Chapter 14

Effects of Upscaling in Food Supply Chains and Changed Vulnerabilities to Disasters and Food Security

Meinhard Breiling

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CHAPTER 14

EFFECTS OF UPSCALING IN FOOD SUPPLY CHAINS AND CHANGED VULNERABILITIES TO DISASTERS AND FOOD SECURITY

Meinhard Breiling
Technology, Tourism, Landscape Interfaculty Cooperation Centre,
Technische Universität Wien, Austria

Introduction

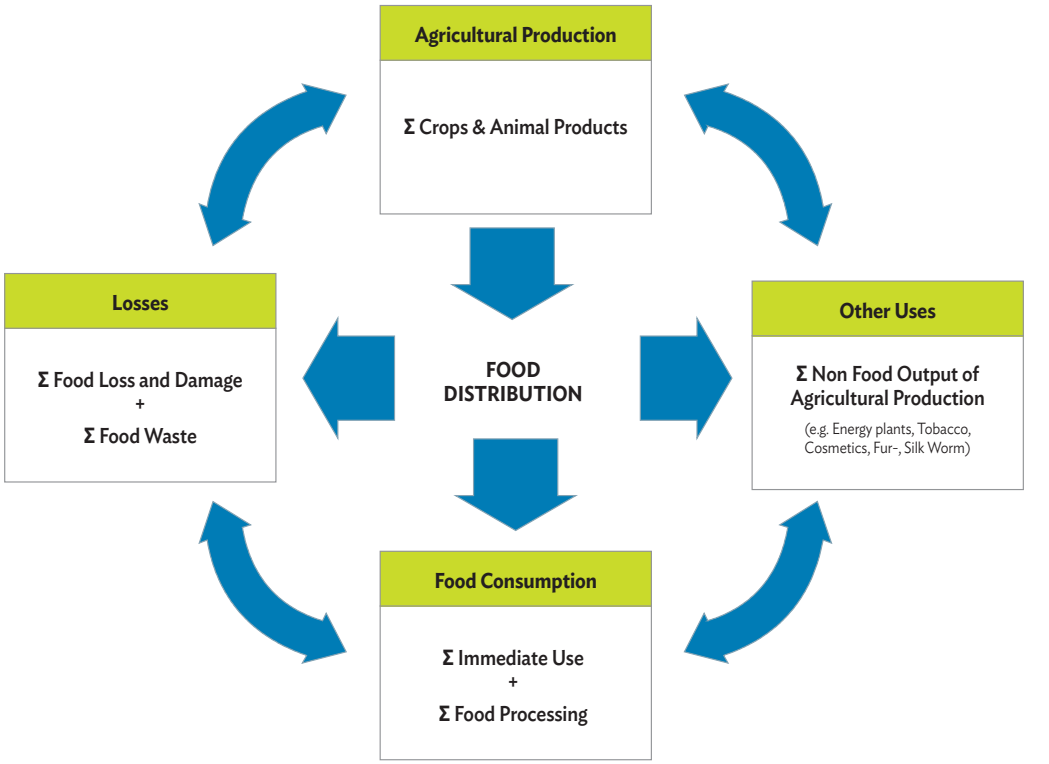
Agricultural production as the beginning and food consumption as a final output have never been more distant from each other than today. Distribution plays a central role in food security. Starting with local distribution and establishment of regional trade networks, we are now in an era of global agriculture and food trade, accelerating changes in human lifestyles and related food consumption patterns. Agricultural production includes all crops and animal products, which are considerably more than what is consumed by mankind. Along the way from source (agricultural production) to target (food consumption) are high risks and unwanted surprises. Many stakeholders are involved in the food value chain and influence the way we produce and consume food.

Climate change and increased frequencies of extreme weather events are relatively new phenomena along many old ones in the history of food security as the human population is dependent on available food. Food security also includes the important crossway between losses and other uses (Figure 1). Losses include all kinds of food failure like food waste and damage, while other uses indicate that quite a large portion of agricultural output is not considered for alimentation and is eventually in conflict with the need for food security, particularly of the poor people in the world.

The increase in disasters coincided with a 70% increase in traded agricultural goods in 2006–2016 (WTO, 2017) and a general trade increase from 12% of global gross domestic product (GDP) in 1970 to 31% of GDP in 2008 (IMF, 2009), a number that fell again to 29% of GDP in 2015 (World Bank, 2017). A high proportion of domestically produced food in the total food supply is of key concern for almost all countries despite the fact that more food is being imported. Food security is not only related to continuous success in productivity but also to safeguarding the current flow of resources, controlling

the international trade of inputs, and providing an efficient global transportation network. The global energy prices fell by 45% in 2005–2015 (WTO, 2016). When the first General Agreement on Tariffs and Trade was negotiated in the 1990s (Saylor Foundation, 2017), special exceptions for agriculture were included, e.g. an allowance to use export subsidies. This enabled countries to keep prices of farm products high in the domestic markets. Those prices, however, generated a surplus of food which was dumped on international markets through export subsidies. Thereby, agricultural producers in developing countries were forced to compete with low-priced subsidised food from the developed world.

Figure 1: The Central Role of Distribution in the Food Security System



Source: Author.

The global food security system offers flexibility and trade-offs for most people around the globe. Some 90% of global citizens enjoy food security while 10% suffer from occasional or even permanent food insecurity or hunger (International Food Policy Research Institute, 2016). Comprehensive food security has become widely possible due to a combination of inexpensive external energy, fertiliser and material inputs, and sufficient internal land and water resources. It is a declared aim of the United Nations (2015) to eradicate hunger by 2030 and that more than 97% of the global population

should become food secure within the coming 15 years. Accordingly, appropriate food production and food distribution policies should be in place to guarantee food availability for all consumers. Many ways to improve the efficiency between agricultural production and food consumption will have to be considered.

One option is to produce more food (FAO, 2013) than what can be consumed. Already today, we produce food for 10–12 billion people (Holt-Giménez et al., 2012; Tiwari, 2017). But so far, the food security system fails in distributing food accordingly to all people in need. Challenges arise in deciding how the food will be distributed amongst the people, who holds the power of distribution, and what methods should be used for distribution (Mission, 2014). Producing more food than what is necessary leads to more robustness after harvest failures in case of additional climate-induced changes (Worldwatch Institute, 2013), unexpected animal diseases, or other sorts of crises. Food price is important in the distribution system. If it is not high enough, local producers may be pushed out of business in favour of larger food producers. If it is too high, the number of poor and hungry people unable to buy sufficient food will increase. Food price fluctuations relate to petroleum prices, crop yields, food stock levels, and exchange rates (Ghanem, 2011).

A second option is to change the ratio within the agricultural production of non-food uses and food consumption in favour of the latter. For example, grains can be feed for livestock or food for humans. In 2016, 1.03 billion tonnes of grains or 136 kg for every person on earth were used as feed for animals, an increase of 8% compared to the 2012 volume (Alltech, 2017). A high percentage of meat in a society's diet can also be considered as a hidden food reserve if people would again substitute meat with cereals. In addition, vegetarian diet is considered an efficient means to cut greenhouse gas emissions from agriculture (Hedenus et al., 2014). We should further question if cereal production is a good alternative for bioethanol production. In the case of India, it is considered a viable option for marginal lands while it is deemed that it should not compete with food production in densely populated areas (Srinivasan, 2009). In total, global cereal production amounted to 2.49 billion tonnes in 2016–2017 (FAO, USDA, 2017) or 328 kg per person. Considering 200 kg as the annual minimum requirement for one person, the amount produced implies that, theoretically, 12.45 billion people could get food by the current cereal production. Similar concerns exist with regards to food oil productions and conversion to biofuel. Lam et al. (2009) investigated into the production of biodiesel based on palm oil in Malaysia and how far this option is challenging food security. At least in the near-term future, increased production of palm oil for biodiesel is no threat to food security. Compared with other oil fruits used for fuel productions, palm oil has the highest efficiency with regards to energy input and output. Yet another concern is if wide application of non-food uses of agricultural products will

increase food prices and availability. Ajanovic (2011) considers no food price increase for the second generation of biofuel plants. Also, the food-competing feed production will alter in parallel. However, even if all global agricultural harvests would be used for biofuel production, the annual transport energy demand could not be supplied with.

