

**ERIA Discussion Paper Series****Managing Stranded Assets and Protecting Food Value Chains from Natural Disasters**

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**Abstract:** *Stranded assets are those that have suffered unanticipated or premature write-downs, lost value, or turned into liabilities due to external shocks. Environmental risk factors, such as natural disasters, climate change, and water scarcity, which can cause asset stranding of agriculture are poorly understood in the context of food value chains (FVCs). The value at risk (VaR) globally is significant in agriculture due to overexposure to stranded assets throughout financial and economic systems. Our objective is to discuss the issue of stranded assets and the environmental risks involved with FVCs. This paper provides an overview of the disasters and climate change as contributors to agricultural asset stranding along FVCs. We present the impacts of disasters triggered by natural hazards on the economic losses of the agricultural value chain and the loss of value added growth with further discussion on the principles of effective disaster risk reduction in FVCs. Disasters, when combined with climate change, pose challenges by creating fluctuations in yields, supply shortfalls, and subsequent global trading patterns, and have substantial effects on FVCs. Finally, we present strategies for building resilient FVCs in partnership with communities.*

**Keywords:** *Climate change, disasters, food value chain, stranded assets*

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## **1. Introduction**

The recent escalation in agricultural commodity prices has increased interest in agriculture as an asset category. It has also diverted the flow of capital into much-needed productivity enhancing investments and added to the rise in the value of underlying assets, such as farmland. Stranded assets, where assets are affected by obligations from early or unanticipated write-offs, down-valuations, or conversions, can result from a range of environment-related hazards (Caldecott and McDaniels, 2014). Environment-associated risk factors, such as natural disasters and climate change, are substantial and can become risk creating agricultural stranded assets throughout the entire food value chain (FVC). The potential value at risk (VaR) in agriculture worldwide is considerable due to environmental risk factors and could equate to a loss of more than US\$11.2 trillion annually, measured by 0.5% VaR under the extreme loss of natural capital scenario. This would clearly represent a significant stranding of assets (Caldecott et al., 2013).

To date, much of the debate and research into stranded assets – broadly defined as assets incurring significant unanticipated or premature write-downs or devaluations – have focused on the energy sector. With the growing understanding that disasters and climate change are becoming major factors in the creation of stranded assets it has become clear that not only the energy sector will be affected. Assets in agriculture may also be at risk of stranding because physical impacts, such floods and droughts, affect FVCs. Regulatory and technological change amplifies the risks of stranding further.

Stranding risks have potential impacts on various actors positioned along the FVC. In FVCs, everyone along the chain, from the producer (farmer/rancher) to the consumer, becomes invested and tends to be collaborative rather than merely transactional in ensuring the production of a sustainable value added product. FVCs have the potential to supply nutrition and food security to the entire global population. The accumulation of greenhouse gases and accelerated global population growth are additional emerging pressures on agricultural assets that increase their exposure and susceptibility to disasters and the threat of climate change. Natural disasters and climate change are the sorts of threat that restrict the ability of global FVCs to provide complete food and nutritional security, which can result in economic losses and affect internal equilibrium in some vulnerable nations (Hill and Pittman, 2012). This causes

an advantage loss to agricultural assets and affects the entire FVC. Food is produced and consumed in an increasingly complicated global system, where environmental shocks in one part of the system can have major impacts on others. These pressures will probably demand the adaptation of agricultural value chain systems to effectively meet the challenges presented (Hill and Pittman, 2012).

Reducing the hazards to agriculture from environmental risks, such as natural disasters and climate change, in FVCs is critical to ensuring the resilience of global food systems. Analysing disaster risk in FVCs is an emerging field of study that can assist the development of effective disaster risk reduction strategies (Hill and Pittman, 2012). Agricultural value chains provide linkages between global food system components and mechanics through which food travels from manufacturers to consumers. Using various risk management and adaptation strategies can address the threats in these systems and protect the agricultural assets that are at risk.

The objective of this paper is to provide an overview of agriculture as a stranded asset and the risks to the FVC due to environmental risks, especially natural disasters and climate change. We discuss the challenges faced by FVCs due to environmental risks and the principles for reducing these risks. The paper also includes illustrative case studies of disaster risk reduction and the building of climate resilient FVCs to provide insights into ways of transitioning to a more resilient future for protecting agricultural stranded assets.

