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Food Supply Chain Disruption due to Natural Disasters: Entities, Risks, and Strategies for Resilience

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Abstract: *The resilience of the food supply chain (FSC) to disruptions has not kept pace with the extended, globalised, and complex network of modern food chain. This study presents a holistic view of the FSC, including the dynamics among its components, and risks and vulnerabilities to disruptions, particularly natural disasters. Natural disasters pose huge economic challenges to nations, communities, and corporations worldwide. Agriculture is one of the sectors most affected by natural disasters, including the increasing effects of global climate change. Specifically, the annual fluctuation in crop production as well as trade in agricultural products that affect food supply chains has been closely linked to natural disasters and extreme weather. This paper discusses how FSC's dependency on existing infrastructure and how a country's lack of preparedness for emergencies potentially aggravate the disruptions brought by natural disasters. It underscores how the identification of challenges and knowledge gaps can be part of the process to enhance the resilience of FSC and provides examples of disaster relief operations. In particular, it explores the challenges and opportunities for a robust FSC in ASEAN and other developing countries through capacity building and good governance.*

Keywords: business continuity plans, infrastructure, trade policy, vulnerabilities

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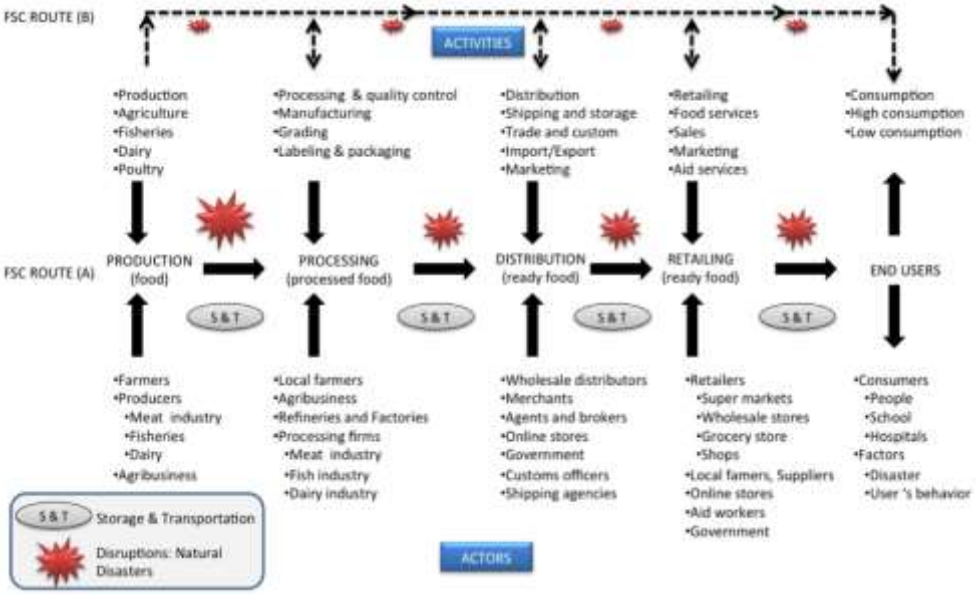
1. Introduction

Food supply chain (FSC) is a network of activities involving production, processing, distribution and consumption and highly dependent on the partners (actors), supporting services and infrastructure. It is an essential component of the global value system of organisations and people engaged in the movement of products and services. From production, food products flow via a series of actors or activities in processing, distribution, retailing and consumption (See Route A in Figure 1). Actors or activities can interact with each other at any stage of the chain. For example, a producer or agribusiness can directly supply products to a consumer that is providing an alternative route, Route (B) in Figure 1.

The extent of the global supply of goods and services can be seen in the total value of world trade. World merchandise trade (import and export) increased >2.4 times between years 2003 and 2013, amounting to US$18.89 trillion (UN-ESCAP, 2015). The Asia-Pacific region is the largest trading region, accounting for approximately 37 percent of the total merchandise world trade in year 2013. The 10 Association of Southeast Asian Nations (ASEAN) countries accounted for about 6.4 percent of the world's merchandise trade in 2013, which has remained significant despite the negative impact of various disasters during past decades on their economic growth. Food and live animals (including edibles commodities, dairy, meat, fish, vegetables, fruits, tea, and coffee) totalled around 6 percent of all world merchandise trade in 2013. These statistics underscore the importance of the FSC's global value (UN-ESCAP, 2015).

Disruptions to FSC can be referred to as any significant breakdown in a supply chain node between the production and consumption activities. Such disruption can occur at any stage of the flow of food products. However, it is the disruptions due to disaster at the production level that can bring the most significant impact on the whole FSC. Natural disaster is one of the major crises that affect not only the FSC of the geographical location it hit, but also has consequences on the global retail trade of food products.

Figure 1: Food Supply Chain Framework



Note : Food product flows via the two major directions, Route-A and/or alternate Route-B. Storage and transportation (S&T) is a common practice occurring almost at every node in the FSC. Disruptions due to disaster can also occur at any stage of FSC with the greatest impact caused at the production stage.

This paper discusses the actors and commodities in the FSC and various natural causes of disruptions at any node of the supply chain. Factors that can potentially amplify the impact of FSC disruptions brought by natural disasters as well as pre-emptive planning in case of emergencies are discussed. The framework for a resilient FSC and disaster relief system is also discussed.

2. Actors and Commodities in the FSC, Risks and Natural Causes of Disruptions

Major players in a FSC system are producers, processors, distributors, retailers, and consumers (Figure 1). Thus, the FSC consists of a range of activities such as primary production, processing and manufacturing, distribution and trade, retailing, food services, and consumption. The level of coordination in these activities and their business and marketing strategies determine how smooth goods and services flow in the face of certain factors.

A clear framework is necessary for a resilient FSC. It is therefore important to know the strength, weakness, and business plan in each activity. As detailed by Bienabe, *et al*. (2004), there is a need to connect small-scale producers to the national and international FSC through direct participation in local and regional markets. Thus, good governance and fair opportunity are important for producers.

In recent years, industrialisation and consumers' desire for cheaper food products have dramatically increased the number of middlemen or players in FSC. This, in effect, requires more coordination efforts among FSC players on one hand as well as increases the risk of disruptions on the other hand. As the FSC becomes more complex, any lack of transparency and traceability poses some aggravated risks when natural disasters such as floods occur. Thus, the appropriate early warning systems and accompanying regulatory actions by governments and international authorities become critical in improving the resilience of the FSC.

2.1. Entities in the FSC

2.1.1. Producers

Producers are key players during the primary stage of the production and manufacturing stages of the FSC. Production of food material depends highly on the small and large commercial producers in various sectors of the food production system. Agricultural production is one of the main contributors in ASEAN countries' economic growth. Food and live animal (including edible commodities, dairy, meat, fish, vegetables, fruits, tea and coffee) comprised approximately six percent of the total merchandise world trade in 2013. The primary food products include grain staples such as rice, wheat, maize and pulses, vegetable, fruits, tea, coffee, fish, meat, and poultry.

Small- or mid-size farmers play a crucial role in the food supply and economic growth in rural and suburban areas. They are highly affected by changes in the food and market policies at national and international levels. Any integration of supermarkets and influx of foreign food materials can put them at risk of being marginalised, thus discouraging local food production. When the dependence shifts to outside food resources, the rural and nearby urban populations become more prone to further disruptions in FSC.

2.1.2. Processors and manufacturers

Most food products require further processing, storage, and transport. In fact, processed foods are critical in the immediate relief response system in case of disasters. Most national agencies and governments depend on processed food supplies as their primary response to a disaster zone. This is why processing is a vital activity in FSC.