A third option is to minimise agricultural production losses and avoid food waste. Here, disasters-related loss and damage come in, which will be particularly considered in the further sections of this paper. On the demand side, reducing food waste can have a significant impact on the availability of food. FAO (2011) suggests that about one-third of food produced for human consumption is lost or wasted globally, which amounts to about 1.3 billion tonnes per year. Huge amounts of resources used in food production are used in vain. Related greenhouse gas emissions are also emissions in vain. The average European is wasting 179 kg of food in the value chain from the farm gate to the lunch or dinner table (Stenmarck et al., 2016). This is close to the annual consumption of a poor person mainly living on 200 kg cereals. Reducing food waste can improve the efficiency of food value chains and help improve food security.

A fourth option is to support the poorest nations with targeted food programmes. Assisting 80 million people in around 80 countries with 12 billion meals, the World Food Program, (2017) is the leading humanitarian organisation fighting hunger worldwide, delivering food assistance in emergencies, and working with communities to improve nutrition and build resilience. In the case of ASEAN countries, Myanmar and Cambodia have benefited from such programmes and, since 2000, have seen the largest percentage reductions of hunger worldwide (International Food Policy Research Institute, 2016). Some particular directions of the World Food Program include food for work, school meals, or the first 1,000 days actions. The food for work action targets repairing irrigation facilities or other infrastructure after emergencies. Some countries like India have established their own national work for food programmes for disfavoured regions. The school meals action and the first 1,000 days action are directed towards children and infants and their mothers, usually the most vulnerable individuals after disasters (WFP, 2017).

Yet another strategy is to further improve food safety and to early detect emerging food security issue. While the eating of insects in some Asian countries is common, it is entirely new in Europe. Without appropriate standards and government advice, introducing new food items seems precarious. In recent years, entrepreneurial activities have developed to introduce insects as food. Several startups have been established in the European Community, e.g. the Austrian Zirpinsekt (2017) that produces food with high protein content from grasshoppers. This led to a process within the European Community to regulate risk and safety aspects related to insect food. In 2015, considerations to introduce insects as food and feed were published by EFSA Scientific Committee.

Common standards might be published soon. Other topics to food safety are food fraud, sabotage in food industries, or terrorism, when food items are contaminated.

Relevance of Disasters on Agriculture and Food Security

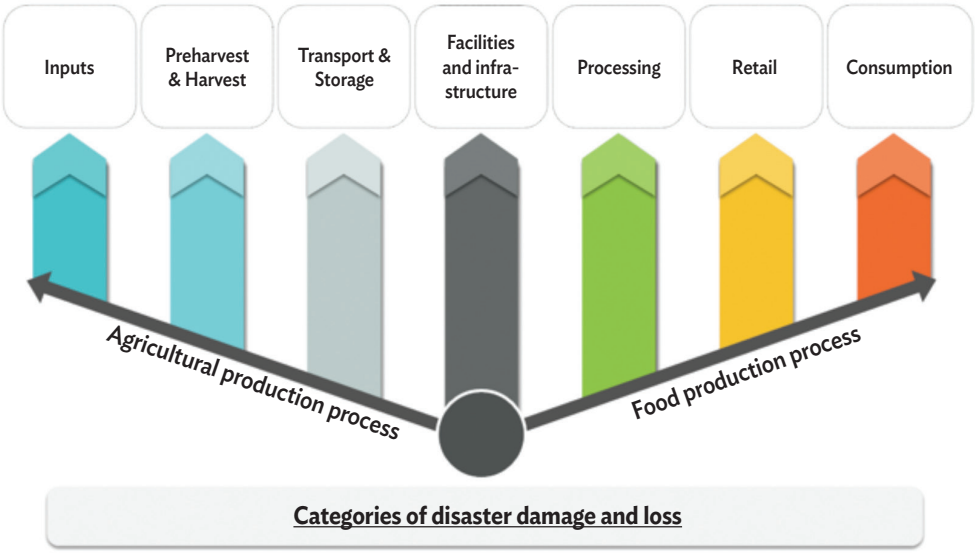
Disasters can ruin parts or entire harvests of agricultural products, hinder food distribution and food storage, and seriously impair the flow of food value chains. But there are important differences in relation to scales of disasters and food value chains. When disasters hit particular areas, we can count losses in the agricultural production, damage on food production infrastructure, or damage on transportation network. Disasters disturb the flow in the supply of certain food products and this may lead to growing disparities within regions.

Disasters hinder development as many peripheries in countries with emerging economy depend on income from cash crops. Certain areas get excluded from further development prospects when affected regions are given up and the population has to move. While parts of the world, region, or country lose profits and development potential, other regions may profit from disasters due to better prices for their products and decreased competition. In summary, more disasters mean more fluctuations, price insecurity, and difficulties in business operations. In Figure 2, we show categories of disaster loss and damage that relate to the agricultural production process or the food production process. We can differentiate harvest and pre-harvest, transport by road or sea, storage and conservation of agricultural products, and inputs to agricultural production; and distinguish facilities and infrastructure like machinery halls, irrigation systems, livestock shelters, fishing boats and equipment, landing sites, hatcheries and more, food processing technology, retail and distribution to customers; or final consumption in households, restaurants, and canteens.

The first World Conference on Disaster Risk Reduction took place in Yokohama in 1994. Of the 10 principles stated in the Yokohama strategy for a safer world (UNISDR, 1994), we do not find any reference to agriculture and food. The second conference in 2005 in Kobe came up with the Hyogo Framework for Action (UNISDR, 2005). Here, we can read that the promotion of food security is an important factor in ensuring the resilience of communities against hazards, particularly in areas prone to droughts, floods, cyclones, and other hazards that can weaken agriculture-based livelihoods. Ten years later, an updated Sendai Framework for Disaster Risk Reduction 2015–2030 was approved by the General Assembly of the United Nations as an outcome of the third World Conference on Disaster Risk Reduction in March 2015 in Sendai. Article 28b of the framework targets collaboration across global and regional mechanisms and institutions

for the implementation and coherence of instruments and tools relevant to disaster risk reduction such as those that relate to climate change, biodiversity, sustainable development, poverty eradication, environment, agriculture, health, food and nutrition, etc. (UNISDR, 2015).

Figure 2: Vulnerability of Food Value Chain to Disaster Damage



Source: Author.

A joint international methodology on how to assess disaster loss and damage in agriculture and food security is still missing (Cutter, 2017) but is likely to emerge in the next few years. Recently, the Food and Agriculture Organization (2017) came forward to lead in this issue after analysing disaster impacts in developing countries (FAO, 2015, 2016). Connected with huge food losses, natural disasters attack one or several components of the food security system: agricultural production, food production, food storage, food distribution, food durability, and more. Floods and droughts, the most common natural disasters, are primarily climate-induced. On the average, FAO counted 149 disaster events in 1980–1990 and 332 in 2004–2014. While the number of climate-related disasters more than doubled, the related damage was seven times higher. The average damage tripled with each disaster. One can expect a continuation of this trend with even more damage in the future. The total damage from these disasters in the first period was US$14 billion annually and US$100 billion annually in the second period (FAO, 2016). This is a rise of disaster damage from less than 1% (annual average in 1980–1990) to more than 3% of the total global agricultural production value (2004–2014) within one-third of a century. The situation is particularly dramatic in developing countries that are much dependent on the agricultural sector and vulnerable to droughts, in particular,

where loss and damage from medium- to large-scaled disasters already account today for a 22% loss in agricultural production (FAO, 2015).

