hur, C. (2021). Predictors of households at risk for food insecurity in the United States during the COVID-19 pandemic. *Public health nutrition*, *24*(12), 3929-3936. doi:10.1017/S1368980021000355, Accepted manuscript

Leal Filho, W., Fedoruk, M., Paulino Pires Eustachio, J. H., Barbir, J., Lisovska, T., Lingos, A., and Baars, C. (2023). How the War in Ukraine Affects Food Security. *Foods*, 12(21), 3996.

Litton, M. M., & Beavers, A. W. (2021). The relationship between food security status and fruit and vegetable intake during the COVID-19 pandemic. *Nutrients*, *13*(3), 712. doi:10.3390/nu13030712.

Martin-Prevel, Y., Becquey, E., Tapsoba, S., Castan, F., Coulibaly, D., Fortin, S., ... & Savy, M. (2012). The 2008 food price crisis negatively affected household food security and dietary diversity in urban Burkina Faso. *The Journal of nutrition*, *142*(9), 1748-1755.

Marty, L., de Lauzon-Guillain, B., Labesse, M., & Nicklaus, S. (2021). Food choice motives and the nutritional quality of diet during the COVID-19 lockdown in France. *Appetite*, *157*, 105005. doi:10.1016/j.appet.2020.105005.

Maxwell, S. and Smith, M. (1992). Household food security; a conceptual review. In: S. Maxwell and T.R. Frankenberger, (eds.) Household Food Security: Concepts, Indicators, Measurements: A Technical Review. New York and Rome: UNICEF – IFAD.

McCarron B., Tan S., Giunti A. (2018). Charting Asia's Protein Journey. Singapore (Singapore): Asia Research and Engagement; 2018.

Mialki, K., House, L. A., Mathews, A. E., & Shelnutt, K. P. (2021). Covid-19 and college students: food security status before and after the onset of a pandemic. *Nutrients*, *13*(2), 628. doi:10.3390/nu13020628.

Middendorf, B. J., Faye, A., Middendorf, G., Stewart, Z. P., Jha, P. K., & Prasad, P. V. (2021). Smallholder farmer perceptions about the impact of COVID-19 on agriculture and livelihoods in Senegal. *Agricultural Systems*, *190*, 103108. doi:10.1016/j.agsy.2021.103108.

Mitroff, I.I., Pearson, C.M. and Harrington, L.K. (1996). The Essential Guide to Managing Corporate Crisis: A Step-by-step Handbook for Surviving Major Catastrophes, Oxford University Press, Oxford.

Molitor, F., & Doerr, C. (2021). Peer Reviewed: Very Low Food Security Among Low-Income Households With Children in California Before and Shortly After the Economic Downturn From COVID-19. *Preventing chronic disease*, *18*. 200517, doi:10.5888/PCD18.200517.

Mutisya M., Ngware M. W., Kabiru C. W., Kandala N. B. (2016). The effect of education on household food security in two informal urban settlements in Kenya: a longitudinal analysis. *Food Secur.* 8:743-56. doi.org/10.1007/s12571-016-0589-3

Naja, F., & Hamadeh, R. (2020). Nutrition amid the COVID-19 pandemic: a multi-level framework for action. *European journal of clinical nutrition*, *74*(8), 1117-1121., doi:10.1038/s41430-020-0634-3.

Nchanji, E. B., Lutomia, C. K., Chirwa, R., Templer, N., Rubyogo, J. C., & Onyango, P. (2021). Immediate impacts of COVID-19 pandemic on bean value chain in selected countries in sub-Saharan Africa. *Agricultural systems*, *188*, 103034. doi:10.1016/j.agsy.2020.103034.

Nébih (2019). Nébih Food and Feed Safety Directorate, Catering and Public Catering Supervision Unit Summary. https://portal.nebih.gov.hu/documents/10182/1487366/honlapra_%C3%89M+report%C3%A9s+2019.pdf/1fe72e40-049a-964c-a838-5c0d34ae70d9?t=1594899201668

Nébih (2022). Our food waste has been cut by a quarter. https://portal.nebih.gov.hu/-/negyedevel-csokkent-az-elelmiszerpazarlasunk

Ngongi, A. M., and Urassa, K. (2014). Farm households food production and households' food security status: a case of Kahama district, Tanzania. *Tanzania Journal of Agricultural Sciences*, 13(2).

Niles, M. T., Bertmann, F., Belarmino, E. H., Wentworth, T., Biehl, E., & Neff, R. (2020). The early food insecurity impacts of COVID-19. *Nutrients*, *12*(7), 2096. doi:10.3390/nu12072096.