Processing involves small to large firms or processing industries. It may entail simply cleaning and grading tasks such as for rice and other staple grains, extraction and refining such as for edible oils, or may require multiple steps such as for meat and dairy products. Fish and other meat require processing and preservation for long-distance transport. A food-processing firm can also be a distributor and actively engage in national or international trade. Examples of major ready-to-eat food are high-calorie food products, dried dairy products, dried fruits, canned food, dried and packed food items such as noodles, cheese, vegetable oil, and cooked food products of meat and fish.

2.1.3. Distributors and trade

Distribution of food products involves local and regional allocation/transportation or global trade (export/import) in the FSC. A nation's economy benefits from exports of goods and services, and consumers benefit from the import of food products that are not produced locally/nationally, have a wider variety of selections and are often priced lower. A distributor may act as a wholesaler or food-retailer depending on the size of its operation.

2.1.4. Retailers and food service

Retailers act as the final players of the marketing system and directly work with consumers. They purchase food products directly from producers, processors, or distributors. Some are also capable of processing certain food products. Example of retailers of food products include local grocery and convenience stores, supermarkets, vegetable and fruit stores, and bakery, dairy, meat, and fish stores. Food services such as restaurants, bars, and clubs are direct outlets in that they serve food products directly to consumers.

2.1.5. Consumers

The FSC culminates with the consumption of food products. In the event of a disaster, consumers are the ultimate group impacted by FSC disruptions. Factors such as natural disasters and change in human behaviour can cause large fluctuation in the food demand and consumption of food products. For example, the import of food products spikes in a region that has recently experienced a natural disaster (Figure 4). Consumers here may include schools, hospitals, shelter camps, humanitarian agencies, and aid workers.

2.1.6. Infrastructure and services and other necessary components

Infrastructure such as those in storage, transportation, and water and energy supply services are important components of FSCs. Because the Asian food supply chain incorporates diverse production areas and retailers ranging from highly sophisticated international companies to local traders, both infrastructure and information systems become critical. Longer supply chains make transport routes more vulnerable to risks during such events as storms and earthquakes. The closure of major transport corridors becomes the immediate concern for the food industry, as roads are the predominant mode of food transport in Asia. Communications and financial services also influence the level and nature of FSC resilience to a disaster.

2.2. Natural Causes of FSC Disruptions

2.2.1. Natural disasters and FSC disruption

Natural disasters pose serious impact on the FSC worldwide. According to the international disaster management database, storms from year 2004 to 2014 caused the largest number of unnatural deaths (42.14%), followed by earthquakes (29.89%) (EM-DAT, 2015). However, earthquakes caused the greatest economic damage (61.21%), followed by storms (17.31%) for the same period. In the past decade, earthquakes had been the leading cause of death in ASEAN member states, followed by storms and floods (Table 2). Developing nations, especially those in the ASEAN and East Asia, are the most vulnerable to natural disasters (Jha and Stanton-Geddes, 2013).

According to a World Bank report, the global economic losses from disasters increased 15 times from the 1950s to the 1990s (Jha and Stanton-Geddes, 2013). The report estimates that East Asia and the Pacific regions accounted for about 80 percent

of the total global losses due to disasters in the first nine months of 2011. Furthermore, according to the United Nation's Economic and Social Commission for Asia and the Pacific's (UN-ESCAP) Statistical Database, developing regions such as Asia and Africa show faster urbanisation than the developed world (UN-ESCAP, 2015). Rapid urbanisation in developing countries makes them increasingly vulnerable to disasters due to the lack of adequate infrastructure planning and land management. As citizens migrate to cities, so do the market and other food value chain services also concentrate near cities.

The urban population has more than doubled (increased by over 115%) in ASEAN member states between 1990 and 2015. Such demographic shift always demands for a resilient urban infrastructure and FSC. Otherwise, an unplanned or poorly planned migration of people and assets to highly concentrated places exposes them to more risks when disaster strikes. So do the lack of adequate infrastructure that should support the rapid urbanisation and poorly planned land use.

The business continuity plan in the FSC must be considered as an integral part of disaster recovery. Demand for food and clean water is the most urgent need and immediately follows search and rescue operations in the event of disasters. In recent decades, the occurrence of natural disasters has become more frequent in the developing countries, especially Asia (UN-ESCAP, 2013). According to the United Nations report, the likelihood of natural disasters in Asia is nine and 67 times greater than in North America and Europe, respectively (UN-ESCAP, 2013). The average annual damage caused by natural disasters in the past 10 years (2004-2014) is about US$141 billion worldwide (Table 1). Although ASEAN member states' share in this figure is only 5.8 percent annually on average, they experienced the most number of natural disasters and had the biggest number of affected population (16.56 million). Aside from Latin America, most casualties were in Asia, averaging 27,200 annually in the past 10 years.

The lower value of damages due to natural disasters in developing countries might be attributed to smaller economy and lesser expensive infrastructure as compared to that of developed nations. Often, natural disasters (such as Typhoon Haiyan, the tropical cyclone in 2013) impact a huge population, who suddenly find themselves in urgent need of humanitarian assistance. Despite an impressive search

and rescue, and recovery response from local and international agencies, and foreign governments, the implementation of the basic business continuity plan on FSC is relatively slow. Such slow response in terms of supply distribution is partly due to difficulty in transport and delivery aids of relief goods to the locations of varied topographies.

Table 1: Annual Number of Natural Disasters, People Affected, Casualties and Economic Damage for ASEAN, Other Regions, and the World

Region/Group	Natural disaster (number)	People affected (million)	Deaths (thousands)	Economic damage (billion, US$)
Latin America	14	2.55	38.18	7.44
Africa	19	7.11	3.66	0.37
North America	24	1.90	0.45	46.47
Europe	46	0.77	0.85	10.80
ASEAN	50	16.56	27.20	8.19
World	394	165.86	89.06	141.02

Note: Data are 10-year averages from 2004 to 2014.
Source: United Nations ESCAP Statistical Database 2015.

Table 2: ASEAN Statistics on Occurrences and Resulting Casualties, People Affected and Total Economic Damage per Type of Natural Disaster (2001–2014)

Disaster type	Occurrence	Total deaths	Total affected	Total damage (billion, US$)
Extreme temperature	1 (<0.2)	63 (<0.02)	1,000,000 (0.5)	–
Wildfire	6 (0.9)	–	400 (<0.01)	0.014 (<0.01)
Drought	15 (2.2)	–	26,957,602 (12.3)	0.704 (<0.02)
Volcanic activity	27 (3.9)	367 (<0.2)	732,085 (0.3)	0.189 (0.8)
Epidemic	34 (4.9)	2,568 (0.7)	325,826 (<0.2)	–
Landslide	54 (7.8)	2,930 (0.8)	698,728 (0.3)	0.070 (<0.1)
Earthquake	59 (8.5)	**184,362 (51.43)**	11365300 (5.2)	13.024 (<14.0)
Storm	182 (26.2)	158,810 (44.3)	**102,372,657 (46.6)**	23.887 (<25.7)
Flood	**317 (45.6)**	9,382 (2.62)	76,059,664 (34.6)	55.078 (<59.2)
Total (ASEAN)	695	358,482	219,512,262	92.965

Note : The percentage of the total value is given inside parentheses. Source: (EM-DAT, 2015).