Disasters trigger and accelerate migration primarily in developing countries (Lutz, 2013). How well countries can cope with this situation depends on internal capacities. Currently, we count 218 million or 3% of the global population touched annually by natural disasters, contributing to 65 million forcibly displaced persons and 22 million or 0.3% of the population as refugees (UNDP, 2016). Weather- and climate-related disasters are taking heavy tolls which are difficult to calculate because of under-reporting in low- and middle-income countries, particularly with regards to mortality from heatwaves. The period 1996–2015 saw 7,056 disasters recorded worldwide by EM-DAT, the Emergency Events Database, taking the lives of 1.35 million people or 68,000 deaths every year. The number of weather- and climate-related disasters (floods, storms, heatwaves) more than doubled over the past 40 years, accounting for 6,392 events in 1996–2015, up from 3,017 in 1976–1995. In comparison, the frequency of geophysical disasters (earthquakes, tsunamis, volcanic eruptions) remained constant. In total, climate-related disasters claimed more lives than those by earthquakes (CRED, 2016). The number of displacement risk due to natural disasters has quadrupled since the 1970s. This is twice the rate of population growth, which means that people are twice more likely to be displaced now than they were in the 1970s. Countries in Asia have the highest risk of displacement because a large number of vulnerable people in them are exposed to multiple natural hazards (IDMC, 2015).

The Food Scarcity Threat

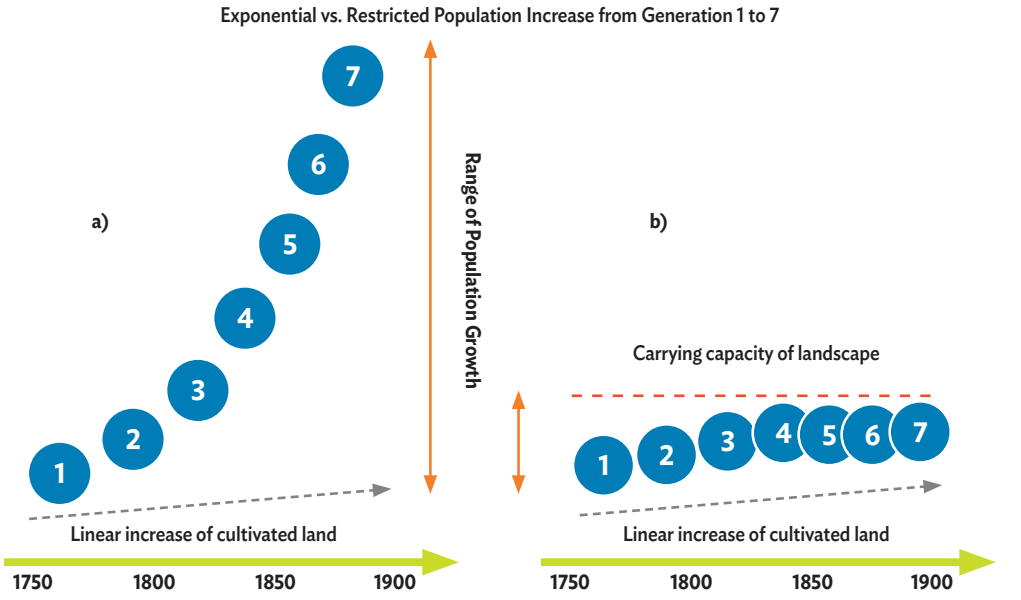
For hundreds of years, a persistent concern and theory is that human population growth would not be met by sufficient increases in agricultural production. Malthus (1798) pointed out that population doubles in a given period – the so-called exponential growth – while agricultural production only increases due to more agricultural land with linear growth at stable productivity. At that time, this meant gaining agricultural land by clearing forests. As land was limited and the possibilities of converting forest into agricultural land became gradually impossible, famine and war was a logical consequence after few generations due to reduced food supplies.

In Figure 3, the left side a) depicts an example of the exponential growth of population in a condition of limited arable land. This is typically for development in the centre of a region. We start in 1750 at generation 1. After six generations – each at 25 years average or some 150 years – the arable land has grown modestly while population has skyrocketed from the original value. Malthus intended to show his contemporaries the impossibility of

such a development and that any society sooner or later has to break down due to famine and war. In fact, his doom model was – and still is – viable for urban areas. A precondition is that enough food can be imported from adjacent rural areas.

The Malthus model was contrasted by a resource constraint theory model (Verhulst, 1838) and stabilisation function to describe the relation of population and food supply. This situation is depicted in Figure 3, right side under b) and typical for the rural area. The population cannot grow out of a certain range due to local resource constraints which define the carrying capacity of a given territory. If exceeded, the people have to migrate to other areas or suffer from scarcity, famine, and bad health, and this will limit the reproduction rate as well. An equilibrium of agricultural land area and population will, therefore, be reached before extraordinary population growth. The surplus population of rural areas has to migrate either to urban areas within the region or to new less populated regions. In Malthus and Verhulst time, many people emigrated from Europe to America and other continents. The global population increased from 679 million in 1700 to 957 million in 1800 and 1,650 million in 1900 (Demeny, 1990). For a very long time, the scale of operation was comparatively small and one was restricted to local food resources and limited interactions with the outside. Optimisations were achieved primarily from inside territories.

Figure 3: Land and Population in Dependence According to (a) Malthus and (b) Verhulst

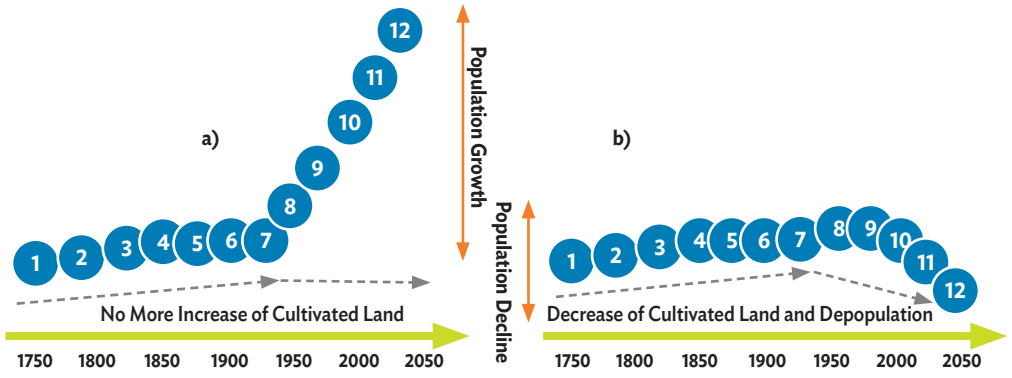


Source: Author.

