Feature Article

Balancing international trade and local production for food and nutrition security: animal-sourced foods' contribution to human welfare

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Implications

- Animal-sourced foods make a valuable contribution to the diets of consumers from countries across the economic development spectrum. They provide essential micronutrients including iron, vitamin A, vitamin B12, iodine, and zinc, to balance diets which, apart from vitamin B12, are more bioavailable than in plant-sourced foods. This is important for consumers with high needs including young children, pregnant and lactating women, and malnourished people.
- Although international trade has great potential to distribute animal products to satisfy global food demand, current trade flows are not achieving this goal in many low and lower middle-income countries. Multilateral efforts, supported by high-income countries, are needed to orientate international trade systems to provide better food and nutrition security.
- The continuity of trade in filling nutrient deficiencies is often disrupted in times of economic depression, conflict, or natural disaster. Suppliers can retain food resources for their own consumers, while in low-income countries most consumers can ill-afford expensive imports.
- Stability in most countries' supply of animal-sourced foods must rely on the resourcefulness of domestic family-based farmers, who produce up to 80% of the world's food.
- While encouraging the international trade of animal-sourced foods, governments need to ensure that they develop policies that support these local production units to remain profitable to meet domestic consumption needs.
- These policies must be developed in the context of the UN's doctrine of a Right to Food designed to ensure individual countries provide good governance and resources to minimize hunger and poverty.

Key words: animal, climate change, food security, global, nutrition security, trade

Introduction

Of the 17 sustainable development goals (SDGs) developed by the United Nations General assembly in 2015, the second of these, to "End hunger, achieve food security and improved nutrition and promote sustainable agriculture" is dependent on the development of sustainable farming systems balancing the production of foods derived from animals and plants and then facilitating their distribution to ensure an adequate food supply is available to communities worldwide. This emanates from the UN's doctrine of "The Right to Food" which explicitly provides directives for state policies worldwide to recognize the right of all citizens to food that meets international standards of nutrition (FAO, 2021c).

The elimination of hunger will require sustainable agriculture practices, involving a significant rural transformation in

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many global regions to preserve farmer profitability, terrestrial ecosystems and reverse land degradation while conserving biodiversity.

Globally, agriculture already utilizes 50% of the habitable land area and 70% of the freshwater withdrawals for irrigation (Bruinsma, 2017) with any further land acquisition being challenged by further urbanization of fertile arable land, increased pollution, and deteriorating water supplies. The expansion of domestic food supplies in many lower-income countries is dependent on reclamation of arid and semi-arid regions putting further pressure on already scarce water resources. The gap between food supply and demand has created economic burdens that hinder the socioeconomic growth of these countries (D'Odorico et al., 2019).

The attainment of food security involves many factors illustrated in Figure 1.

For some time it has been recognized that world food production exceeds demand (Holt-Giménez et al., 2012). Utilization of food at the household level is entirely dependent on its worldwide availability and accessibility. Given that human health is dependent on accessing a balanced diet involving both macro- and micronutrients, it is clear that the mapping of the world supply of micronutrients together with major sources of dietary protein and energy would assist in identifying the problem of undernutrition (Wood et al., 2018). International trade then has the potential to play a key role in the process of nutrient redistribution derived from both plant and animal agriculture.

Today, however, progress towards food security and nutrition targets is largely trending in the wrong direction. At the global level, both the absolute number of undernourished people and the prevalence of undernourishment have been increasing since 2017. Projected 2030 results for these indicators against the SDG targets at both the global level and the majority of regions are listed as "no progress or worsening" (FAO, 2020a). This crisis of undernutrition covers both macronutrients (carbohydrates, proteins, and fats) and micronutrients (vitamins and minerals) (Willett et al., 2019).

The objective of this perspective is therefore to explore how trade in animal products can alleviate our current failures to distribute key nutrients in sufficient quantities to meet the ever-increasing demands of our global communities. We will also note the current limitations of international trade to provide such nutrients to communities most in need of them. We will demonstrate the importance of animal products to dietary regimes in communities across the globe.

However, the importance of domestic production relative to the provision of nutrient supply through trade cannot be underestimated, especially for low and lower middle-income countries most vulnerable to any shocks in the trade of food commodities. Therefore, it is important that such countries continue to develop their own local production in a way that improves incomes in rural and agricultural areas, balancing this with international trade to ensure national food and nutrition security

Nutrient Deficiencies as a Global Public Health Problem

Nutrient deficiencies cost millions of lives each year, with infants, children, adolescents, and women bearing the overwhelming burden of undernutrition. Currently, 47 million children under 5 years are wasted (low weight-for-height) and 144 million stunted (low height-for-age) (UNICEF et al., 2021). With the COVID pandemic still on the rise in many countries, these numbers are expected to worsen considerably in the future. An estimated 90-117 million children are likely to fall into poverty with severe consequences to their health, nutrition status, and possibly also their survival (Fore, 2020; Manley et al., 2020). According to a modeling study carried out by Osendarp et al., in a "moderate" scenario, pandemic-related disruptions of the food and health system could result in an additional 9.3 million wasted children and 2.6 million stunted children by 2022 (Osendarp et al., 2021)

All aggregate forms of undernutrition are estimated to contribute to 45% of all child deaths (Black et al., 2013). From a public health perspective, insufficient intake of iron, vitamin A and iodine are the greatest concern and represent a major threat to health and optimal development of affected populations (WHO, 2021).