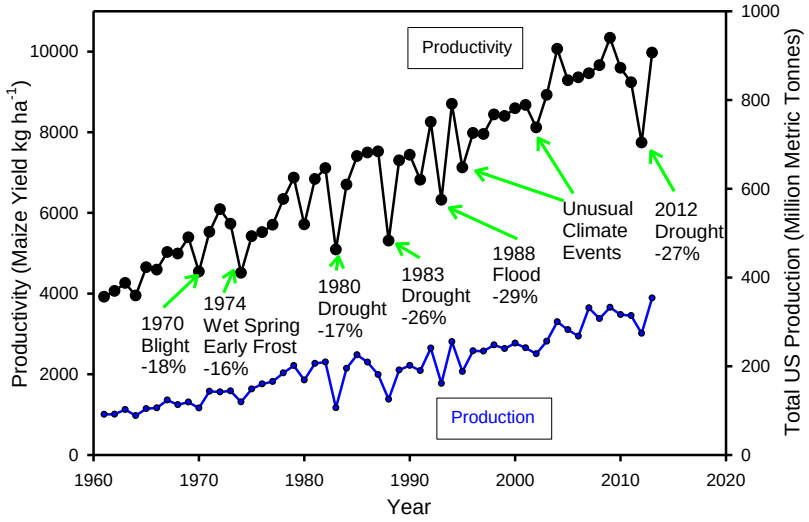
2.2.2. Global climate change and FSC disruptions

Global climate change is a critical issue as it affects food production, processing, storage and transport, and therefore can disrupt the food service chain. Climate change is already affecting natural resources in such industries as terrestrial vegetation, animal husbandry, and fisheries, which societies depend on for food, fibre, fuel, several industrial products, and recreational services (World Bank, 2010). Therefore, the world's food supply for a growing population, which is primarily dependent on agriculture, has become a major concern. The world's human population of approximately 7.2 billion is expected to increase to 8 billion by 2025, about 9.6 billion by 2050, and about 10.6 billion by 2100 (U.S. Census Bureau, Population Division, 2014). A significant increase in agricultural productivity must be achieved to meet the future food demand in the face of changing climate, limited or diminishing natural resources such as land and irrigation water, and global conflict. Nations face intensified competition for land, water, energy, and other natural resources to produce more food in a sustainable manner. For instance, water shortage is at a critical level in many regions; it has to be used efficiently given that there is competing demand for water for various uses: for human survival, energy, urban development, industry, recreation, agriculture, fisheries, etc. Recently, the severe drought in California, United States, drove the State Water Resources Control Board of California to set water conservation measures to mitigate the reduced water resources. A strict water conservation measure might also affect the grapes and wine industry, as well as the FSC for crops such as vegetables, almonds and other nuts, cotton and rice in the region.

The earth's climate has changed rapidly in the past 150 years, although this is a brief time span when compared to the geological time scale. The average global temperature has already gone up by close to 1°C since the beginning of the industrial era (Allison, *et al*., 2009). Widespread melting of snow and ice, rise in sea level and frequent heat waves are being observed and pose risks to FSC. Although global precipitation has increased, heavy rainfall and floods are more common, and many regions have seen more frequent and intense droughts. Moreover, the intensity and frequency of extreme events (storms, heat waves, droughts, flash floods) are expected to increase in the future because of the amplified effect of climate change

(Allison *et al*., 2009). Extreme weather conditions are closely linked to a decline in agricultural production and a rise in prices of food commodities. There have been several incidents when crop production significantly fell due to extreme weather such as heat and drought. For example, in 2012, the drought and heat in the United States reduced the crop productivity of corn, soybean, and forage crops to over US$35 billion loss (Masters Jeff, 2012). As shown in Figure 2, the annual decline in the US corn (maize) production was closely linked to the occurrence of extreme weather such as drought in a given year. Weather uncertainties have affected the agricultural production worldwide.

Figure 2: Yield and Total Production of Corn (Maize) in the United States between 1961 and 2013



Note: The inter-annual variability in part might be attributed to the extreme natural or weather events leading to dramatic reduction in the corn yield in a particular year. Percentage reduction in a year is calculated against the preceding year.
Data source: FAO (2015a) and events updated from Thomas, Jerry, and Thomas (2009).

The increasing frequencies of extreme weather not only reduce the food production but also disrupt other FSC elements. The expected change in climate and global warming directly influences processing, transportation, storage and distribution activities in the food supply chain. When facilities affiliated with these activities are exposed to storms and flooding inland or of coastal areas, the storage and transportation of food products are affected. Specifically, warehouses and supermarkets near coastal areas are at high risk from the rise in sea level and storms.

Also, costs of storage and distribution of food products increase along with the rise in temperature due to extra energy cost for temperature-controlled facilities.

3. Factors that Amplify the Impact of FSC Disruption due to Natural Disasters

When natural disasters affect FSC, factors that aggravate the disruption on the local and national economy include

- Scale factors – whether FSC can adapt to disruption up to a certain population or geographic scale, with elements breaking down beyond that point.
- Scope factors – whether FSC can adapt to disruptions for particular types of foods or inputs to foods up to a certain level of scope, with elements breaking down beyond a certain point.
- Temporal factors – whether FSC can respond with resilience to a disruption for a certain period of time, with elements breaking down beyond that point.
- Distributional factors – whether the FSC is less resilient in some section of the community rather than others (such as small-scale farmers, low-income households, etc.).
- Industry factors – whether some sections of the industry, by function and product type, are less resilient than others given their particular circumstances, and any dependencies across the industries.

Based on case studies in Asia (APO, 2013), key vulnerabilities that can substantially threaten FSC's resilience include

- Concurrent loss of a number of distribution centre facilities (including power loss).
- Concurrent loss of a number of transport links between cities---for example, extensive storm events that cut land transport links, both road and rail.
- Shortage of transport fuel for food distribution in the case of a national fuel emergency
- Ongoing constraints on workforce availability beyond which affected companies can manage using standard backfilling and causal pool arrangements.
- Extended material disruption due to lack of access to key finished foods or inputs to foods that are only produced overseas.

Disruptions to the supply chain across sectors are a major concern and an unavoidable discussion point of managers across industries. The greater complexity brought by increased partnerships among ‘actors’ or ‘activities’ in modern supply chains, including FSC, also intensifies the risk of disruptions. Such risk of FSC disruptions also depends on the availability of storage and transport facilities, water, labour or manpower, and energy supplies. Likewise, the FSC may be affected by a range of domestic, regional and global factors related to the shortage of production/raw material, geographical location and topography of the disaster-impacted areas, market size, preparedness, inter- and intra-coordination among aid agencies, intergovernmental relationships and tariff trade policies.

3.1. FSC Dependency on Other Infrastructure and Services (Key Capacities)

Infrastructure that affects FSC may include storage and transportation, communication and networking facilities, water and energy supplies, availability of manpower and modern technologies. For example, failure to supply energy to a food production industry can severely affect the production, thus disrupting the food chain. Damages to the storage and transport facilities can further hinder any recovery effort.

3.2. Food Production (Domestic and regional: Shortage of raw materials)

According to a Food and Agriculture Organization (FAO) report, the agriculture sector bears the major brunt of the impact of natural disasters (FAO, 2015). Natural disasters or weather extremes bring about an immediate shortage of food products derived from crops, livestock, fisheries and forestry. Regular inventory and buffer stocks for certain food products help to reduce the impact of disruptions.

3.3. Nature of Commodities in FSC (Bulky and perishable)

Often, bulky or perishable food or food products require extra care and cost for storage and transportation. This makes the continuity of FSC more challenging than other supply chain sectors. Compared to other sectors of global supply chain such as automobiles or computer-tech industry, FSC is less fragmented geographically, at least in the case of food products. Often, certain food or food products (e.g. vegetable, some grains, and fruits) are produced, processed, and marketed in the same geographical locations or bordering nations. This might be both an advantage

and disadvantage depending on the nature of natural disasters. If the production and processing area is outside the disaster-stricken area, then the food can swiftly be made available.