In 1950, the world population was 2.5 billion people. Gradually, the resource supply region extended and more resource imports became possible, optimising the scale of interaction for larger areas. With non-local inputs like machinery and chemical fertilisers widely increasing productivity, the laws of the economy of scale could now be applied. Due to higher agricultural productivity and larger food quantities, larger territories would subsequently be regarded as food markets. Arable land was for a long time considered as the single most important asset of grain and food production (Malenbaum, 1953). Local water availability and the possibility for irrigation contributed to a first productivity increase. Traded resources like energy, fertilisers, pesticides, machinery, and more input materials became more important with easy access, allowing further growth of productivity and hence, food supply. Rural regions (as described in Figure 3b), restricted in growth up to the eighth generation, could now leave the state of equilibrium and overcome the limits imposed by the carrying capacity of the landscape. They could start an intensification process (Figure 4a), similar to the one previously projected by Malthus (Figure 3a) and become urbanised. Alternatively, they could become marginalised, less populated, or even unpopulated due to better living conditions elsewhere and the strong incentive to the population to migrate to places with more opportunities (Figure 4b). We have both a decline of population and land in use due to marginal profitability. Fields that were used under hard conditions of external resource constraints are no longer managed in the new economic context with better opportunities. The disappearance of smaller local settlements – hamlets, villages, and sometimes even towns – happens in parallel to the prospering of new regional centres and results in more 'food retreat landscapes' (later described in Figure 6) and in larger dependence from external food supply combined with further potential for additional population growth in central areas.

Figure 4: Land and Population in Verhulst Model Modified by Economies of Scale

Initial restricted population growth in generation 1 to 7 is followed by growth (a) or decline (b) variant in generation 8 to 12



Source: Author.

As of 2017, the world population was almost 7.6 billion and, using the medium growth projection, is expected to grow to 9.8 billion in 2050 and 11.2 in 2100 (UNDESA, 2017). The urban population and the rural population are currently equal if we look at the globe. But the ratio is going to change in favour of the former, which will grow to an estimated 80% in 2050. In addition, we have peak rural population in absolute numbers and we expect this number to halve until 2050.

Many limitations first expressed by Malthus and Verhulst are continuously repeated in modern context by groups of scientists such as the Club of Rome (1972), or in a report to former US president Jimmy Carter (Global 2000, 1980), the Brundtland report (WCED, 1987), the Agenda 21 of the Rio Conference 1992, the millennium development goals, or the recent 2030 Sustainable Development Goals (United Nations, 2015). The scales, however differ. While Malthus and Verhulst were considering local regions and nations, we now consider the globe as our scale of operation. Malthus and Verhulst were concerned with lack of resources; our time is more troubled by the pollution of resource use. We enjoy the benefits of global cooperation and joint exploitation at the expense of threats like climate change and more climate-induced disasters.

More ambitious and targeted frameworks to regulate climate change and greenhouse gases, such as the Kyoto Protocol (1997), failed and were substituted by less ambitious but more realistic frameworks like the Paris Agreement (2015), to reduce greenhouse gas emissions to levels that are not considered dangerous to surpass a warming threshold of 2°C. However, after achieving this milestone, the US government – the second largest greenhouse gas emitter – expressed its desire to withdraw from this treaty (New York Times, 2017). The regulation of global climate as one of the most important parts of sustainable development remains uncertain.

Contrary to all efforts in managing or regulating scarce resources, the current practice is that agricultural production and food consumption have never had a larger volume than today. The number of people being victims of hunger has fallen from more than one billion to less than 800 million (FAO/IFAD/WFP, 2015). The supply of food has increased proportionally, fuelled by resource- and capital-intensive agriculture, continuing application of biological/genetic science to food production, greater ability to save crops from pests, and greater ability to preserve perishable products during transport. Here, the advantage of the economies of scale applies.

The Case of Austria

Like other industrialised countries, Austria can now enjoy an unknown variety of foods. This process from mainly local food supply to regional and finally global food supply was not straightforward but took time over several generations and included changes in food policy and strategy.

Looking back to the times before Malthus and Verhulst, the territory of Austria, with 84,000 sq km, could hardly feed its 2 million people that were in the 18th century living within its borders. Major famine periods were reported in 1709, 1770, and 1772 (Linsboth, 2017). Some 80% of the population were working in agriculture, struggling hard to gain the needed food from their land. There were frequent periods of famine, often leading to armed conflicts and migration to other parts of the empire in Southeast Europe.

During its industrialisation at the second half of the 19th century, Austria's population and urban areas were growing fast. Hunger was particularly a problem for poorer, mainly working-class people. This contributed to major instabilities and difficult political situations that ended up in two world wars. Just 100 years or four generations ago, food supply was uncertain for the 2 million people of Vienna. In 1904, the local government started to provide small allotments of gardens of 200 sq m–600 sq m – the so called Kleingärten – for the working-class people. Thousands of Viennese families started growing vegetables and fruit trees within the borders of the city and the risk of famine and riots was substantially reduced. In particular, during the war in 1916 and 1917, when major regional distribution channels were not working, these gardens were the source of local food production and survival (Autengruber, 2018).

Today, 8.8 million people live in the same territory, perfectly served with great and diverse supply of food. Tropical fruits or food items out of their usual season, fresh seafood, and more are now offered throughout the year not only in Vienna but even in smaller towns in the countryside. The country could possibly provide food to 20 million people despite having no changes in its local resource base.

In less than 12 generations from 1750 to the present, the capacity to feed people in Vienna increased 10 times. In addition, the food has higher quality and is continuously available. What has changed is the global resource availability due to international trade, access to capital previously unavailable, a sharp decrease in transportation cost, and the resulting possibility to import and export more kinds of foods in different qualities and larger quantities from various countries. In addition, less land is needed; marginal agricultural fields are again afforested.

In 1990 and 2010, more than 2000 sq km or 2.5% of the total land area or 6% of the agricultural land area in Austria were afforested (A M AF E, 2015). About 1.5% of the Austrian land area was converted to building land, thus supporting the wish of many Austrians to move out from the city centre to the rural fringe. The Austrian society has got used to full food stores where a diversity of food is inexpensively available. The necessity of yore of the non-farming population to produce food has turned into a hobby of producing one´s own food. Many people now use their gardens more for recreation and less for fruit and vegetable cultivation as two generations before them did. Sometimes, fruits are not even harvested as the owners are busy with more profitable tasks than gardening. This indicates a radical change within both the society and the food support system.

Endogenous population growth like those in ASEAN countries with currently 639 million people (2016) is not happening in Austria or in the EU with currently 512 million people. It happened in 1850 and 1970 when the fertility rate was well over two and much over simple reproduction rate. It is 1.47 at present (2015) and is principally in a situation of decline. However, Austria is an attractive immigration or refuge country and its population growth continues. A lot of periphery sub-regions, however, have depopulation. Mostly in these remote areas, people have fewer services and less sophisticated food offer.

There was the incentive before to open up to a much larger and wider food market and impetus to further changes. Due to the importance of tourism – economically three times more important than agriculture – the former preference on agricultural productivity has changed to preference for tourists (Breiling, 2006). Before, a beautiful landscape was a byproduct of agricultural activity. It is now the main product. Landscape maintenance is a precondition for modern mass tourism. A healthy, ecologically well-functioning landscape is not only the source of tourism revenues but also a means to cope better with disaster risks.

The Case in ASEAN Countries

Also, in principle, ASEAN countries follow a similar development pattern like that of Austria's in a Malthus or Verhulst model of the 19th century, but this is not directly correlated in time but cross-correlated with some two or three generations difference. Due to technological development, better global infrastructure, considerably more capital, and international trade, hunger seems to have been eradicated in Austria like in many other countries within the EU. This is not yet the case in ASEAN, but might be in the near future if one follows the trend in Table 1.