Nosratabadi, S., Khazami, N., Abdallah, M. B., Lackner, Z., S. Band, S., Mosavi, A., and Mako, C. (2020). Social capital contributions to food security: A comprehensive literature review. *Foods*, 9(11), 1650.

OTÁP 2019 — Evaluation presentations. https://ogyei.gov.hu/otap2019/

Owens, M. R., Brito-Silva, F., Kirkland, T., Moore, C. E., Davis, K. E., Patterson, M. A., ... & Tucker, W. J. (2020). Prevalence and social determinants of food insecurity among college students during the COVID-19 pandemic. *Nutrients*, *12*(9), 2515. doi:10.3390/nu12092515.

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., ... and Moher, D. (2021). The PRISMA 2020 Statement: an Updated Guideline for Reporting Systematic Reviews. *Bmj*, 372. Nr. 72. doi: https://doi.org/10.1136/bmj.n71

Pakravan-Charvadeh, M. R., Mohammadi-Nasrabadi, F., Gholamrezai, S., Vatanparast, H., Flora, C., & Nabavi-Pelesaraei, A. (2021). The short-term effects of COVID-19 outbreak on dietary diversity and food security status of Iranian households (A case study in Tehran province). *Journal of cleaner production*, *281*, 124537. doi:10.1016/j.jclepro.2020.124537.

Parigi, M. (2024). The effect of violent conflict on calorie consumption and dietary quality in Iraq. *Journal of Agricultural Economics.* 75 (1), 341-361. https://doi.org/10.1111/1477-9552.12560

Parnham, J.C.; Laverty, A.A.; Majeed, A.; Vamos, E.P. (2020). Half of Children Entitled to Free School Meals Did Not Have Access to the Scheme during COVID-19 Lockdown in the UK. *Public Health*, 187, 161–164, doi:10.1016/j.puhe.2020.08.019.

Patrick, S. W., Henkhaus, L. E., Zickafoose, J. S., Lovell, K., Halvorson, A., Loch, S., ... & Davis, M. M. (2020). Well-being of parents and children during the COVID-19 pandemic: a national survey. *Pediatrics*, *146*(4). doi:10.1542/peds.2020-0836.

Polsky, J. Y., & Gilmour, H. (2020). Food insecurity and mental health during the COVID-19 pandemic. *Health Rep*, *31*(12), 3-11. doi:10.25318/82-003-x202001200001-eng.

Population Reference Bureau (2023). World Population Data Sheet, 2023, https://2023-wpds.prb.org/. Accessed 2024 March 10

Quaife, M., Van Zandvoort, K., Gimma, A., Shah, K., McCreesh, N., Prem, K., ... & Austrian, K. (2020). The impact of COVID-19 control measures on social contacts and transmission in Kenyan informal settlements. *BMC Medicine*, *18*, 1-11. doi:10.1186/s12916-020-01779-4.

Quarantelli, E. L., and Dynes, R. R. (1977). Response to social crisis and disaster. *Annual review of sociology*, 3(1), 23-49.

Rahman, S., Hossain, I., Mullick, A. R., & Khan, M. H. (2020). Food security and the coronavirus disease 2019 (COVID-19): a systemic review. *J. Med. Sci. Clin. Res*, *8*(5), 180-184. doi:10.18535/jmscr/v8i5.34.

Ramessur T. S. and Bundhun S. (2022). Responsiveness of food security to macroeconomic variables: the cases of Maldives, Mauritius and Seychelles. *Small States Territ*., 5(2):293-312.

Reutlinger, S. (1986). Poverty and Hunger: Issues and Options for Food Security in Developing Countries. A World Bank Policy Study. The World Bank, 1818 H Street, NW, Washington, DC 20433. https://documents1.worldbank.org/curated/en/166331467990005748/pdf/multi-page.pdf

Rocha, H. A., Sudfeld, C. R., Leite, Á. J., Rocha, S. G., Machado, M. M., Campos, J. S., ... & Correia, L. L. (2021). Coronavirus disease 2019, food security and maternal mental health in Ceará, Brazil: a repeated cross-sectional survey. *Public Health Nutrition*, *24*(7), 1836-1840. doi:10.1017/s1368980021000628.