However, due to the need for cheaper food products, FSC has been industrialised in past decades, which also tends to depend on the complex network of global markets (Manners-Bell, 2014). For example, many agricultural and food products serve as the raw material for relatively big industries (e.g. cotton for the textile industry and grains or grapes for drink beverage or alcohol industries).

3.4. Centralised Food Production and Processing System (e.g. in affected area)

Food producers and industries that are over-concentrated in a particular location often mean their service chain is at a larger risk of being disrupted by natural disasters. For example, the meat industry in Nepal was highly affected by the earthquake of April-May 2015. Kathmandu, which is situated near the epicentre of the recent earthquake, had thousands of meat producers and retailers centralised locally. This means that the sale of (and access to) meat products was not available to the whole region, thus aggravating Nepal's FSC disruption.

3.5. Distribution Networks (also depend on other infrastructure)

Often, natural disasters such as earthquakes and hurricanes damage the already weak transport facilities and roadways, thus disrupting FSC. Risky terrains and damaged or blocked roads were some of the main causes of disruption or delayed food distribution in Nepal's recent earthquake. The challenge centred on how the food products could reach the affected areas and how the affected people could be mobilised towards safe and accessible areas.

A well-planned distribution network should therefore minimise the impact of any natural disaster on the supply chain. A distribution network consisting of interconnected transport infrastructure can serve as the 'backbone' of FSC and facilitate disaster relief systems. Well-positioned distribution centres can only coordinate and work as teams under functional and suitable transport infrastructure.

3.6. Weather Conditions (Cause of delayed aid delivery)

Rainfall aggravates the FSC disruption as it presents transportation issues and hinders the efficiency of aid workers. Such disruptions due to weather conditions were observed during Typhoon Haiyan in the Philippines in 2013. Thus, an advanced

weather forecasting system serves as an important supporting component of FSC as the information it provides can help nations plan better the allocation and distribution of food supplies.

3.7. Forecasting and Telecommunication (Important tool for preparation and coordination)

Modern technologies and meteorological forecasting can help nations prepare for upcoming natural disasters such as storms and hurricanes days up to weeks in advance. These allow governments and aid agencies to closely monitor meteorological events and follow warnings so as to minimise the impact of natural disasters. Telecommunication plays a critical role in the coordination of relief efforts during the distribution stage of the supply chain, in the monitoring of aid workers' safety, and in the operation of humanitarian assistance in affected areas. For instance, telecommunications can help prevent redundant deployment of aid supply trucks as well as track their whereabouts. With the help of global positioning systems, trucks' location and delivery status can be closely monitored. Better yet, the trucks can be easily diverted to areas most in need while preventing duplication or redundancy of efforts.

3.8. Looting and Violence (Making the situation worse)

Looting and violence were observed during calamities such as the case during Hurricane Katrina (in 2005 in the United States) and Typhoon Haiyan (in 2013 in the Philippines). Often, opportunistic individuals or people in dire need attempt to possess the food and properties allotted for other disaster victims. This can seriously obstruct the aid distribution to all victims.

3.9. Food Security and Health (Planning to be self-dependent)

Both the damage on existing agricultural primary products and the failure to plant and produce for the next seasons, further disrupt the food chain. These issues delay local victims' move to regain self-sufficiency and even increase a nation's dependence on external resources for a longer period. Damages on health centres, and the lack of medical facilities and proper medicine pose risks of disease outbreaks and thus exacerbate the situation.

3.10. Shelter, Water and Sanitation (Key to avoid disease outbreak)

Natural disasters that damage the water resources and sanitation facilities can contaminate the usable water. Thus, places severely affected by disasters might need a sustained supply of water from external sources for several days or weeks. Also, to prevent any disease outbreak that might further hamper the relief efforts, the disaster-stricken area must provide hygiene kits, hand soaps, and mosquito nets as part of its sanitation system.

3.11. Education and Psychological Support (Planning for the future)

Disasters have long-term psychological impact on children. Destruction of education centres, the death of kin and loss of friends and family members can bring distress in children. According to a United Nations report, close to a million children will not be able to attend school due to the 2015 earthquake in Nepal (OCHA, 2015). Child and women trafficking is another issue that can arise from mega disasters as seen in the 2015 earthquake in Nepal and 2011 typhoon in the Philippines.

3.12. Logistics (Complex logistics, an invitation to FSC chain disruptions)

The procurement, maintenance, distribution, transport and management of goods and services are often governed by a legal framework. Food products flow from the point of origin to the point of consumption, but legal laws such as border custom procedures and travel permits (e.g. Visa) can seriously delay the movement of either food supplies or aid workers. During the recent Nepal earthquake, flights carrying relief items were prevented to land because some basic items such as tools for road repair were not included in the list of goods for humanitarian aid (OCHA, 2015). Trade barriers such as high international trade tariff and quotas may also hinder the delivery of food (i.e., non-perishables and staple or grain products) in times of natural disasters. In such cases, trade policies should be tailored to provide incentives for export and import of food products and ease of travel for authorised aid workers across borders.

3.13. Funding

Despite the best planning, aid agencies' capabilities often depend on external fund sources. The cost of supplies needed for disaster aid —as well as their cost of storage, transportation and distribution —rises every year. Since the demand for aid supplies varies based on the number and type of natural disasters and the size of

affected people in a given country, the needed stock reserves on food supplies are difficult to predict. Such uncertainty can further disrupt the FSC, particularly when there is a higher demand for food products due to disasters.

4. Preparation for Emergency Situation Due to FSC Disruption after Natural Disasters

Most factors that can further disrupt the FSC must be identified and addressed to prepare for eventualities. While both internal (e.g. production and management activities) and external (e.g. natural disaster) occurrences can disrupt the FSC, the impact of natural disasters is more dramatic. After all, natural disasters bring many elements of unpredictability and need a quick response time, sometimes even requiring resources to be diverted towards location where the need is most exigent.

Preparing for an emergency situation begins with an expectation of a FSC disruption. Thus, societies, entrepreneurs, and nations do not need to experience an actual disruption in the food chain due to natural disasters to be prepared. Instead, lessons learned from past experiences or events can help a country get ready for FSC disruptions. Evaluating the threats and weighing the risks of FSC disruption is critical to prepare for an emergency situation.

4.1. Preparation for FSC Disruption Early On

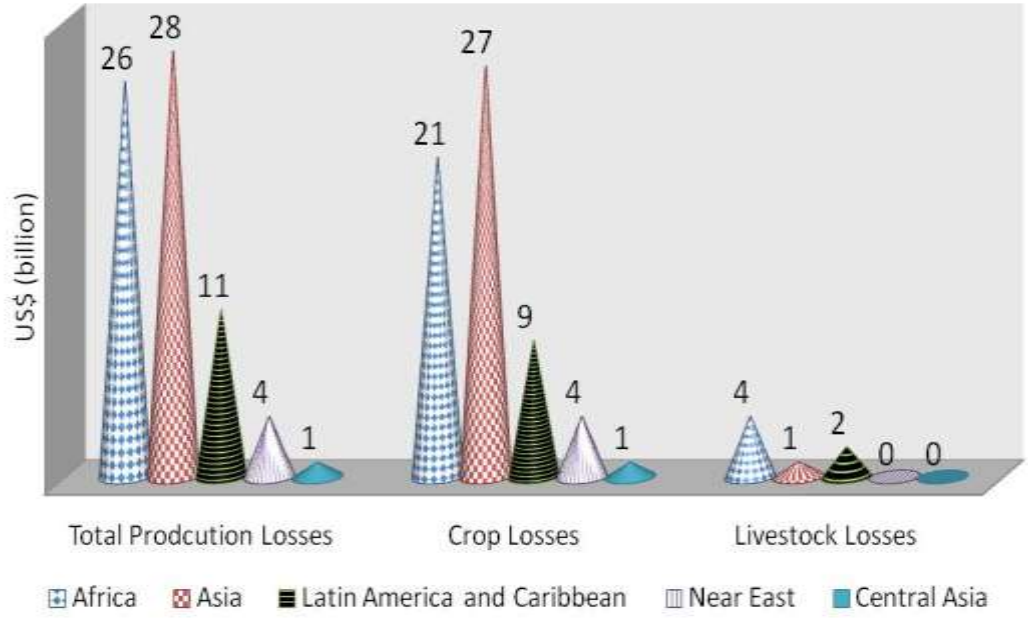
Planning, the first step, is key in the preparation for FSC disruptions. Resilient buildings/houses constructed on safer locations and acknowledging that natural disasters are always a possibility can be made part of a long-term plan that can save human lives. On the other hand, short-term planning may cover buffer food stock, health and safety equipment and deciding on how to swiftly mobilise response teams in times of natural disasters.