Table 1: Food Insecurity Over Time Based on Global Hunger Index

Rank GHI	Country	1992	2000	2008	2017
best 14	Lithuania		5,9	<5	<5
best 14	Latvia		6,7	<5	<5
best 14	Estonia		6,2	<5	<5
15	Romania	9,3	8,7	6	5,2
18	Bulgaria	7,9	8,2	7,6	5,4
44	Malaysia	19,8	15,5	13,7	10,2
46	Thailand	25,8	18,1	12,0	10,2
64	Viet Nam	40,2	28,6	21,6	16,0
68	Philippines	30,5	25,9	20,2	20,0
72	Indonesia	35,0	25,5	28,3	22,0
75	Cambodia	45,8	43,6	27,1	22,2
77	Myanmar	55,6	43,6	30,1	22,6
91	Lao PDR	52,3	48,1	33,4	27,5

Lao PDR = Lao People's Democratic Republic.

Note: Global Hunger Index Scores out of 119 observed countries.

Source: Welthungerhilfe WHH, International Food Policy Research Institute IFPRI, Concern Worldwide CW, 2017.

A current indicator on food security is the Global Hunger Index where 119 countries are regularly monitored. Within the EU, considerable differences in economic development exist between member countries as new member countries – Bulgaria and Romania, formerly part of the centrally planned economy – have recently (2007) entered and require adjustments. This is similar to ASEAN countries where countries like Cambodia, Lao PDR, or Myanmar also root in systems with centrally planned economies.

More diverse than the 28 EU countries, the ASEAN countries have higher risk of hunger and are more exposed to natural disasters. Their economic progress and development of regional food chains and, partly, participation in global food chains are beneficial in terms of food security. The Global Hunger Index of the East and the Southeast Asian region fell by 57% in 1992 and 2016 (WHH/IFPRI/CW, 2017). This is remarkable considering that the region was most severely hit by disasters during this period.

The group of poorest countries has yet to establish a sophisticated food processing and food distribution network. A high number in agricultural income is also associated with low national income. Many people produce food through subsistence agriculture using almost entirely local resources and human or animal labour input. Most of the food is eaten by locals and is not generating income, profits, or balance sheets. These countries are not very attractive for expanding the global food value chain as the required parts

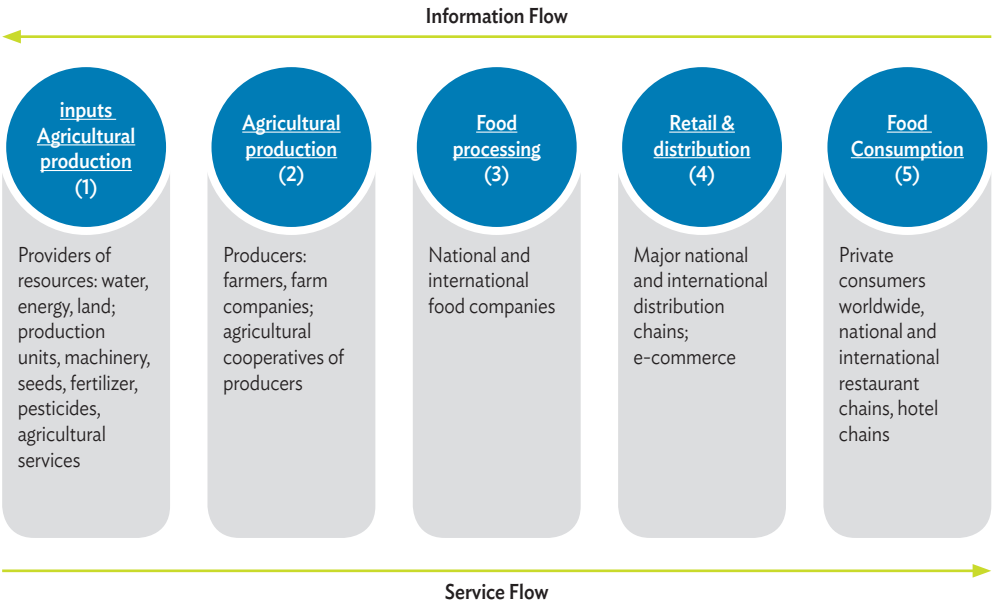
for food supply and demand chains like electricity networks, cooling facilities, fast transportation networks, etc. are lacking infrastructure and capital for investments.

Within ASEAN, five countries – Lao PDR, Myanmar, Cambodia, Indonesia, and the Philippines – had serious, alarming GHI scores, with more than one-fifth of their population partly food insecure in 2017. Viet Nam showed the best progress within one generation, reducing its percentage of food insecure people from over 40% in 1992 to 16% in 2017. Malaysia and Thailand are somehow global average in the risk to become food insecure. This risk does not exist in the richest countries of ASEAN; Singapore would be an excellent performer and Brunei Darussalam a good one in the ranking of EU countries.

The Food Supply Chain

Food consumption is the end of a production chain. In Figure 5, we divided the food supply chain into the following groups of stakeholders: (1) those providing inputs to agricultural production, (2) the producers of agricultural output, (3) the food processing industry, (4) the retail and distribution organisations, and the (5) food consumers.

Figure 5: Actors in the Food Supply Chain



Source: Author.

The first group are stakeholders that relate to agricultural inputs. Any agricultural production is dependent on inputs. We need the provision of basic resources such as farmland with some 1.5 billion ha globally, the right amount of water resources, and

energy in various forms such as gasoline and electricity. Then we need particular inputs such as seeds, fertilisers, pesticides, machinery, and production units like greenhouses, storage halls, and other built environment. Finally, we can name agricultural research and services as an input class. During the last decade after the financial crisis in 2008, farmland became an important post of speculation. Since then, every year, at least 10 million ha are sold from family farms to institutional investors at approximately US$500 per hectare (based on Deloitte, 2013). Climate-induced water problems challenge agricultural production and more frequent droughts and floods have increased price levels for agricultural commodities. Unpredictable price levels of energy may further aggravate the situation. Progress in agricultural research – like introduction of drought-resistant wheat varieties – allows countering some of the new threats. Decreased levels of fertilisers and pesticides due to precision farming allow important reductions in inputs. The development in smart farming may offer important new possibilities of even lower resource input.

To the second group belong producers that deal with growing agricultural crops and breeding animals. The global producers comprise 100 million mainly small family farm units often organised in cooperatives, and few large agricultural production units. They represent the core of agricultural production. The long-lasting trend is of smaller farms being bought up by larger, more profitable agricultural units, and the constantly decreasing number of producers. Still, for many farms, the current farm structure is considered too small as to run profitably. Usually, developed states support their farmers with product, production, or environment-improvement subsidies to keep them economically alive. Many poor countries cannot support their farmers in a similar way. Here, the production base is challenged due to lack of capital to compensate for the threats of land and soil degradation or more frequent water scarcity. Wu et al. (2012) report on the introduction of genetically modified organism in developing countries to make crops more durable, and avoiding post-harvest food losses, which can be as high as 50%, by introducing small silos, appropriate transport, refrigeration, and storage facilities.

The third group of stakeholders deals with food processing which is organised in many national and international food companies. So far, food processing is of regional extent but is now getting global. More food companies are merging or trying to buy each other to encourage synergies in cheaper production for a worldwide market. In February 2017, the US food giant Kraft Heinz attempted to buy Unilever, its competitor from Britain/Netherlands, for US$143 billion (Hughes and Felsted, 2017). This would have been the largest food company takeover ever in history. Just two years ago, the Swiss-based Nestle, the world´s largest food processing company, tried to buy Heinz but the deal failed. Instead, Kraft and the Brazilian 3G investment companies bought Heinz and founded Kraft Heinz Co., now the fifth largest food company in the world. We can expect further

moves in food companies that try to reduce costs by becoming larger multinational companies and overtaking each other, thereby reducing the number of players.