Iron deficiency is the most common nutrient deficiency, affecting an estimated 30 percent of the population worldwide, most severely in children under five and women of childbearing age due to menstruation and the substantial iron demands of pregnancy (Black et al., 2008). Depleted iron levels most notably lead to iron-deficient anemia, resulting in fatigue, weakness, headaches, and apathy, but also to adverse pregnancy outcomes, including an increased risk of maternal mortality (Black et al., 2013). Vitamin A deficiency is the number one cause of preventable blindness, leading to the loss of sight in approximately half a million children each year, and is further increasing the risk of infections with critical health outcomes such as pneumonia and severe diarrhea (Whitney and Rolfes, 2017). Insufficient levels of this vitamin are responsible for about 600,000 deaths annually (Black et al., 2008).

Long-Term Consequences

Undernutrition is a result and driver of reduced economic productivity and poverty. It leads to severe long-term consequences and has been associated with shorter height in adults, cognitive impairment, and weak educational performance (Victora et al., 2008). On the individual level, it hinders children to reach their full potential. On a macro level, it impedes a country's ability to accumulate human capital. The World Bank estimates the annual economic costs arising from reduced national productivity and economic growth due to undernutrition to be as high as 11% of GDP in some low-income countries(World Bank, 2019).

A Role for Trade in Resolving Nutrient Deficiencies

Approximately 80% of global food consumption is produced locally but the share of internationally traded food

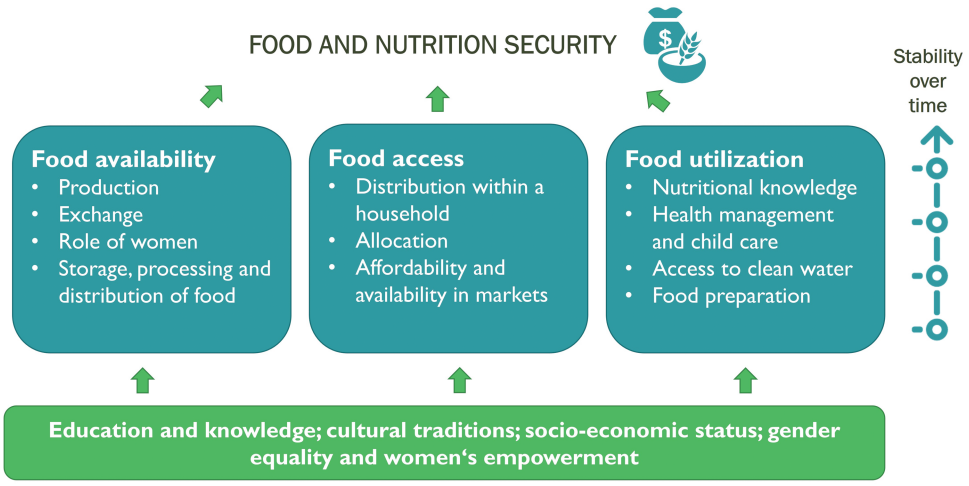

Figure 1. Major factors influencing world food security. Source: adapted from Negin et al. (2009).

commodities has been steadily increasing from 10% in 1985 to 14% in 2017 (Geyik et al., 2021). The demand for imported food products in low- and middle-income countries is increasing, with current projections anticipating an increase in their importation of major food commodities by 2–3.5 times from 2012 to 2050 (FAO, 2018b). In 2020 the demand for imported food commodities in lower-income countries made up 80% of the annual rise in the world's total food import bill (FAO, 2021a). In such an environment international trade has great potential to ensure the availability of food and nutrients where they are most needed, acting as a resilient pillar for global food and nutrition security (D'Odorico et al., 2019; Geyik et al., 2021)

The potential for the global redistribution of specific nutrients to nourish the world population has been calculated recently, with dietary protein, vitamin A, iron, vitamin B12, and zinc being the key nutrients to consider (Figure 2). Trade in animal-sourced products ideally would assist in this nutrient redistribution, given that the bioavailability of these nutrients is higher compared to plant-based foods and that diets low in animal-sourced products are often deficient in key micronutrients (Allen and Sachs, 2012).