4.1.1. Accept the vulnerabilities to natural disasters and risk to FSC disruption

Based on the frequency of natural disasters annually as shown in Table 1, no community or nation is completely safe, including ASEAN member countries. In fact, ASEAN nations have the highest average occurrence (50/year) of natural disasters. The region experienced one of the biggest casualties and affected

population due to disasters in the last 10 years. Because of the coastal location of most ASEAN countries, earthquakes, floods, and storms are the three natural disasters that brought the most number of deaths and damages (Table 2). According to a United Nations report, Asian countries suffer the most total production losses, including damage to agricultural crops (Figure 3). Therefore, acknowledging the region's vulnerability to natural disasters is the starting point in its preparation.

Figure 3: Crop and Livestock Production Losses by Region Due to Disasters



Note: Data are from 67 developing countries that were affected by at least one medium- to larger-scale disaster between 2003 and 2013.
Source: FAO (2015b).

4.1.2. Identify the nature of FSC disruption

In the planning process, the first step is to identify the type of FSC disruption to expect. Is it going to be a disruption of the whole FSC? Or is it a disruption specifically on water, certain food or food products or such items as energy or fuel used for preparing/cooking food? For example, as mentioned earlier, floods and storms cause greater damage to the production node of the FSC. Therefore, seasonal agricultural products such as wheat, rice and maize, and vegetables and fruits are most likely to be affected.

4.1.3. Food storage for emergency

Food reserves should be in the priority lists of communities, businesses, and nations' disaster preparedness plans. Maintaining a safety stock requires an up-to-date inventory of food products. The mix of perishable and non-perishable forms of food should also be part of the decision. Often, non-perishables that can be eaten uncooked or require very few steps to prepare are best for long-time storage. Large storage facilities for food products should be built in sites less likely to be affected by natural disasters.

4.1.4. Monitoring the progress of natural disasters

By closely monitoring and tracking the possible causes of natural disasters such as storms, cyclones and tornados, communities and businesses are better equipped to rapidly adjust their food supply chain. Current technologies on weather forecasting and on hurricane and storm tracking give nations anywhere from a few days to weeks of preparation before the disaster happen.

4.1.5. Bracing for natural disasters

Because the most crucial period is often the first few days after a disaster strikes, communities must take steps to stock up on food supplies and other necessities that will last them for at least a week. Canned and bottled food products and water, cooked grains and processed food can be stored in locations less likely to be hit by calamities. Nations and national aid agencies must relocate their resources to a safer distance from disaster-prone areas to be able to swiftly mobilise them when the need arises.

4.1.6. Means of transportation

Ground transport of food supplies is often hampered after a disaster occurs. Therefore, aerial transport facilities and carriers should be on standby for action when needed. Water transport (used for river, lakes and oceans), too, can be vital in case of flooding.

4.2. Preparation at the Time of FSC Disruption

Communities, businesses, and governments are collectively affected when natural disasters hit their area. Businesses and governments often mobilise the needed supplies and resources to affected areas right after disaster hits and endeavours to find means to address any shortage in supplies.

How the different tiers in each relief agency/unit coordinate with each other partly defines the success of their relief operation. However, not everything should be left in the hands of authorities. On the ground, communities should also prepare food supplies and survival kits beforehand, enough to last them until external aid arrives.

4.2.1. Safety first

In disaster operations, protecting lives is the primary goal. This may mean having to move survivors to safer grounds or to structures that are less likely to be damaged by natural calamities such as strong typhoons. In the case of floods, this will mean moving people to higher storeys of a house or building. Communities in flood-prone locations such as those in the ASEAN region should be encouraged to keep boats in their homes. A boat is useful during the initial stage of flooding to carry families and food supplies to safer grounds.

4.2.2. Share and care

Sharing extra food and shelter with other survivors should be the encouraged behaviour when there is a disruption in the FSC. Communities can work together in clean-up efforts, and in caring and feeding the injured. Patience, too, should be encouraged as survivors wait for aid to arrive.

4.2.3. Communication and up-to-date information

Communities and businesses should take it upon themselves to seek information on the nature of disasters and the availability of outside aid. Government and aid agencies' initiative to disseminate such information can help to prevent mass panic and instead provide hope for rescue and recovery.

4.2.4. Other measures

Measures such as changing the community's eating habits can help to maximise the limited resources. People with special needs such as those with health issues should be prioritised in the food distribution. Edible food in the form of vegetative or animal sources such as fruits and fish that are available around the disaster-affected areas should be considered as alternate options for food.

5. Resilience of FSC to Disruptions and Framework for Relief System: Directions

As mentioned above, how various agencies, governments, and groups coordinate (Figure 1) defines a FSC's sustainability. In the recent decade, longer and complex food supply networks (e.g. the involvement of more cross-border suppliers and contractors) have dominated the food market locally and internationally. Such increased interdependencies among entities have made today's FSC more sophisticated on one hand, as well as more prone to breakdowns on the other hand. This is why it is imperative for food producers and industries, and government officials to work together.

In addition, as the number of FSC entities (players) increases, the relationships among these become less transparent. The food supply chain also depends on other infrastructure such as storage and transportation, communication and networking, water and energy supplies and is influenced by local and regional government policies. As discussed earlier, failure in these infrastructure and services can further disrupt the supply chain.

5.1. Improving the Resilience to the FSC

A resilient FSC is less likely to be disrupted by internal or external factors and is capable of recovering quickly from any disruption after a disaster. Factors ranging from risk assessment to planning and implementation contribute to such resilience. The next subsections identify ways to improve the resilience of FSCs.

5.1.1. Identification of risks

Accepting the existing risks to FSC is the starting point towards a successful plan of action and implementation. The risks can be grouped into two categories: predictable or under human control; and unpredictable or beyond human control. Production failure, shortage of supply, government intervention, and trade tariffs are factors that can be controlled and manipulated. Natural disasters, weather conditions, and consumer behaviour are harder to predict and often drive the fluctuations in the demand for food supply.

5.1.2. Improvement of infrastructure and services (e.g. transport and freight handling)

In ASEAN countries, the transport infrastructure (roads, rail, seaports, and airports) has not kept pace with the increasing volume of vehicle and carriers. Since the supporting infrastructure are the "legs" for the supply of food as well as all goods and services, efforts have to be made to strengthen the transit of supplies domestically and globally.