Rockmore, M. (2020). Conflict-risk and agricultural portfolios: evidence from Northern Uganda. *The Journal of Development Studies*, *56*(10), 1856-1876. DOI: 10.1080/00220388.2019.1703953

Rodríguez-Pérez, C., Molina-Montes, E., Verardo, V., Artacho, R., García-Villanova, B., Guerra-Hernández, E. J., & Ruíz-López, M. D. (2020). Changes in dietary

behaviours during the COVID-19 outbreak confinement in the Spanish COVIDiet study. *Nutrients*, *12*(6), 1730. doi:10.3390/nu12061730.

Russo, C., Simeone, M., Demartini, E., Marescotti, M. E., & Gaviglio, A. (2021). Psychological pressure and changes in food consumption: the effect of COVID-19 crisis. *Heliyon*, *7*(4). doi:10.1016/j.heliyon.2021.e06607.

Ruszczyk, H. A., Rahman, M. F., Bracken, L. J., & Sudha, S. (2021). Contextualizing the COVID-19 pandemic's impact on food security in two small cities in Bangladesh. *Environment and Urbanization*, *33*(1), 239-254. doi:10.1177/0956247820965156.

Sahu, R. S., Tiwari, M., and Deka, N. (2024). The role of organic farming in creating food security and sustainable livelihoods for India's smallholder farmers: a systematic review using PRISMA. *Organic Agriculture*, 1-27.

Saxena, A., Amin, A., Mohan, S. B., & Mohan, P. (2020). Food insecurity in tribal high migration communities in Rajasthan, India. *Food and Nutrition Bulletin*, *41*(4), 513-518. doi:10.1177/0379572120967163.

Scacchi, A., Catozzi, D., Boietti, E., Bert, F., & Siliquini, R. (2021). COVID-19 lockdown and self-perceived changes of food choice, waste, impulse buying and their determinants in Italy: QuarantEat, a cross-sectional study. *Foods*, *10*(2), 306. doi:10.3390/foods10020306.

Schober, P., Boer, C., and Schwarte, L. A. (2018). Correlation coefficients: appropriate use and interpretation. *Anesthesia & analgesia*, *126*(5), 1763-1768.

Segovia, A. (2017). The relationships between food security and violent conflicts: The case of Colombia. FAO Agricultural Development Economics Working Paper 17-06

Sen, A. (1981). Poverty and Famines. Oxford: Clarendon Press.

Sereenonchai, S., & Arunrat, N. (2021). Understanding food security behaviors during the COVID-19 pandemic in Thailand: a review. *Agronomy*, *11*(3), 497. doi:10.3390/agronomy11030497.

Shamir-Stein, N., Feldblum, I., Rotman, E., Cohen, S., Brand, E., Kivity, S., & Saban, M. (2024). Exploring the self-reported physical and psychological effects in a population exposed to a regional conflict. *Journal of community health*, 1-8. doi.org/10.1007/s10900-024-01337-6

Shen, W., Long, L. M., Shih, C. H., & Ludy, M. J. (2020). A humanities-based explanation for the effects of emotional eating and perceived stress on food choice motives during the COVID-19 pandemic. *Nutrients*, *12*(9), 2712. doi:10.3390/nu12092712.

Shrestha, C., Acharya, S., Sharma, R., Khanal, R., Joshi, J., Ghimire, C., ... & Agrawal, A. (2020). Changes and compromises in health choices during COVID-19 lockdown in Kathmandu Valley: a descriptive cross-sectional study. *JNMA: Journal of the Nepal Medical Association*, *58*(232), 1046. doi:10.31729/jnma.5790.

Sidor, A., & Rzymski, P. (2020). Dietary choices and habits during COVID-19 lockdown: experience from Poland. *Nutrients*, *12*(6), 1657. doi:10.3390/nu12061657.

Sietz, D., Mamani Choque, S. E., and Lüdeke, M. K. (2012). Typical patterns of smallholder vulnerability to weather extremes with regard to food security in the Peruvian Altiplano. *Regional Environmental Change*, 12, 489-505.

Smith, L. C., and Subandoro, A. (2007) *Measuring food security using household expenditure surveys (Vol. 3*) Intl Food Policy Res Inst.

Snuggs, S., & McGregor, S. (2021). Food & meal decision making in lockdown: How and who has Covid-19 affected?. *Food quality and preference*, *89*, 104145. doi:10.1016/j.foodqual.2020.104145.

Sousa, L. R. M. D., Segall-Corrêa, A. M., Ville, A. S., and Melgar-Quiñonez, H. (2019). Food security status in times of financial and political crisis in Brazil. *Cadernos de Saúde Pública*, *35*.