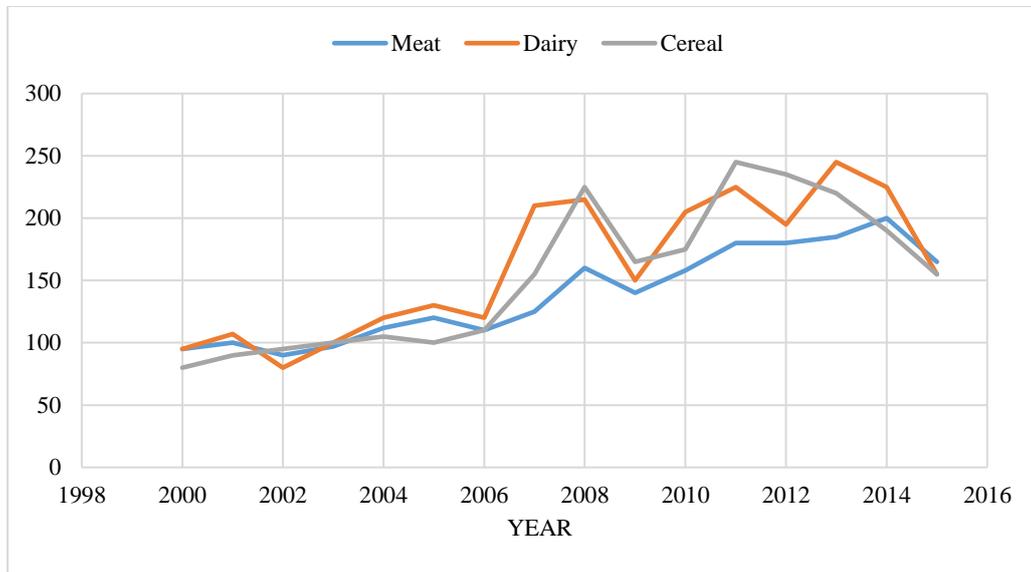
## **2. Stranded Assets and Agriculture as a Stranded Asset**

Stranded assets can be defined as those that have endured before the end of their economic life to obligations from conversion or devaluations. While assets may become stranded for many different reasons, in this context, the risks of stranded assets can be divided into broad categories. The first category is physical risks, such as disaster and climate variability, which have various consequences on food production, trade, and distribution. The second is regulatory and economic risks affecting FVCs, such as new legislation to support the Sendai Framework of Action on Disasters and standards to avoid maladaptation. It is critical to recognise that the various factors underlying the risks of stranding do not operate in isolation; rather, they influence each

other. Assets risk becoming stranded as an effect of sudden change driven by environmental or social factors. The recent boom in agricultural commodity prices (Figure 1) has ignited an interest in agriculture as an asset class. Stranded assets, where environmentally unsustainable assets have problems with unanticipated or early write-offs, down-valuations, or conversion to obligations, can result from a variety of environment-related hazards (Caldecott et al., 2013). The food sector is one of the least prepared for future megatrends, such as natural disasters and climate change (KPMG, 2012). Exposure to the stranding of assets will be highest where the value of assets and the susceptibility to the drivers are high. It is important to take into account, nevertheless, that a major element of the value of agricultural assets will not be priced by markets (Caldecott et al., 2013). So far, most of the studies on stranded assets have centred on particular assets or individual firms and sectors, specifically those associated with fossil fuel extraction. The economical operation of markets at the national level will change if asset stranding linked to environmental risks happens on a large scale (Kepler Chevreux, 2014).

No established definition of ‘stranded assets’ exists in the current literature. While some have concentrated narrowly on petroleum or other fossil fuel reserves (Kepler Chevreux, 2014), others have taken a much more comprehensive strategy that takes into account any asset whose value may be endangered by environmental risks (Caldecott et al., 2013). The list of the assets regarded by Caldecott et al. (2013) as stranded in agriculture by environmental hazards is provided in Table 1.

**Figure 1. Changes in the Agricultural Commodities Price Index  
(Base year: 2000)**



Source: FAOSTAT.

**Table 1. Classification of Stranded Assets**

Type of Stranded Asset	Example
Natural assets	Farmland, land improvements, ecosystem services, poorly defined water property rights
Physical assets	Animals, plantation crops, farm buildings, infrastructure, processing facilities, dams, roads, towns
Financial assets	Farm loans, financial derivatives of commodities, well-defined water rights
Human assets	R&D expertise, agricultural technologies, and management experience
Social assets	Policy, business, and community networks

Source: Authors.