5.1.3. Dual or multiple sourcing (e.g. dependency to supplier)

Globalisation and extended FSCs might reduce the cost and burden of management due to the dependence on a single major supplier, but it will also increase the risk of disruptions. A food industry expends fewer resources (money and labour) when it depends on a single supplier, to obtain the same raw material. While it is less costly, the flipside of single sourcing is that such opens stakeholders easily to disruptions if a disaster hits the area. Dual sourcing (or having two or more suppliers) is better in terms of the FSC continuity plan as it gives players the option to reroute the flow of raw materials or supplies from alternative sources in times of crisis.

5.1.4. Redundancy (e.g. alternatives and surplus)

Easy access to tools and machinery that improve productivity, staffing pool, and transport vehicles (trucks, rails, ships, and plane) and related options (freight handling capacity, road, rail tracks, water, and air); more storage capacity; and improved handling capacity of firms/agencies are needed so as to respond effectively to a disaster-driven crisis. Likewise, alternate means of energy supply such as generators are an essential part of a contingency plan. The stronger these elements are integrated within the FSC network, the more resilient the supply chain.

5.1.5. Greater flexibility (e.g. ability to adjust between FSC entities)

Flexibility refers to the ability of the FSC entities to vary their production, distribution or supply according to the need. It allows agencies to quickly respond to a crisis. For example, disruption in the production or availability of one produce caused by natural disasters might be substituted by another produce such as rice

versus maize or wheat. However, such flexibility requires transparency and coordination among the FSC players.

5.1.6. Enhanced visibility and coordination (e.g. achieving flexibility)

Wider collaboration and data sharing among the supply chain's agencies, businesses, and government authorities paves the way for transparency of the supply chain's products and activities. The cross-sectoral and multi-stakeholder collaboration in the, say, energy and transportation departments further strengthens the FSC continuity plan. Parties involved in the collaboration are able to monitor the status of each FSC component and to prepare a plan of action for the expected risks and disruptions. Such preparations aim to improve responders' efficiency and response time in times of natural disasters.

5.1.7. Sensitivity analyses among FSC parties (e.g. between suppliers and distributors)

Sensitivity analyses monitor behaviours and gauge the capacity of various FSC players to adjust their activities. The analyses can be undertaken as exercises between partners in a simulated FSC disruption scenario. This practice identifies the strength and shortcoming in FSC and helps to better prepare the stakeholders for real-world situations. Such practice strengthens relationship among the FSC partners and enhances the transparency and quality of their collaboration.

5.1.8. Disaster management training and simulation (e.g. exercising)

So that all parties can effectively respond to a disaster crisis, a disaster management training exercise should be given to communities, businesses, and government authorities. In the ASEAN, the ASEAN Agreement for Disaster Management and Emergency Response Work Program has set up the ASEAN Disaster Management Training Institutes Network to facilitate the training. Such exercises help to bring out the weaknesses in FSC entities' ability to respond and help them take steps to rectify their processes.

5.1.9. Dense supply distribution hubs (e.g. enhancing capacity to respond)

One of the reasons for the slow response to the Hurricane Katrina crisis in 2005 was the lack of sufficient distribution centres near the affected zone. This had a

two-fold impact: It limited the amount of supplies as well as prolonged the time to respond due to transportation issues. Dense distribution centres near the hurricane-affected area could thus have greatly enhanced agencies' capacity to respond in a timely manner.

5.1.10. Inventory and safety stock (e.g. increasing the size of supplies)

Stockpiling, or holding larger inventories, is one practice FSC entities have adopted at various levels. This practice is relatively easier to do and more cost effective, and can be used effectively at the time of disruption. Stocks of non-perishable supplies such as canned and processed food, medicines and hygiene products prove to be most needed right after disasters occur. However, the challenge here is how to assess the right amount/size of safety stock vis-à-vis the timing and extent of the natural disaster's occurrence.

5.1.11. Business continuity plan (e.g. contingency plan)

The ASEAN countries are producers and assemblers of various products. They have grown to be some of the world's top production centres for computer and electrical products, auto industries, and processed food products. However, as they are often threatened by natural disasters such as earthquakes, floods, and storms (Table 2), it is these nations' small businesses and stakeholders that suffer the most and are under constant threat of insecurity. It thus has become important for these nations to set a business continuity plan so as to assure the smooth flow of goods in their supply chain, particularly in times of fortuitous events.

The establishment of a good business continuity plan among the FSC stakeholders and industries (such as in the transport and energy supply sectors) depends on the level of collaboration and visibility of the food supply activities. Although the investments required are larger in these contingency plans, the rewards are even greater as they secure the continuity of business operations, including the flow of goods in the supply chain.

5.1.12. Insurance and subsidy (e.g. providing incentive to participate in the FSC)

Insurance and subsidies provide a short- or long-term support by mitigating the financial impact of fortuitous events on FSC stakeholders. Insured businesses, industries, and shipping companies can recover and bounce back more swiftly after a

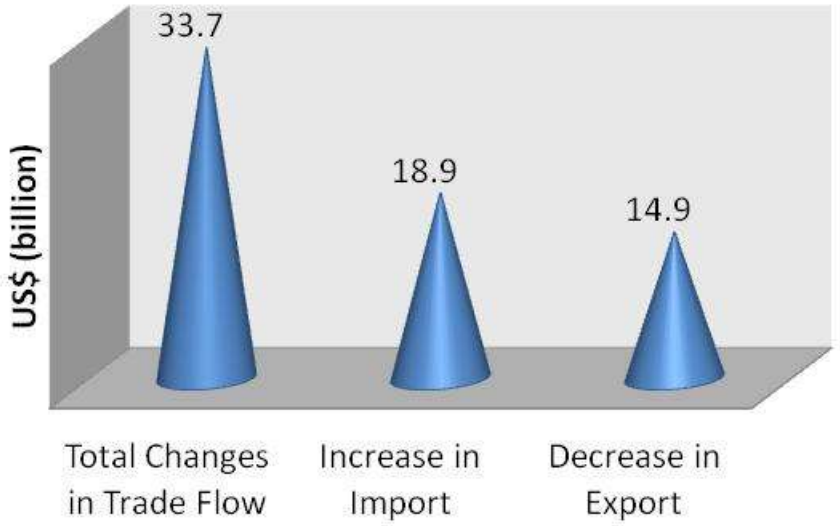
disruption. Meanwhile, the assurance of government subsidies incentivises all partners in the FSC to fully participate in the FSC continuity plan. Thus, insurance and subsidies established prior to the crises (disruption or natural disasters) are vital to the FSC's resilience.

5.1.13. Government intervention and flexible trade policy (e.g. no internal politics; simple logistics)

Figure 4 highlights the impact of natural disasters on world trade. The world import of agricultural products increased while that of export decreased after major disasters. For the FSC to achieve some level of resilience in the event of a natural disaster, it is essential for government to intervene and set the standard for food quality control and safety measures. On the other hand, politically motivated interventions, red tapes and mismanagement, especially in times of disasters, can have serious consequences. For example, the 2011 Thailand flood was worsened by local authorities' mismanagement, which encompassed a range of inappropriate judgement calls such as poor decisions on the operations of dams, weak infrastructure of flood protection embankments, slower response to repair the structural damages to facilities, failure to manage conflicts between victims and flood relief management, and lack of effective flood forecasting and warning systems (Poaponsakorn, Pistom, and Kamphol, 2015). These shortcomings ultimately affected the food and aid supplies for flood victims.

High trade tariffs and limited quotas can weaken the supply chain and further aggravate its disruption in the event of a natural disaster. Customs and trade policies should be tailored to provide incentives for export and import of food products and ease the movement of authorised aid workers across borders. A common standard for quality control will likewise accelerate the cross-border delivery of food products as well as ease the work of customs officers of countries. According to The Logistic Institute, the primary logistic barrier to free trade in ASEAN countries are customs procedures and inspection (TLI, 2004). The recent ASEAN initiative to establish a free trade single-market system among member states will thus aid towards making the FSC in the region more resilient.