Steenbergen, D. J., Neihapi, P. T., Koran, D., Sami, A., Malverus, V., Ephraim, R., & Andrew, N. (2020). COVID-19 restrictions amidst cyclones and volcanoes: A rapid assessment of early impacts on livelihoods and food security in coastal communities in Vanuatu. *Marine policy*, *121*, 104199. doi:10.1016/j.marpol.2020.104199.

Subramanyam M. A., Kawachi I., Berkman L. F., Subramanian S. V. (2011). Is economic growth associated with reduction in child undernutrition in India? *PLoS Med.*, 8(3):e1000424. doi.org/10.1371/journal.pmed.1000424

Szabó, P., Kabai, G., Fekete, K. (2019). The main characteristics of retail food supply in Hungary and the supply problems and opportunities of small villages in the 21st century. *Tér-Gazdaság-Ember, 7*(2-3), 205-229.

Szenderák, J., and Popp, J. (2022). Sectoral concentration along the food chain in Hungary. Gazdálkodás, *66*(2), 99-116.

Tulach, P., and Foltin, P. (2020). Improving Supply Chain Resilience Through Methods of Fast Adaptation to Sudden Demand Shifts In The Time of Crisis. *Business Logistics in Modern Management*, 165-179.

United Nations (1975). Report of the World Food Conference, Rome, 5-16 November 1974. United Nations Publication, New York. E/CONF.65/20.

Uppsala Conflict Data Program. Available from: https://ucdp.uu.se/downloads/. Accessed 2024 Feb 10.

Vargas, R., Fonseca, C., Hareau, G., Ordinola, M., Pradel, W., Robiglio, V., & Suarez, V. (2021). Health crisis and quarantine measures in Peru: Effects on livelihoods of coffee and potato farmers. *Agricultural Systems*, *187*, 103033. doi:10.1016/j.agsy.2020.103033.

Vlassenroot, K., and Raeymaekers, T. (2008). Crisis and food security profile: The Democratic Republic of the Congo. In: Alinovi, L., Hemrich, G., and Russo, L. (2008). Beyond relief: food security in protracted crises. Practical Action Publishing. pp. 157-168.

Vlassenroot, K., and Raeymaekers, T. (Eds.). (2004). Conflict and social transformation in Eastern DR Congo. Academia Press.

Walker, B., Gunderson, L., Kinzig, A., Folke, C., Carpenter, S., and Schultz, L. (2006). A handful of heuristics and some propositions for understanding resilience in social-ecological systems. *Ecology and society,* 11(1).

Warr P. (2014). Food insecurity and its determinants. *Australian Journal of Agricultural and Resource Economics*, 58(4):519-37. doi.org/10.1111/1467-8489.12073

Wei, T., Glomsrød, S., and Zhang, T. (2017). Extreme weather, food security and the capacity to adapt–the case of crops in China. *Food Security*, *9*, 523-535.

WHO (2020a). Mission summary: WHO Field Visit to Wuhan, China 20–21 January 2020. 22 January 2020 Available online: https://www.who.int/china/news/detail/22-01-2020-field-visit-wuhan-china-jan-2020 (accessed on 11 March 2021).

WHO (2020b). Director-General's Opening Remarks at the Mission Briefing on COVID-19—12 March 2020. Available online: https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020 (accessed on 11 March 2021).

Wineman, A., Mason, N. M., Ochieng, J., and Kirimi, L. (2017). Weather extremes and household welfare in rural Kenya. *Food security,* 9(2), 281-300.

Wolfson, J. A., & Leung, C. W. (2020). Food insecurity and COVID-19: disparities in early effects for US adults. *Nutrients*, *12*(6), 1648. doi:10.3390/nu12061648.

Workie, E., Mackolil, J., Nyika, J., & Ramadas, S. (2020). Deciphering the impact of COVID-19 pandemic on food security, agriculture, and livelihoods: A review of the evidence from developing countries. *Current Research in Environmental Sustainability*, *2*, 100014. doi:10.1016/j.crsust.2020.100014.

World Bank Data. Available from: https://databank.worldbank.org/home.aspx. Accessed 2024 Feb 28.

World Bank. Poverty and Hunger: Issues and Options for Food Security in Developing Countries. World Bank: Washington, DC, USA, 1986. Available online: http://documents1.worldbank.org/curated/en/166331467990005748/pdf/multi-page.pdf (ac-cessed on 20 March 2021).

Worldometers. COVID-19 Coronavirus Pandemic. Available online: https://www.worldometers.info/coronavirus/ (accessed on 25 March 2021).