When domestic food production is affected by shocks, including conflicts, climate extremes, and more insidiously, global warming, international trade offers an opportunity to mitigate the risks of increased yield variability and ensure collective food security across the world (Kinnunen et al., 2020). One such study for example emphasized the positive role open international trade can play in reducing the impact of the worst projected climate scenarios on global hunger (Janssens et al., 2020). This study showed that removal of trade costs by withdrawing tariffs that were in place prior to the World Trade Organisation's Doha round of trade negotiations combined with minimizing the cost for infrastructure associated with increased trade has the potential to lower the risk of hunger by an estimated 11–64% in the face of climate change. Retention of restricted trade scenarios, in contrast, is likely to increase the risk of hunger by an estimated 33–47%. In each case, the most impacted regions would be sub-Saharan Africa and South Asia (Janssens et al., 2020).

Is Trade an Effective Antidote to World Hunger?

Geyik's analysis (Geyik et al., 2021) in quantifying the impact of international food trade on nutrient adequacy of national food supplies has highlighted the limited role that international trade currently plays in meeting the nutrient gaps in most low and lower middle-income countries. Market concentration for nutrient exports is high and 80% of global nutrient trade is between high and upper middle-income countries which typically already have strong local production. Despite the inadequacy of supply in nutrients in many low and lower middle-income countries, trade flows do not necessarily move from nutrient-rich countries to fill this gap.

Additionally, when the market concentration for nutrient exporters is high as Geyik describes, particularly for vitamins A and B12, potential mitigation benefits provided by international trade are eroded. In the face of our COVID-19 pandemic induced economic down-turn, the Agricultural Commodity Price Index, as of June 15, 2021 was approximately 35% higher than in January 2020 (World Bank, 2021). The crisis has also prompted a number of countries including Russia, Ukraine, Turkey, Romania, Vietnam, and Cambodia to place export restrictions on key products to conserve their own food supplies (Laborde, 2020). Although record production and high stocks of staple grains, combined with historically low oil prices, have greatly limited the extent and impact of such export restrictions compared to the 2007–2008 food crisis (FAO, 2021d), it is nonetheless a reminder that international trade will not always function as a reliable mechanism to meet short-term nutrient gaps. Oligopolistic markets in agricultural commodities that exist in many countries also tend to amplify such export instabilities (May, 2015)

Low or lower-middle income countries bear the brunt of the impact in such crisis situations. Food and nutrient availability and stability at the national level are determined by the level

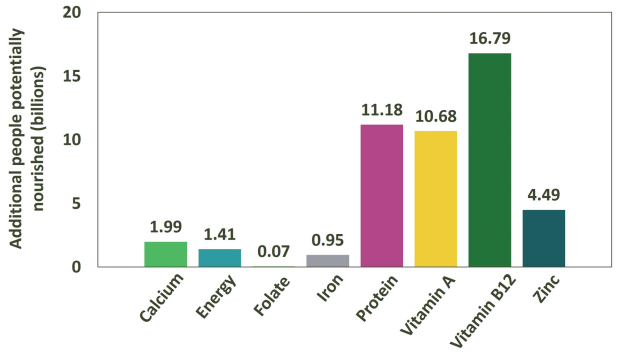

Figure 2. The number of extra people, in billions, who could be nourished if nutrients in excess of current global needs were evenly distributed. Source: Wood et al. (2018) with permission.

of domestic production or the ability of the country to pay for imports (FAO, 2018b). The capacity for low-income countries to pay for imports is increasingly challenging where the same volumes of food must be purchased at a higher cost, as is the case in 2021, and where these countries have to dedicate more of their foreign exchange reserves to pay for it: up to 90% in some instances (FAO, 2021a). Even once this food is available at the national level, poor consumers in these countries do not have the same capacity to pay more. They shoulder the burden by actually reducing the quality and quantity of the food they consume, especially nutrient-rich animal proteins and vegetables, compromising their nutrition and negatively affecting all dimensions of their quality of life (Hossain and Green, 2011).

Many studies and policy papers have been devoted to how international trade systems can be orientated towards better food and nutrition security outcomes, increasing the reliability of trade, reducing volatilities in trading systems and the risks they pose, especially for low and lower middle-income countries (HLPE, 2011; FAO, 2020b). Ultimately though, low and lower middle-income countries would be best served in pursuing a two-prong approach by coupling support for trade facilitation together with greater investments in local production of key nutrients. To ensure nutrition security such countries should take advantage of international trade. Although key nutrients can perhaps be more cheaply sourced through international trade, a reliable local supply must be developed to protect against trade disruptions. Domestic production is also subject to risks. However, by taking advantage of international trade when it suits a country's food and nutrition security goals and combining it with a stable base level of domestic production of key nutrients, a resilient and dependable supply will be better ensured.