### 3. Environmental Risks

Environmental risk can be described as the probability of an unwanted event and its effects, which arise from a spontaneous natural origin or from human action, that are transmitted through the environment (Fisher, 1980). There are many emerging risks that may lead to asset stranding. Environment-associated risks impacting

agriculture resources may strand assets through the entire FVC and are candid (Caldecott et al., 2013). A report by the Stranded Assets Programme at the University of Oxford's Smith School of Enterprise and the Environment (Caldecott et al., 2013) recognises numerous risks to agricultural assets from the environment, including increased weather variability, climate change, water scarcity, land degradation, biodiversity reduction, land-use regulations, changing biofuels regulations, and the greening of the agricultural value chain. Comprehensive effects that work to alter system functions are usually produced from the combined results of different environmental risks, such as natural disasters, climate change, water scarcity, and land-use change. Thresholds are anticipated to be crossed more frequently in the coming decades due to individual agitations (Caldecott et al., 2013).

These environmental risks are inadequately understood and therefore often mispriced, which has resulted in a significant overexposure to environmentally unsustainable assets throughout economic and fiscal systems. VaR, arising from unanticipated changes in output and/or input prices, can change investment decisions determined by its origin. Research at Oxford University's Smithsonian Business School (Caldecott et al., 2013) determined VaR computations under current, moderate, and extreme scenarios. The research identified a 1-in-20 chance that the world's agricultural assets and stock investments would fall by US\$4.4 billion per annum for the present scenario, US\$6.2 billion per annum for the moderate scenario, and US\$8 billion for the extreme scenario at 5% VaR; at 0.5% VaR, the loss could double from US\$6.3 billion in the current scenario to US\$11.2 billion in the extreme scenario.

It is crucial for traders, companies, and public policymakers to adopt strategies to manage agricultural stranded assets resulting from environmental hazards as critical infrastructure and trillions of dollars in value across the agricultural value chain are at risk. In addition, efforts to take into consideration the effects of environmental risks on the economy may require discussions on global risk, resilience, and adaptation.

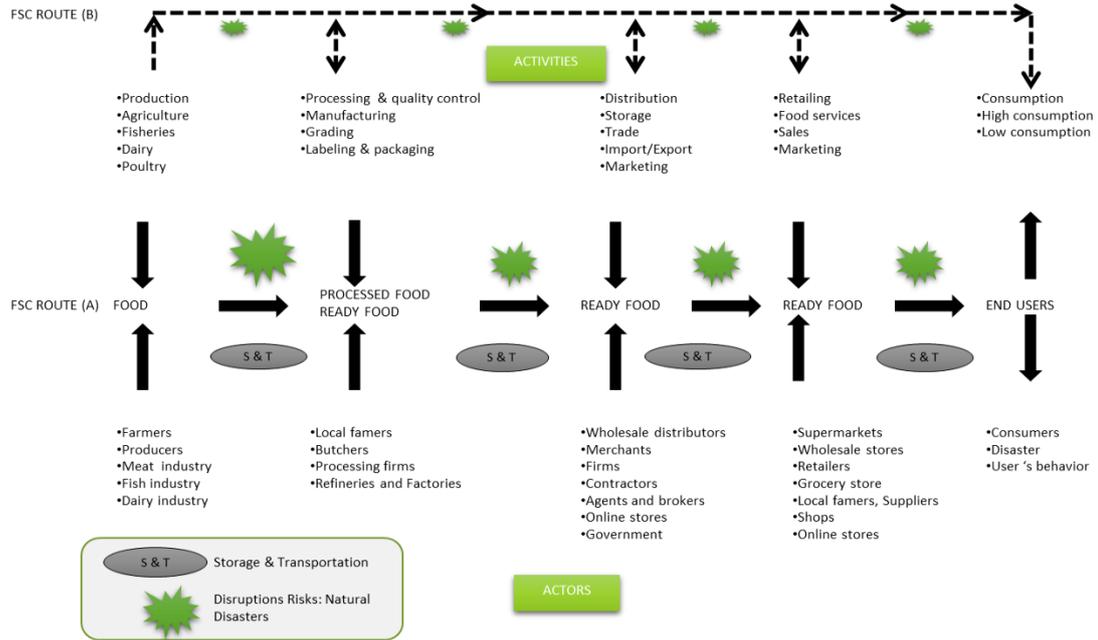
## **4. The Food Value Chain and Environmental Risks**

### **4.1. Overview of the Food Value Chain**

A value chain is a series of organisations or players working together for a specific product to meet market demand. FVCs are fundamental elements of the global food system. FVCs represent a model of action by which farmers and consumers of agricultural products form vital cooperation with other actors in the chain (for example aggregators, processors, distributors, retailers, and customers) to enhance financial returns through product differentiation that progresses environmental or social principles. Associates in these business partnerships understand that producing a product of the highest quality and maximising its value depends on mutuality, cooperation, and shared support (Diamond et al., 2014). The FVC incorporates a network of partners required for growing, processing, and selling the food that consumers eat, from farm to table. The FVC includes various steps and the participation of diverse actors.