Retail and distribution chains form the fourth group of stakeholders. Distribution is the key issue for global food chains as the production capacity today is high enough to produce food for some 12 billion people, although it cannot be distributed to all people who need it. The global food retail industry has been experiencing steady growth in the last couple of years. In 2016, the highest growth in merchandise trade was achieved by agricultural products, which increased by 67% in value (WTO, 2017). The global food retail industry accounted for US$7 trillion annual sales or 8% of global GDP in 2016, which was more than twice the value of global agricultural production amounting to US$3.2 trillion. The top 15 global supermarket companies account for more than 30% of world supermarket sales. With improved technologies and economies of scale, these retailers enjoy operating cost advantages over smaller local retailers (USDA, 2017). With a marked change in consumer preference, online shopping, rising populations, and an increase in purchasing power in emerging markets, the global food retail industry continues to grow. The entry of global food giants in emerging economies has led to a boom in the food retail sectors of these markets. China and India, in particular, are driving rapid growth in the global food retail industry as Asia-Pacific remains the largest market for food retail globally. Indonesia and Thailand are also witnessing excellent growth as modernisation of traditional outlets is taking place. Meanwhile, food retail markets in Europe, particularly Western Europe, are thought to have already reached a saturation point. Italy, Spain, Denmark, France, and Greece are in fact seeing a decline in their food retail industries. Recently, food delivery chains like Foodora and UberEat celebrated success and expansion by delivering restaurant-type food directly to offices and homes (Nicola, 2016).

The consumers constitute the final group of stakeholders. The value of food consumption continually increases; people eat in restaurants, canteens, food stalls, private households, etc. Consumer preferences lead to changes in food consumption pattern which widely depends on disposable income, education, food availability, and other factors. Beside price, high on the agenda of food consumers are freshness, quality, customer service, and shopping experience. Very often, countries do not only have a single food market but several markets for different consumer types. In Europe and the US, for instance, organic, green, or sustainable food is high on the agenda, while in other countries, high quality might be sufficient in buying food items. As an example of the increasing complexity in food items from the EU, three classes of eggs currently fulfil hygienic quality criteria but of different ethical standards. The fourth class of eggs – with the worst ethical standard but nevertheless an appropriate hygienic standard – are eggs from cage breeding. This method was banned by the EU but is still used outside the region (Utopia, 2017). In

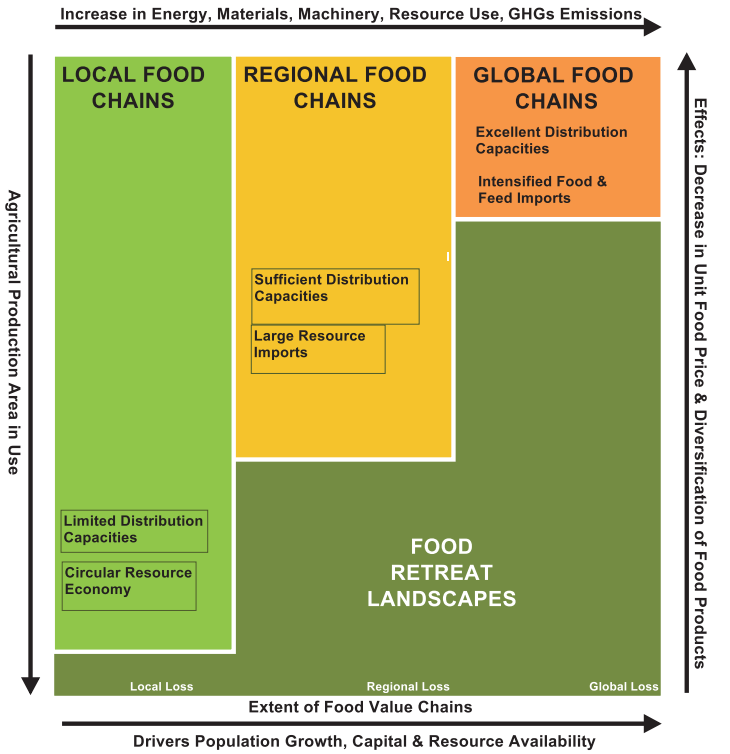
ASEAN countries, there is particular concern regarding certified food for religious groups, like halal food, that differ from organic food criteria.

Operational efficiency, food waste management, a high degree of control towards nutrition norms, gaining technical expertise on data management, and innovative packaging solutions are additional focus areas (Frost and Sullivan, 2017). Yet, the question arises as to whether this process of improvement can continue to meet the needs of all people in mature economies. There now exist the so-called food deserts (Cutter, 2017), where particular sections of the population have no access to adequate or high-quality food in otherwise wealthy countries. In the US, individuals spending less than US$5 a day on food are considered to be at risk of food insecurity as they lack access to healthy and affordable food. Other parts of the population living in scarcely populated areas do not have access to supermarkets where most food is traded. Some 7% of the US population is affected. We can assume that considerably more people in ASEAN countries do not have adequate access to healthy food.

Growing Distance, Capacities, and Resource Demand in Food Chains

The scaling up agricultural production networks and food supply chains are visualised in Figure 6 with global, regional, and local food chains. We consider that distribution gets a more important role. At the beginning, in the circular economy of subsistence agriculture, the produced food is often directly consumed at the local spot. More sophisticated agricultural production, food distribution, and consumption are emerging at regional scale. Finally, we reach a global exchange food system. The distance between agricultural production, food processing, and food consumption can become very wide and food components may travel several times around the globe. It is further perceived that the local, regional, and global food systems exist in parallel and complement – or even overcomplement – each other. More space efficient, the local food system can reach periphery places inaccessible to regional and global food systems where poor people find place for subsistence agriculture. They still follow local resource economy traditions and can cultivate food according to the given carrying capacity of the landscape without major inputs from the outside. The global food systems provide more food output based on highly industrialised agriculture, thereby making major global centres better connected. This leads to population densities many times higher than what any dense net of local food systems could provide. They are dependent on huge capital investments and secure supply of external resources. The regional food system is in between local and global food systems.

Figure 6: Food Distribution Upscaling from Local to Global



Source: Author.

As Figure 6 shows, in traditional economies represented by local food chains, food production and food consumption are identical or very close to each other. There is only one stakeholder – the peasant family – who combines all steps described in the food supply chain: providing inputs to production in the form of human and animal manure, required hand and animal work for agricultural production, processing and storing of food, distribution between family members, and finally, eating food. These economies are widely based on local circular resource flows and subsistence agriculture and include methods entirely dependent on local resource base such as shifting cultivation or agro-forestry practices. The number of foods is limited to the availability of local foods which can vary from place to place. No or little money is needed to make a living in modest circumstances. Often, these systems were stable for centuries, but as population or financial expectations increase, they no longer suffice for the needs of larger population groups.

Increasingly, more food has to be imported and gradually, the situation symbolised in regional food chains (Figure 6) emerges. Food trade becomes more important. The capacity adjusts to higher volumes of the regional scale and increasingly more kinds of food are regionally available. In past decades since industrialisation, food production and food

trade networks could grow according to regional or national possibilities. Regional dishes such as pizza in Italy/Europe or sushi in Japan/East Asia have developed dependence on regional interactions. Every region was for long time only sticking to endogenous food traditions simply because of no or limited interaction with the outside. The regional food supply chain has many more stakeholders. Specialisation in the food chain takes place according to managing inputs, agricultural production, food processing, retail, and consumption. Capital is needed to promote this specialisation that leads to higher capacities. The resource flows are increasing as well. Water availability for irrigation of agricultural fields is a way to boost agricultural productivity and, accordingly, population growth.