Figure 4. Changes in Trade Flow of Agricultural Products (Primary Crops and Livestock Commodities) After a Major Disaster between 2003 and 2013



Note: Graph represents 67 developing countries.
Source: FAO (2015b)**.**

5.1.14. Planning and implementation lessons on FSC: Learning from Hurricane Katrina

Given the extent of damage wrought by Hurricane Katrina in the United States in August 2005, it took several nations and international aid agencies, government agencies such as the Federal Emergency Management Agency, and private sector companies such as supermarket giant Wal-Mart to undertake rescue, recovery and rebuilding efforts in locations badly hit in several US states. The disaster took more than 1,800 human lives and caused one of the biggest damages (about US$108 billion) in the history of natural disasters. The whole supply chain, including that of food and water, was seriously affected by the hurricane.

The post-event evaluation of various agencies' responses in terms of the delivery process of food and relief supplies to victims brought out the planning and implementation issues as well as provided opportunities to improve the process. The involvement of federal aid agencies such as the Federal Emergency Management Agency in the relief operations was highly criticised for their slow response and inefficiency, whereas the aid efforts of the private sectors were commended (Manners-Bell, 2014). Manners-Bell also notes that most issues on the slow response

to the crisis were associated with the planning and implementation of the aid relief system at the distribution node of the supply chain.

a. Pre-planning issues

Government agencies' initial reaction to Hurricane Katrina was, rightfully so, to set up several coordination hubs and distribution centres near the potentially impacted areas and to gather food and other aid supplies (Manners-Bell, 2014). However, the scale of the devastation was overwhelming, destroying much of the transport and communication infrastructure. This severely impeded the government agency's coordination and management ability in crisis zones.

Meanwhile, the private sector's (such as Walmart, Home Depot, and Lowe's) planning and response to disaster were more flexible and rapid due to the transparency of their distribution network and tracking systems. This visibility throughout the supply chain was crucial for the efficient use of available resources within a limited time. Communication, too, was the key towards achieving a coordinated and timely delivery of food products and supplies to victims. Information on the status of the food supply and deliveries was relayed to distribution hubs and higher authorities so that the food supply chain would be tweaked accordingly for the proper allocation of supplies. These supplies included pre-packaged meals as well as bottled water that were dispatched quickly. Due to limited communication, authorities in government agencies were found to have been unaware of the details of the problems in the supply chain. As a consequence, the food and water supply was delayed in one site while duplicated in other places.

b. Implementation issues

In the event of a disaster, time is critical. Manners-Bell (2014) notes that the failure of government agencies to implement an efficient delivery system was amplified due to the ongoing relief operation's lack of visibility. Mismanagement occurred due to the lack of coordination within and between aid agencies. Part of the problem was the government aid agencies' tendency to outsource as well as depend on contractors for supplies and transportation, who eventually failed to provide the much-needed assistance in the relief operations.

As mentioned above, government agencies have taken steps to increase the number of distribution centres near the disaster-prone areas so as to avoid transportation delays and to improve the coordination. However, it is the private sectors that can efficiently distribute and locate their services, as they can easily monitor the delivery status and whereabouts of their supply vehicles. In fact, the private sector has the advantage when it comes to supplying relief goods during disaster situations because of the following factors:

- Self-sufficiency in many areas of response attributes such as supplies, transportation, networking, and tightly managed teams;
- Early planning, accurate assessment of the impact and a clear plan of action;
- Establishment of dense distribution facilities and coordination centres;
- Tracking and clear visibility of the distribution network;
- Strong management and coordination capabilities;
- Use of global positioning systems (GPS) for relief delivery vehicles;
- Robust contingency plan in mobilising workers and assets.

5.2. Framework for FSC Disruption Relief System Due to Natural Disasters: Recommendations

For the past decade, around 50 natural disasters hit the ASEAN region annually (Table 1). This is a significant number given that ASEAN nations account for only three percent of the world's total land area. Similarly, while the ASEAN nations have 8.8 percent of the world's population, the region's residents are the ones hardest hit by natural disasters annually (Table 1). Most of the losses were due to earthquakes, storms, and floods (Table 2).

The World Bank report by Jha and Stanton-Geddes (2013) highlights the various aspects of the strategic policy guidelines for disaster risk management in East Asia and the Pacific. It emphasises the importance of emergency preparedness and contingency plans in the disaster management framework and as part of the goal towards building a resilient supply chain. Planning and preparing for the continuity of food supply as well as of other supply chains is a must for communities, stakeholders, government agencies, and industries.

Disaster management features different stages: prevention, mitigation, response to emergency, rescue, recovery, rehabilitation, and rebuilding. Meanwhile, important

components of any disaster relief system include capacity building of the FSC's stakeholders, disaster forecasting, and management. Some of the essential components of a disaster relief system that agencies and governments should take into account so that their FSC are prepared for any disruptions are discussed below.

5.2.1. Capacity building

Capacity building is a broad term that refers to the process of enhancing the strength and effectiveness of individuals, communities, societies, businesses, aid agencies, or governments. Capacity building improves the stakeholders' ability to meet the development challenges and is important for a resilient system. Some critical areas for development within organisations include (a) disaster management and emergency response teams; (b) a disaster-related database, which is integrated with distribution of local and regional population and available resources and infrastructures; and (c) transport and communication, including the building of (storage and transport) infrastructure to support long-term disaster management goals.

The ASEAN Agreement for Disaster Management and Emergency Response Work Program is one example of an initiative that aims to improve the disaster management awareness within communities and within its network of training institutions called the ASEAN Disaster Management Training Institutes Network. However, capacity building requires large funding, and the investment priorities must be based on available resources. Some recommendations on capacity building are listed below.

a. Emergency plans - disaster response and assessment team
b. Disaster management training centres
c. Humanitarian assistance programs
d. Institutional capacity to respond to a disaster
e. Infrastructure - storage and transport, flood levee, dams and bridges
f. Freight handling capacity – by sea and air
g. Staffing - manpower or adequate number of officials
h. Agricultural and rural development – encourage small-holder farmers, agribusinesses
i. Energy supply and alternate source
j. Collaboration with other regional organisations
k. Strong intergovernmental relations

5.2.2. Investment priorities

Established rules and regulations govern the relations among citizens, societies, and businesses as well as their degree of relationship with the governments. In the same vein, policies that direct investments towards improving the welfare of communities and businesses, infrastructure, and communications can greatly minimise the disruptions brought by natural disasters on supply chains and communities. Common investment areas for capacity building include but are not limited to: (a) development of suitable and location-specific infrastructure (storage and transport, levees, dams and bridges, rail tracks, sea ports); (b) planned urbanisation to support long-term habitation for communities and businesses; (c) building of a risk assessment team to develop scenario-based contingency plans; (d) advanced meteorological and weather forecasting centres and disaster data base; (e) teaching, research and extension services; and (f) a framework for improving the public- and private-sector partnership. These investments required here might seem substantial but result in greater outcomes and safety for future generations. For examples, levees as embankment —once built to prevent the overflow of a river or seawater during the storm or hurricane —can save lives and prevent damages to properties for many years to come.

Food safety in terms of food availability and quality is an important component of the food chain. The establishment of the ASEAN Food Safety Network is a major step towards developing a food safety database in the region. Investments to support local and regional agribusinesses and producers, and their competitiveness in the domestic and international markets are critical to achieve sustainable food production and safety. Such investments and support by government strengthen the FSC and encourage producers and food industries to pursue their own investment activities. It can address issues related to international standards for food safety. Its general guidelines for food safety, preparation and handling must consider the societal diversity in the region, including ethical and religious standards.