Although investment in the resilience of domestic food supplies lies with governments, international support from donors can provide the impetus for major reform and productivity gains. The typology of food value chains divided between traditional, mixed, and modern food systems provided by the Committee on World Food Security and its guide on investment areas to maximize nutrition security in each food system is an important contribution to help in prioritizing such interventions depending on the context (HLPE, 2017). In one such example, the FAO and World Bank have funded a project to improve the productivity, market access, and resilience of Bangladeshi small-scale livestock producers and agro-entrepreneurs. The focus has been on Bangladesh's largely informal meat and dairy value chains through providing improvements in storage and cooling systems to the upgrading of slaughterhouses and collection centers. The support has extended to promoting climate-smart practices, such as improved feeding strategies, as well as animal health, food safety, and livestock insurance to protect the assets and incomes of small-scale livestock producers. Given the high proportion of women engaged in livestock rearing such a project also helps boost women's incomes, status, and access to nutrient-rich food products (FAO, 2018a).

Sustaining Domestic Food Production

The importance of investment in domestic agriculture to emerging economies is illustrated by the contribution that this sector contributes to the economic output of the country (Table 1). Given that domestic productivity in lower-income economies is dominated by smallholder farmers, investing in their resilience is important in sustaining domestic food chains and national food security. In considering government domestic investment it is important to focus on the need to meet their contractual arrangements under the agreed 17 SDGs. Sustainable diets are those diets with low environmental impacts that contribute to food and nutrition security and to a healthy life for present and future generations. They are designed to be protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable, nutritionally adequate, safe, and healthy, while optimizing natural and human resources (Burlingame and Dernini, 2010).

Investing in local production of key nutrients is also a critical part of increasing rural employment and incomes. The poorest people in countries across all regions and all levels of income are predominantly concentrated in rural and agricultural areas (Olinto et al., 2013). In low and lower middle income countries people living in rural areas are three times more likely to live in poverty compared to those in urban areas (World Bank, 2013) and the prevalence of underweight children under five years of age is worse in rural areas compared to urban environments in almost every country in the world

Table 1. The contribution of agriculture, forestry, and fishing make to countries differing in economic development: value added (% of GDP)

Country category	% of GDP
High income	1.3
Upper middle income	6.3
Middle income	8.0
Low and middle income	8.2
Lower middle income	15.0
Low income	22.1

Source: https://www.worldbank.org/en/topic/agriculture/overview

(FAO, 2015). Strategic investments in domestic food production in many contexts both strengthens availability of nutrients at the national level and also helps provide the poorest citizens the incomes needed to purchase them. An outline of key investment areas is provided in Figure 3, with the aforementioned detailed list of interventions provided by the Committee on World Food Security (HLPE, 2017).

The Role of Livestock in Meeting Global Nutrient Requirements

The potential for livestock to meeting the world's burgeoning food requirements was well articulated by Delgado et al. (1999) in their proclamation of the livestock revolution. This was characterized by a forecast of rapid worldwide increases in consumption and production of livestock products, a greater expansion in both production and consumption in low- and middle-income countries, an increase in substitution of milk and meat into the human diet, a rapid rise in the availability of cereal-based feeds and more effective use of grazing resources. Improvements in processing and transport technologies were projected to increase the contribution of animal-based foods for trading globally in integrated markets. While some of this optimism is well placed in balancing diets, the recent realization of the significant contribution that livestock play in the greenhouse gas output has added a further level of complexity to the equation. The advice of dietitians in dictating consumer food choices is also playing an important role in limiting meat consumption due to its link with a range of cancers (Huang et al., 2021) most noticeably in high-income countries, but also now in developing and transition economies. However, this report has also identified a possible role for red meat working in conjunction with the colonic biome to inhibit colon cancer (Abu-Ghazaleh et al., 2021). It is now clear that many meat consumers in high-income economies consume in excess of dietary recommendations (Leme et al., 2021).

The resilience of domestic animal industries in developing economies is important as both a source of food and nutrition security and economic development, the dairy farmers of West Africa being one important example. Since the abolition of milk production quotas in the European Union in 2015, Europe's dairy industry has been on the lookout for export markets to sell government-subsidized milk products to. The enrichment of powdered milk with up to 26% of vegetable oil has provided a nutritionally inferior but substantially cheaper product compared to pasteurized milk for communities in the developing economies of West Africa (Marks and Livingstone, 2020). Thus, for example, in Burkina Faso, a country in which salaries are mostly less than US$2,000 per year, one liter of pasteurized locally produced milk costs the equivalent of US$0.91 as compared to 0.34 for a liter of milk made from these milk powder blends (European Milk Board, 2019). Unclear labeling practices also mean consumers often have no easy way to distinguish between these products (Choplin, 2019). Given that milk consumption is increasing exponentially it is important that the government protect local producers and legislate to find an effective balance between local production and imports, ideally requiring foreign dairy companies to make substantial investments in the local dairy value chain. Alongside this, it is important that the EU and its commercial entities do not undermine its own sustainable development goals and objectives (European Commission, 2021). They should avoid the overproduction that creates adverse effects for milk producers in both Europe and West Africa and provide greater support for existing initiatives in West African countries to develop the strong potential of their local dairy sector (Choplin, 2019).