A few out of regional networks are developing into global food chains (Figure 6,) with huge international food production and trade networks and are represented by major global companies. They incorporate other regional networks under their umbrella and become more important by cooperating with, buying, or merging with their competitors. Large holdings enable global food availability over different climate and production zones of every state and region that is wealthy enough to import food. The transition from regional to global follows the economy of scale. As with global, once the largest possible scale is reached, other means to alter the food value chain are needed. This means more differentiations in conventional food items and invention of new food items, e.g. energy drinks, or differentiation of known food items into quality categories.

But more energy will be needed to fuel the growth of global food chain. This will lead to additional greenhouse gases in the atmosphere and, accordingly, to more severe climate change. The International Panel on Climate Change (2014) cited research 'that food accounts for the largest share of consumption-based GHGs with nearly 20% of the global carbon footprint, followed by housing, mobility, services, manufactured products, and construction'. This, in turn, can cause more climate-related disasters and even higher damage than what we are used to in relation to current disasters. The direct greenhouse gases from global agriculture – which also includes nonfood agricultural production – are 12% (IPCC, 2007). However, the indirect load of GHGs, including inputs to agricultural production, is much higher. In the case of Japanese rice production, direct agricultural emissions were calculated to be 40% of total emissions within the production process in 1990 (Breiling et al., 2005). The remaining 60% came from secondary emissions related to industrial inputs of rice production such as agricultural machinery, chemical fertiliser or pesticide inputs, and transportation. Analogous to this, and in expectation for a targeted study to cite, we can hypothesise that the global food chain and all inputs to global agriculture contribute between one-third up to half of the carbon footprint of climate change.

Figure 6 also depicts the so called 'food retreat landscapes', also previously described in Figure 4b, indicating that with increasing spatial scales, technical progress, and resource inputs, less land is needed to produce sufficient food for an increasing global population. The distance of agricultural land to markets and food streams (von Thünen, 1842) becomes more important. In the times of Malthus and Verhulst (Figure 3), the entire land was used for food production and a food retreat landscape did not exist. The world was just covered with a web of independent smaller-scale food supply chains with limited interactions. Humans were fighting so as not to exceed the given carrying capacity of the landscape which was the limiting factor. The world population doubled during the 1750s to the 1900s from 0.8 billion to 1.7 billion (Durand, 1977). Up to a few decades ago, increasing agricultural land from converted forest land was the sole means to increase food productivity (Malenbaum, 1953). With increasing affluence brought upon by the developing regional and global food chains, some, many, or most food items now are imported. In particular, agricultural fields that are difficult to manage are given up first or afforested. Gradually, more land is taken out of food production due to limitations in increasing productivity. Finally, only the most suited easy-to-cultivate landscapes targeted for regional and global markets are used for food production. In a local system, the share of food retreat landscapes is small. In a regional system, this is considerably larger. In a global system, large parts of former food production areas are converted to other purposes such as for bioenergy, afforestation, or ecosystem service without an impact on food supply levels and despite population growth.

Change of Disaster Risk and Food Security Strategies in ASEAN

Development in Peripheral, Small, and Remote Local Areas

Disasters bring the worst impact on poor countries with traditional economy where ordinary people have no flexibility against disasters. The variety of food in a region relates to its climate and is considerably lower than in countries with large food imports. With every disaster, these countries become more dependent on international aid and relief programmes. Decision-making within the country becomes more limited after disasters. There is a firm connection between environmental and ecosystem management, climate change adaptation, and disaster risk reduction (Munang et al., 2013). This is particularly true at local scale. Attributing a single hazard event or specific losses to climate change is still difficult due to the relevance of different spatial and temporal scales (Birkmann and von Teichman, 2010). Over time, there can be reactions to the larger regional or even – assumingly – very robust global scale. How much time this can take depends on frequency of disasters and preparedness to counter them.

At the local level, natural disasters have much more disturbing consequences. Very often, a disaster means additional weakening of an already weak local society or, in an extreme, a collapse of local villages. Local people mainly rely on ties and support of family members. These ties are disturbed when children migrate. Sometimes, local people do not trust local governments or public authorities to positively influence their fate. Anyhow, many small villages are on the way to be given up when old and weak people are the ones primarily inhabiting them. A drought or flood might be seen as only the last step in a series of decline processes. Thus, many natural disasters in remote locations are not reported as they are not dramatic enough to find their way into the news. They can be a further stimulus for younger inhabitants to migrate for better future.

Development in Regional Centres

At the regional or national level, we observe that an increase in disasters and even higher increase in loss and damage due to disasters are widely balanced by increase in GDP and enlarged food trading possibilities. We can postpone adverse effects of local disasters up to a point when several local disaster areas become a larger regional disaster area. A local disaster is regionally relevant if it affects particular strategic nodes of the regional food value chain. Better access to more foods and more variety of food in regional centres can be an important stimulus for migration to well-supplied areas. The loss of young population, in turn, reduces the local food production capacity and disaster resilience.

The dynamics of general development indicators and frequency of disasters are important. As long as GDP and international trade growth rates are higher than the increase rate of disasters, the challenge of food security in relation to disasters can be addressed. Sudden changes in resource availability – oil price shocks, for instance – can eventually be more problematic than anticipated increase in climate-induced disasters. In Vienna, smart farms producing paprika or cucumbers in indoor environments have long-term contracts with the local government that ensure fixed energy prices. Water scarcity induced or aggravated by droughts, infiltration of salt water, and high price of water can become a serious hindrance for irrigation. The current prices might not last in a timeframe of 10 or more years and food producers should have emergency plans with some alternatives to cope with such a development.

Wars and serious political crises could change the effects of disasters and food security. While droughts or floods have perhaps limited consequences in peaceful conditions, e.g. damaged infrastructure can be replaced easily in a normal trade situation, the situation can become catastrophic when there are trade restrictions. South Sudan experienced serious droughts in 2011, 2015, and 2016 amidst a civil war (Reliefweb,

2016). Agricultural production was disturbed and coincided with repeated droughts and extremely limited trading possibilities. Up to 5 million people, about half of the country's population, were severely food insecure leading to the starvation of an estimated 30,000 people. In the 1990s, North Korea experienced not only food insecurity but dramatic famine after flooding episodes in combination with the breakdown of trade connections with former partner countries (Lee, 2006).

Development on Global Scale

If a global food value chain and distribution is established – usually intensive flows in between the richer countries and regions – it would initially seem very robust. Disasters are not critical as long as regional food failures can be balanced by food trade on global scale. If important parts of harvest, e.g. coffee, tea, or spices, are destroyed by a disaster, prices will increase and, based on price increases, fewer people can afford to consume food products or people have to reduce frequency in their food consumption. Today, this relates to luxury food products and not to essential commodities like rice, wheat, or corn. There is flexibility here as much of these products are consumed as animal fodder or even used for fuel production. It would take many consecutive large disasters before a major food crisis will be felt in central areas of wealthy countries.

One most important millennium development goal for 2030 is eradicating hunger nothwithstanding global increase in climate-induced disasters (United Nations, 2015). The number of food insecure people has to fall under 3% to reach this goal. Currently, 10% of mankind are food insecure. With the upscaling of food value chains and increase in food trade, this aim is feasible. Out of all ASEAN countries, Lao PDR, in 2017, had 27% of food-insecure people, the highest in the Global Hunger Index (WHH/IFPRI/CW, 2017).

Change of Disaster Risk Strategies in ASEAN

Extreme disruptions in the food supply systems of ASEAN countries are currently not in view. ASEAN countries are intensifying regional cooperation and increasing trade volumes (ASEAN, 2016), which are good for regional food security and disaster resilience. Anyhow, severe conflicts in combination with disaster events can lead to serious situations. The Moro conflict in Southern Philippines, for example, can hinder relief brigades and food distribution efforts after disasters in a way similar to the one described above.