Similar institutions that support local and regional agribusinesses and producers, and their competitiveness in the domestic and international markets contribute towards achieving a sustainable food production. However, regulations for the use of pesticides in agricultural, fruit and vegetable production and cultivation of genetically modified or bioengineered crops need further extensive research before they are delivered to locals (farmers, agribusinesses) through extension. For example, people in developing countries are still reluctant to consume bioengineered crops due to food safety concerns. An investment for active programs in agricultural and training, and use of advanced crop varieties, including bioengineered crops, helps consumers, producers and agribusinesses to make informed decisions.

5.2.3. Trade policy

Domestic and international trade policies across nations should be aligned to avoid delays and problems arising from customs procedures and inspections. The ASEAN countries should follow a common standard on food products and quality, food classification, and measures of contaminations. Such standards should be based on international code and ethics. This will greatly enhance the cross-border flow of food supply, particularly in times of disasters, and encourage more humanitarian assistance from foreign donors. This will also provide an incentive for domestic and international partners to participate freely in the trade of goods and services globally.

5.2.4. Institutional and knowledge gaps: Prevention and mitigation strategies

The rate of urbanisation in ASEAN countries has been tremendous over the past decades. Their urban population increased 2.15 times compared to the population in

1990 (UN-ESCAP, 2015). However, the infrastructure to support the cluster of people in concentrated urban areas has not kept pace with the rapid urbanisation. A way to prevent such issue from affecting the FSC is to get all stakeholders — policymakers, distributors, and consumers —engaged in the decision-making process at various nodes of the supply chain. In the case of urbanisation, for instance, the government's policies should guide the planned urbanisation and land use in a sustainable manner without affecting farmlands and the environment in general.

The World Bank's urbanisation review for Indonesia and Vietnam specifically highlights the importance of outreach and project activities. Research and extension services provide innovative production guidelines for producers. Outreach to local or regional producers and suppliers, and partnerships between public and private sectors facilitate agricultural innovations and adaptation. Producers or farmers are more likely to adopt a new technology or farming system when extensions officers in science and technology or government officials interact with them and closely demonstrate the overall benefit of modern agricultural technologies. Likewise, the FAO supports a framework where developing countries imbibe a good agricultural practice- oriented agricultural food system by enhancing research innovations, extension and outreach (FAO, 2004).

In the discussion on new methods and research insights, stakeholders should eventually realise the benefits of current and modern technologies. It is through modern technologies where a sustainable agriculture and food security can be achieved. Modern agricultural technologies can reduce the input-to-output ratio, increase the productivity and income of farmers while improving environmental sustainability.

Meteorological and weather forecasting and development of database are also important for long-term as well as emergency planning. Forecasts assist farmers and agribusinesses to adjust their crop cultivation and processing strategies so as to maximise food production and to minimise the losses.

The stronger a nation's ability in meteorological forecasting, the better prepared it is against natural disasters. Although ASEAN countries are dominated by monsoon uncertainties, storms and cyclones, the National Meteorological or Hydro-meteorological Services are not adequate to fully support climate forecasting in all

regions. In many East Asian countries, the capacity on meteorological forecasting is inadequate (Jha and Stanton-Geddes, 2013). Substantial investment requirement and lack of expert working force are two of the major problems for such weaknesses.

Another technology that helps sustain the supply chain is the decision support system software, which predicts the impact of weather condition on major crops. The software (or crop models) can be used to make decisions about the best crop management practices from the date of planting to harvest time, and to predict the outcomes of changing weather conditions on crop growth, development, and yield. A typical crop model uses previously established mathematical equations to provide daily simulation of crop growth based on the soil, weather, and cultural input information. The mathematical equation incorporated into the crop model needs to be scientifically developed, tested, and validated under laboratory and field conditions. Research initiatives for the development of local/regional or global climate-based crop models for such crops as wheat, rice, maize, soybean, and cotton have already been undertaken in many countries across the world. Thus, initiating research initiatives, establishing research facilities and collaborating with global scientific communities are a developing nation's important areas for investment.

Another area of constant attention is the government's support and strategies in business continuity planning for food supply chain actors (partners). Often, large and multinational firms have some types of business continuity plan and can swiftly allocate and manage resources when needed. However, in the event of natural disasters, it is the small stakeholders, farmers, and agribusinesses that suffer the most for lack of an adequate business continuity plan. It is the small stakeholders and agribusinesses that government has to support in terms of critical infrastructure/resilience and to offer subsidies or compensation after a crisis.

Finally, knowledge gaps between the government and business operators and between their planning strategies can affect food security. These are also the areas that are more vulnerable to the FSC disruption and less able to withstand or 'bounce back' after a natural disaster. Governments or regional organisations such as ASEAN as well as businesses in the FSC must work together to establish business continuity fora or groups that specifically address the issues related to business contingency plans.

6. Conclusion

In simple terms, FSC is a network of activities whose operation is highly dependent on the partners (actors), supporting services, and infrastructure. Globalisation of markets in past decades has led the food industry to exploit available resources by outsourcing activities such as production, processing and distribution around the world. This extension of the food market has fragmented the FSC while greatly increasing dependencies among various partners. The FSC has become more vulnerable to disruptions and internal failure due to a decrease in transparency and coordination.

Ten ASEAN countries accounted for about 6.4 percent of the world's total merchandise trade in 2013. However, due to their location, the ASEAN countries are highly vulnerable to natural disasters and global climate change when compared to other regions. Reports indicate an increase in imports of agricultural products while exports decline after each major disaster. Thus, trade of goods and services across the world are highly interlinked and sensitive to disasters regardless of nations' geographical position.

Areas that need attention in any business continuity plan include

- Food service resilience
- Parallel supply chains
- Advantages and disadvantages of food stockpiling
- Consumer resilience
- Organisation resilience culture
- Testing disaster plans
- Periodic tracking and analysis of critical import dependencies and capacity for substitution
- Identification and analysis to understand the tipping points
- Governance in FSC resilience planning

Investment priorities should aim to address the weaknesses in FSC management and to improve flexibility in times of natural disasters. This means having the capability to respond swiftly in ensuring food security for communities and to set in place contingency plans for agribusinesses. Governments' policies should also focus

on facilitating small stakeholders and agribusinesses' business continuity plans and on offering support for critical infrastructure, subsidies or compensation after a calamity.

Investments in improving infrastructure capacities such as transport and freight handling, dams, and levees are crucial to the operation of large-scale relief systems. Investments in research and agricultural innovations, weather forecasting and meteorological services, and communication network prepare nations for uncertainties related to weather, climate, and other natural disasters. Investments in increasing the workforce (staffing) of national agencies that directly deal with the FSC components such as the ministries/departments of agriculture, foreign trade, and customs are likewise needed.

Capacity building for regional organisations such as the ASEAN is another area where investments are needed so as to enhance their ability to recognise, prioritise, withstand and recover from a disaster crisis. Public or private sectors should likewise work towards managing the possible causes of FSC disruptions and natural disasters, while keeping politics at bay.

Finally, good national and global governance allows nations to attain resilience against FSC disruptions and natural disasters. Aside from their role in research, outreach, and land use planning, governments must also target their interventions towards insurance and subsidies; and transparency and ease in official procedures as well as policies at various stages of the FSC so as to enhance the partnership and mutual respect of actors involved in the supply chains. Other priorities are those that aim for (a) greater collaboration with other regional organisations such as the South Asian Association for Regional Cooperation; (b) stronger intergovernmental relations; and (c) clearer international trade policies on food products as well as customs procedures for humanitarian aid services.

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