Figure 3. Key components of food chains requiring investment to sustain the availability of food in lower income countries.

Animal Production Systems: Specific Challenges

Given the importance of smallholder mixed farming systems in providing more than 30–34% of the world's food (Ricciardia et al., 2018), their financial wellbeing needs to be prioritized by governments. Their importance relates to their ability to achieve circularity and maximize the utility of nutrient inputs through feeds and fertilizer by recycling crop residues as animal feeds and manure to enrich and sequester carbon into soils and then collecting greenhouse gas for domestic household use. The excrement from 15 goats, for example, produces sufficient biogas to meet the needs of a smallholder farming family in Tanzania (Grimsby et al., 2016).

Their major needs include access to markets, a greater choice of markets; security of tenure rights and equitable access to land; access to superior yielding crop seeds, empowerment of the role of women, improvements in animal health management, encouragement in the use of local, more resistant, livestock breeds and implementation of appropriate high-quality training programs and information (HLPE, 2016).

Strategic diversification of their farming operation also provides the opportunity to increase farm income and therefore the ability to expand their food basket through direct purchase rather than relying solely on their own farm products (Nandi et al., 2021). Welthungerhilfe has had considerable success in projects promoting agroecology farming methods across India,

Bangladesh, and Nepal that aim to address many of these needs (Figure 4) (Deutsche Welthungerhilfe e.V. 2018). These farming methods have increased yields of animal and plant food products, resulting in fewer fallow periods, and with less time and space needed from smallholder farmers.

The creation of farmer cooperatives in these projects has then allowed farmers to process, certify, market, and distribute their produce together through common facility centers. The vast majority of participants have improved their incomes, with over half at least doubling them. Whereas previously farmers earned 75% of their income from crops and vegetables that depended on monsoon rains which are becoming increasingly unpredictable due to climate change, they now earn a major part of their income from livestock, poultry, aquaculture, and value-added products. The dietary diversity of female farmers who participated has also greatly improved, with 70% now eating from at least five food groups as opposed to being reliant solely on stable grains for much of the year. This improvement is particularly critical in many contexts where women tend to sacrifice their own nutrition ahead of other household members when food is scarce (CARE, 2020).

Pastoral systems are typically located in more isolated regions either in arid dry areas or mountainous regions in which grazing is seasonal and not possible in the colder winter months. More than 120 million pastoralists worldwide were identified in 2006 (Rass, 2006) with 50 million in sub-Saharan Africa, 31 million in West Asia and North Africa, 25 million in Central Asia, 10 million in South Asia, and 5 million in Central and South America. Importantly they utilize a quarter of the earth's surface area. Their success relates closely to their mobility to ensure their grazing herds are able to utilize the highest quality pasture on offer which may also coincide with their movement to terminal markets. These farmers need to cope with conflicts for land and water and a lack of government services leading to poor animal health and zoonotic disease within their families. Given these farmers are operating in fragile environments highly susceptible to climate change, it is important that they are resourced with appropriate extension services and have ready access to markets to ensure their financial security. In these marginal regions, livestock provide more food security than growing crops while the efficiency of production from low-quality forages is greater than in more intensive farming systems. In comparing the ratio of feed protein consumed to that produced from livestock, values of between 1:4 and 1:21 were achieved in the pastoral industries of India, Sudan, New Zealand, Mongolia, Ethiopia, and Kenya while much lower efficiency values of below or around 1:1 were calculated for the more intensive industries in Saudi Arabia, USA, Germany, China, the Netherlands, and Brazil (Steinfeld, 2012)

Figure 4. Smallholder farmer participant in Welthungerhilfe sustainable farming and nutrition security program in Bangladesh (Photo: Jens Grossmann, Welthungerhilfe).

This production system not only services the needs of export and domestic markets with cheaper products, it also provides a source of income for the local workforce, in particular for women. These livestock also contribute up to 20% of total draft power in these communities and manure for fertilizer and biogas production. Up to 50,000 workers are employed in meat and skin processing alone in Sudan for example in areas with limited alternative opportunities for employment (Krätli et al., 2013). These pastoralists also utilize residues from cropping enterprises that border their rangelands on an opportunistic basis. The replacement of this source of animal protein through international trade would cause major economic and social disruption in these communities.

One pastoral community which is facing extreme climate hardship are the nomadic herdsmen of the Mongolian steppe, which has been designated a hotspot of global biomass reduction, the extent of which is comparable with tropical rainforest deforestation (Liu et al., 2013). The survival of their herds of horses, sheep, goats, camels, and yaks which provide their main sources of food through self-consumption and an important source of animal-sourced products for the country as a whole is under threat (FAO, 2021b).