ASEAN countries differ largely in economic performance and disaster risk reduction potential. GDP can be an easy indicator. One Singaporean has almost 50 times the income of a person from Myanmar. The ASEAN countries with very high per capita GDP are Singapore and Brunei Darussalam, with about six and three times the average global per capita GDP, respectively, at their disposal. These countries are primarily importers from the global food market. After them follow Malaysia, Thailand, Viet Nam, Indonesia, and the Philippines with average to half of average of the global GDP. They contribute with imports and exports to global food markets. In these countries, larger groups of the population can participate in the global food chain, while the majority are still more bound to local and regional food chains. Lao PDR, Cambodia, and Myanmar, with low GDP and less than a quarter of the global per capita GDP, have difficulties in participating in the global food market as consumers but consider a global market for their products.

The economic differences and resulting ratios in the mix of local, regional, or global food chain participation enforce different disaster risk and food security strategies for ASEAN food producers. All ASEAN countries have producers in the local, regional, and global food chains, but the ratio is varied. Many consumers are still dependent on local production but the shares of regional and global food products are increasing.

We will find different strategies for local, regional and global food chains. ASEAN countries may compose their national strategy according to the dominant food chain or a combination of them.

- In case of local food chains: Have a regular and continued food supply with locally available agricultural crops and traditional farm animals. Employ organic farming methods or agro-forestry methods to manage local resources, soil, and water in the best possible way so that high and sustainable yields and improved local disaster resilience can be expected in coming years. Organic farming methods will further inhibit soil erosion and increase local production base. Keep the water in the landscape and avoid fast runoff. Ensure better local food storage capacities by building small silos, provide natural cooling by exposure to wind, use local resources like salt in coastal regions or smoke conservation in mountain region to save food resources. These will increase local resilience and are means to counter an increased frequency of climate disasters.
- In case of regional food chains: Produce more food at cheaper production costs with less resources used per product unit. Increase transportation and storage capacities for a timely exchange between sub-markets and remote food production networks within the region. Ensure appropriate food safety and control standards. Minimise use of chemical fertilisers and pesticides. Make emergency disaster food supply plans for all settlements. Support poor urban families with some land for small gardens to

allow them to produce their own food. Care for local agricultural production in remote areas to avoid fast migration to urban areas in case of more disasters. This can, in turn, also challenge the state of regional disaster resilience. Organise food quality labels, like for organic food or halal food. Provide hazard zone maps to identify the most vulnerable landscapes.

- In case of global food chains: Avoid planning business in disaster-prone areas. Ensure distribution capacities and their robustness against disasters. Limit resource inputs and be more efficient with available resources. Diversify from established food products or develop products to different levels of sophistication, like it is today with organic coffee or cocoa. Proofed disaster resilience of particular crop and food varieties will be an extra merit and is suited to postpone adverse impacts. Find a better mix of food diet for new target groups on the global market, considering that food tastes and food needs are different. Ensure supply in extraordinary quality and sufficient quantity. Target combined food quality and disaster resilience criteria. Try to meet the food standards of the strictest, most sophisticated, and difficult world regions.

Conclusions

Food security depends on food distribution. Already, more food is produced than what is needed. But poor people do not generate a market and producing more food does not help the food-insecure people. Instead, food becomes feed for animals or fuel for machines. Food waste is another serious issue amounting to one-third of the food produced. An improved food health standard and differentiation of food products might challenge a lot of food producers in emerging economies if they intend to sell on the global food market.

Loss and damage due to disasters in agriculture and food value chains are not yet systematically accounted for. It is possible to differ between harvest, transport, storage, facilities and infrastructure, processing, retail, and consumption loss and damage. In poor nations, losses on the production side are much higher than those in rich nations and account for more than 20% of the annual harvest value. This damage could be even higher due to underreporting.

The role of land or soil – historically the single most important resource of food production – is becoming less pronounced. Access to external resources, like water, energy, minerals, and capital, allows production to exceed land's former local carrying capacity, thus giving way to more pollution and climate change. Out of some 10 billion tonnes of global freight traffic annually, almost 40% are related to agriculture and food. Some 20% of greenhouse gases are attributed to food consumption. Much of the 1.5

billion ha lands get marginalised and are transferred to non-food uses. The best suited lands are used for more intense agriculture and food production.

Within the global food chain, production depends on several groups. Inputs became cheaper during the last decade as global energy prices decreased by 45%. In particular, new food industries were established in emerging economies. Players in the global food chains are getting fewer and larger. Many family farms are being bought up by industrial investors. Large multinational food companies are buying up competitors and record-high business transactions are just happening in the food businesses. Food distribution is changing; new forms of retail are emerging from online food orders to offices. Consumers are becoming more demanding and, beside hygienic standards, ethical standards in animal breeding are also being asked for.

Food chains are scaling up, with larger global food chains coming into existence. This is gradually changing human interactions and settlement structures. People are living more densely and food retreat landscapes are emerging in remote areas. Optimisation of food production for global markets and access to regional and global food flows are important drivers for this densification. Global food chains need sufficient distributional capacities in both directions. Specialisation in food niche products allow intensification for future growth areas.

In emerging economies, local areas are developing intensified trade of agricultural commodities and food products on a regional basis. Companies of national and regional importance are being established. Flow of resource is being multiplied by orders of magnitude and capital is being generated to develop infrastructure with higher capacities. In addition, there exist major regional disparities within these countries. Some parts of the countries – usually the capitals or large cities – are considerably more developed than others, and several systems of agricultural production and food consumption exist in parallel. Rich parts of population can participate in global food value chain operations while others cannot.

In principle, in countries with mature economy, people participate in global food consumption. Singapore and Brunei Darussalam have no hunger risk. Mature economies also have the highest per capita GDP. Food is, in general, cheaply available. But there is considerable product differentiation between healthy food – expensive, in general, and appealing, in particular, to the better-earning groups of society – and mass production of cheap and often unhealthy food. Food safety and consumer preferences are of dominant importance in the food and beverages industry and have a significant impact in dictating terms to food manufacturers and associated companies. There is increased concern on

maintaining the nutritional benefits of food products due to rising health consciousness amongst consumers globally.

The efficiency of global food chains is connected with global environmental deterioration, forced migration, or gradually becoming poorer in remote rural areas. Costs of transportation and distribution of traded commodities are widely given further to customers. In densely populated regions, these costs can be divided amongst many consumers while in remote areas, few people share the burden of distribution costs. In some countries, state government tries to balance inequalities between unequal parts by supporting remote areas at the expense of central areas. This generally works well during economic growth periods, but might be given up during stress periods. Inhabitants of remote areas are often ageing and with far less income than the average inhabitants of the nation. Economic downcuts also reduce food availability and quality. Foods in rural areas might be less fresh than those in cities that are easier and more profitable to reach for distributors. As a consequence, more rural areas are losing people, making it even more difficult for the remaining populations to live there.

An increasing number of natural disasters do not seem a hindrance to development of ASEAN countries if GDP and food trade volume rates can be further accelerated. This, however, means a concentration of population in more favourable areas of ASEAN countries and migration from disfavoured areas and regions to the favourable ones. While some disasters will not be noted as they happen in depopulated remote areas, others will demand an overproportional toll in lives and values if they affect the core production areas of agriculture and food. The number of disaster damage or disaster events alone is not necessarily a decisive indicator. If several disasters simultaneously happen in short space or time interval, food prices will increase. Political instability and armed conflicts pose a danger in particular areas of ASEAN. Here, like in all other war-affected regions, food security is not granted. The effect of natural disasters will increase and further aggravate political instabilities.

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