Similar communities which are highly reliant on meat for their dietary requirements face additional challenges. In times of meat shortages, increased prices force consumers from the lower socioeconomic sector to seek animal products of more marginal quality, forgo meat altogether, or encourage greater consumption of "bushmeats" where available. The potential for viral disease transmission such as Ebola (CDC, 2018) and COVID-19 (Trefon, 2020) with such meat is well documented. Greater demand for bushmeat also threatens the overexploitation of wildlife and loss of biodiversity (Nasi et al., 2008).

Priorities differ for intensive livestock systems in which a balance between increasing production and reducing environmental damage, including minimizing food losses and waste are paramount. Other considerations include finding alternatives to the prophylactic use of antibiotics in animal care and improving animal welfare while the challenges of balancing animal waste nutrient output with the nutrient demands of cropping to feed the animals are ever-present (HLPE, 2016). Feed conversion ratios are all important to maintain profitability and must now be achieved without the aid of hormonal growth promotants (Lean, 2013). As these systems are restricted more to advanced economies, competition from imports is less likely to disrupt their operation.

Do Animal Products Contribute Significantly to Family Food Bowls in Developing and Transitional Economies?

Ideally, governments worldwide work towards achieving a least cost-optimal nutritional diet for their population based on domestic production supplemented with strategic imports to balance the food budget for families. Yet more than 10% of the global population still live in countries at risk of hunger while up to 60% live in countries in which hidden hunger defined as micronutrient deficiency is endemic, if based solely on domestic nutrient production (Geyik et al., 2020).

Designing a country's food basket has to account not only for the basic nutrient needs of the population, but also must consider the health status of the population along with the national health budget and the environmental impact of the production system. There are many other considerations including the role of religion and ethnicity in determining consumer preferences. Increased affluence is also important as consumers change their preferences from traditional foods often based on high fiber to diets higher in refined sugars, refined fats, oils, and meats. This then has consequences for greenhouse gas production in particular with the addition of animal-based products (Tilman and Clark, 2014).

In examining the carbon footprint adjusted for nutrient balance of 66 diets collected predominantly from Europe, but with the inclusion of Peru and India, diets with high nutritional score also attracted a high sustainability (low carbon footprint) score (Gonzalez-Garcia et al., 2018). The best scoring diets were the Mediterranean and vegetarian diets while the Indian and Peruvian diets provided the lowest carbon footprints because of their focus on legumes, grains, and vegetables together with low intake of animal products. Their recommendations were the replacement of red meats with a moderate consumption of chicken and pork and then the isocaloric replacement of all meat products with quinoa and legumes, the promotion of olive oil, and the fostering of consumption of locally produced foodstuffs which minimize transport costs (Gonzalez-Garcia et al., 2018).

The analysis of food baskets in medium- and low-income countries most often takes a different approach. Some other examples of international dietary regimes and their responses to extraneous influences including climate change and the importance of trade are now compared.

Potential adjustments to the content of an ideal national food basket in Iran compared to current consumption patterns have been analyzed recently. The impact of decreasing the quantity of bread, cereal, rice, and pasta, meat, fish, eggs, legumes, and nuts together with fats, oils, sugars, and sweets and increasing cereals, poultry and vegetable oil subgroups, dairy, fruits, and vegetables was calculated. These adjustments resulted in a 14% reduction in the total water footprint, a 14% decrease in the total carbon footprint, a 23% decrease in the cost, and a 7% increase in nutrient-rich foods in the diet compared with the usual consumption (Eini-Zinab et al., 2021). It is important to note the consideration of the water footprint in this arid mountainous country and the planned reduction in some food constituents which would be core ingredients in food baskets for other countries of similar mid-range economic status. Trade with Iran is limited through international sanctions which in this case has dictated the composition of a nation's food basket.

In contrast, the implementation of an ambitious food basket program in a rural district of Kelantan, Malaysia populated by Malays, Chinese, and Indians with a minority of indigenous Orang Asli people has largely failed to combat malnutrition among children (Mas-Harithulfadhli-Agus et al., 2021). The program employed a holistic approach consisting of parental education on nutrition, food aid, immunization services, and treatment for other related diseases. Their different food baskets were designed to utilize available resources in each region. A typical basket contained noodles, full cream milk, biscuits, sardines, margarine, malt chocolate powder, and multivitamins without including any meat or meat products. After a period of 4 years with the trial, it was clear that stunting and thinness of children was still most prevalent among the indigenous Orang Asli people. Their integration into modern society, however, has removed them from their sources of traditional foods while sub-standard housing, sanitation, and education all contribute to their plight (Mas-Harithulfadhli-Agus et al., 2021). The cost and logistical difficulty of supplementing these food baskets with additional animal products in this Malaysian context would have been difficult and for cultural reasons may not have assisted the Orang Asli people. In this case trade in animal products may not have been practicable

The composition and cost of staple food baskets can be influenced by conflict. The conflict in Syria has resulted in highly variable year-on-year increases in the cost of a basic food basket, up to over 300%, while in the same period the national currency (Syrian pound) devalued by over 70%. When adjusted for the cost of staple foods the purchasing power for the consumer for wheat flour, for example, fell by 16% month on month in March 2021, but changes in price for some nutrient-dense foods in the same month varied up to 40%. The food basket used for these comparisons was based on a supply of energy to meet the international humanitarian standard of 8,800 kJ per person per day with protein and fat amounts also considered (REACH, 2021). This basket was more balanced than others including bread, bulgur, chicken, eggs, and fresh vegetables along with ghee/vegetable oil, red lentils, rice, salt, sugar, and tomato paste. The cost of these constituents to feed a family for one month, combined with other essential costs such as water, cooking fuel, and hygiene items is around 411,125 Syrian pounds or U.S.$116, well beyond the means of the average salary of 149,000 Syrian pounds (Relief Web, 2021; UNOCHA 2021). The logistical difficulties which accompany conflict limit severely the supply and distribution of perishable animal products.

In analyzing the cost of a recommended balanced food basket for South Asian populations, the variation was largely due to the cost and availability of vegetables and dairy products. Of concern was that over half of those surveyed in Pakistan and Sri Lanka spent less on food for their families than the

cost of a recommended diet. In other words, they could simply not afford the recommended nutritional diet in their context. Clearly, a diet balanced with vegetables, legumes, fruits, and animal-source foods is not affordable (Dizon and Herforth, 2018). Any policies designed to increase trade in and consumption of animal-sourced products, need to make them more affordable. The alternative is to introduce economic policies to boost incomes of poorer households, otherwise, the increased supply of these nutrient-rich foods will likely just service the needs of the more affluent minority.

The rise in global food prices in 2010–2011 resulted in some significant adjustments to dietary habits across a number of emerging economies. A careful analysis of responses to financial hardship among rural and urban or peri-urban communities in Bangladesh, Indonesia, Kenya, and Zambia has been undertaken (Hossain and Green, 2011). As the financial status of families deteriorated and food prices rose, consumers tended to adjust their diets to cheaper, bland, poorer-quality staples and off-cuts of meat cooked without oil or condiments. This was a common response across these communities with imported animal-sourced products not being considered as these were most often unaffordable.

Similar trends are found in Malawi, where more than half (51.5%) of the population live below the poverty line (CIA, 2021). Children (under 5) are most affected by imbalanced diets with 37% stunted and more than 60% anemic. Only 8% aged 6-23 months old have access to a diet meeting minimum diversity standards which needs to include sufficient iron, vitamin A, calcium, zinc, folate, vitamin B12, and animal-source protein. Poor education of consumers on nutritional principles and methods for food preparation, preservation, and storage provides an additional major limitation (Mpeketula-Soko et al., 2016).

As with other countries, family food baskets become more balanced with improved socioeconomic status in both urban and rural areas across seasons (Ruel, 2002). Food taboos imposed by cultural and religious beliefs restrict the consumption and use of certain foods in all country contexts (Forsythe et al., 2015). Eggs for example are available in areas of rural Malawi but are often avoided by pregnant women on the basis that consuming them will result in a newborn not having hair (Walters et al., 2019). Although such beliefs can often form the basis of sound nutritional advice, others, like the previous example are detrimental in an environment where many pregnant women are undernourished.

Poultry ownership, even of small flocks, can increase household access to a variety of foods by providing a commodity in the form of chicken meat or eggs for sale to cover food expenditures such as maize and other staple foods in times of scarcity (Musemwa et al., 2013).

Dark green leafy vegetables (vitamin A, calcium, iron), small, dried fish (protein, calcium, vitamin B12, zinc), liver (vitamin A, vitamin B12, and, for chicken liver, folate), fresh fish (protein and vitamin B12), pulses (folate; also the second-lowest cost food to meet iron needs), mango (vitamin A and folate), and pumpkin (vitamin A) have been identified as the most affordable foods to fill nutrient gaps in Malawi. When multiple micronutrients were considered, several of these foods (liver, small, dried fish, dark green leafy vegetables) were the most affordable. Milk, groundnuts, eggs, and beef were among the other low-cost foods included in this joint micronutrient analysis. Government policies to improve national nutritional security are focused on consumer education, domestic nutritious food production, and increasing household incomes rather than seeking nutrient-enriched foods through international trade.

In analyzing across these current or optimal food baskets only one of these reports, from Iran, took any consideration of the carbon footprint of the diet. The priority for most low-income countries is first determining the cost of diets that meet energy, protein, fat, and micronutrient requirements given the prevalence of undernutrition in these contexts. Animal-sourced foods play an important role in all these food baskets, but in an environment where there is only limited trade in nutrients to these low- and middle-income countries, the focus in most cases is on those that can be sourced through local production.

Conclusion

While projections for future increases in consumption of animal products dominated by meat and milk are positive, there are some important caveats that need to be considered in determining their role in alleviating world hunger. Even when animal-sourced foods including meat, milk, eggs, and by-products such as offal are imported into lower- and middle-income economies to alleviate nutritional deficiencies, it is often only the more affluent consumers who can afford to purchase them.

Caution must be taken in evaluating the carbon footprints of ruminant species given the rapid advances being made in feeding them to dramatically decrease greenhouse gas output by up to 90% through the use of novel dietary additives (Black et al., 2021). Nor does it consider the importance of production animals in balancing the nutrient supply of village-based communities, while servicing social needs such as providing a form of financial security, access to credit, nutrient recycling, cultural and religious doctrines, or even providing draft power when the cost of mechanization is beyond the family budget. The utility of grassland and rangeland ecosystems to support livestock production when their use for any other agricultural pursuit is impractical helps alleviate the pressure on the world's limited arable farmland resources. However, caution must be taken in relying entirely on carbon footprint estimates which are largely based on the global environmental burdens or attributions belonging to any product, a so-called attributional life cycle assessment (LCA). An estimate of how the global environmental burdens are affected by the production and use of the product, so-called consequential LCA, may better reflect the value of any product (Ekvall, 2019). This approach has recently been refined effectively to help balance the environmental equation for land use in Sweden (Martin et al., 2018).

The debate on the composition of the optimal food basket continues. There is a clear need to reduce the excessive intake

of animal-sourced foods among the more affluent sectors of high-income countries while discouraging over-consumption in rapidly expanding economies in transition. At the same time, access to high nutrient density animal foods needs to be facilitated for the poorer and undernourished consumers in all countries as part of our globalized food system (Perry and Grace, 2015).

While the trade in animal products will continue to provide nutrient-rich foods for affluent consumers worldwide, it is important to note that when serious crises occur that threaten nutrient supplies, countries with the potential to export nutrients can often opt to restrict trade to conserve the nutritional status of their own populations. Kazakhstan, for example, has ceased its sizeable export trade in wheat flour while Vietnam has suspended its important export rice contracts to cite just two examples of many (Bloomberg, 2020). Low-income countries with typically the most significant levels of undernutrition and their poorer population groups cannot absorb the higher cost of food imports that accompany such shocks.

The logical conclusion from this is that all countries across the economic spectrum from high to low-income economies should invest in the resilience of their domestic food industries to ensure a reliable supply of key nutrients, while finding an effective balance between local production and trade to mitigate risks to food and nutrition security (Figure 5). As shown in Figure 1, food and nutrition security ultimately requires stability across the three dimensions of availability, access, and utilization. Weak domestic production of key nutrients leaves low and lower middle-income countries, in particular, highly vulnerable to any shocks in international supply chains, crippling the human capital such countries need to develop the economy as a whole and shift the population to higher income levels.

International trade holds great potential for low and lower middle-income countries to ensure their food and nutrition security. But their power to shift international trade systems to deliver better and more reliable nutrition outcomes is limited.

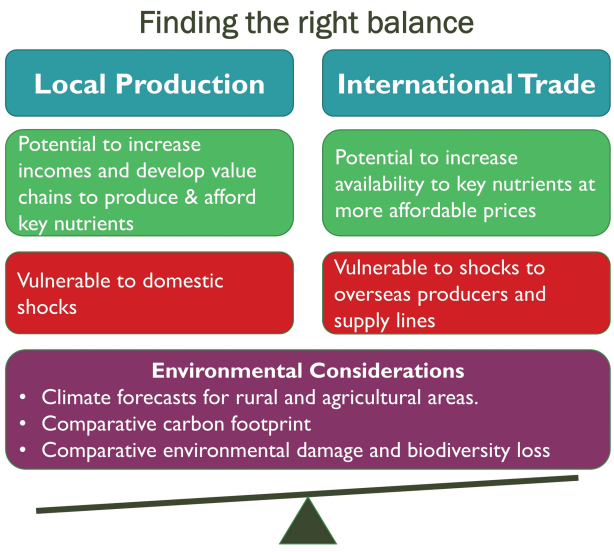

Figure 5. Finding the balance between domestic food production, the supply of nutrients through trade and environmental imperatives.

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A collective effort strongly supported by high-income countries is needed. Broadacre monocultures focusing on cereal crops together with intensive animal production systems are important in feeding the world's ever-growing population, but in most lower-income countries, the focus will remain on sustainable smallholder farming systems together with pastoral animal grazing systems. The efficiency by which we harvest nutrients and convert them into food can most effectively be achieved through the further refinement of the balance between plant and animal food production systems while sustaining our environment. The challenge remains to control the nutrient flow to service the needs of all communities across the globe: the production and trade in animal-sourced foods will need to play an important role in achieving this goal.

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