As illustrated in Figure 2, the FVC reveals the fundamental set of activities that in some situations symbolises the FVC's actors and functional values. Each of the components in these chains has its own unique requirements, which the producer should take into consideration together with the requirements of the consumer.

**Figure 2. Components and Actors in the Food Value Chain**



FSC = food supply chain

Source: Authors.

The nature of the asset classes and the vulnerability of each actor is described in Table 2.

**Table 2. Overview of Disaster Risk at the Component Level along the Food Value Chain**

<b>Value Chain Component</b>	<b>Assets</b>	<b>Vulnerabilities</b>
Producers	Standing crops, irrigation systems, livestock shelters, hatcheries, grain reserves, dams, farm access roads, equipment, farm schools and cooperatives, loans, biodiversity, ecosystems, R&D, agriculture technologies, etc.	Increased costs of farm inputs, such as fertilisers, seeds, livestock feed, and veterinary care. Reduced demand for inputs, decreased production, limited support of technology, increased ineptness and erosion of livelihoods, depleted savings, sales of vital productive assets, etc.
Processors	Infrastructure, processing facilities, roads, dams, towns, facilities for storage, loans, etc.	Lower revenue, high operational costs, unexpected expenditure, reduced quality, high price index, low revenues, etc.
Distributors/retailers	Buildings, roads, dams, towns, facilities for storage, management, community networks, etc.	Income loss, lower purchasing power, reduced quality, loss of market access, weak social support networks, etc.
Consumers	Commodities price index, ecosystems, infrastructure, roads, dams, towns, community networks, etc.	Food inflation, reduced quantity and quality of food, food insecurity, and malnutrition.

Source: Authors.

#### *4.1.1 Producers*

Producers grow, control production, and trade food products to ensure the quality and value added of their products and to function in a cost-effective way. They also adopt safety requirements and rigorous quality and other regulations in the food markets (Dolan and Humphrey 2004). Producers related to food production include producers of crops, livestock, and fisheries. Together with production, they also carry out essential processing, including sorting, grading, and bagging (Deloitte, 2013).

Food production typically includes all agricultural stranded assets specified in Section 2 that are firmly associated with the natural environment, such as soil, water, and ecological systems. Production, consequently, can be affected by environmental

risk factors that are, to a varying degree, beyond the control of producers. Thus, it can have social and environmental effects that are progressively shifting from externalities to production expenses that are internalised.

#### *4.1.2 Processors*

Processors are involved in both the preparation of fresh foods for the market as well as the generation of prepared food products. Both primary and value added manufactures processors process and market food products. Processing may also occur on the farm with food safety precautions and proper facilities to downstream packaging. Aggregation facilities, frequently called regional food hearts, permit multiple smaller companies to unite their capabilities and products to fulfil larger marketplace demands (Deloitte, 2013).

Processors are also generally more susceptible to disasters and climate change. All components in the FVC are interdependent on one another, so the effect of environmental risk on producers causes processors to access fewer commodities, and it also has an effect on processing equipment, which can lead to increased market prices. Processors are additionally inclined to have limited diversification capacity and face an unfavourable policy environment. They are often constrained by a lack of start-up capital and insurance to cover loss and damage to their infrastructure from environmental risks and face high interest rate charges on loans. This has an overall effect on physical, financial, and social assets.

#### *4.1.3 Distributors and Retailers*

Distributors are the chain of intermediaries, including wholesalers and retailers, which markets and distributes food from one business to another until it eventually reaches the consumer. The implications for retailers are important, and the close observation of vendors' quality assurance procedures is becoming an ambitious and vital task that is increasing in complexity as the number of providers grows (Deloitte, 2013).

Extreme environmental events restrict agro-processing capacity and lead to higher production, processing, and promotion costs, with distributional impacts not only at the farm level but across a wide array of industries and sectors. Extreme weather events can also increase transportation costs. In some poor nations, a large share of perishable

food is lost during food distribution as a result of inefficiency or a lack of refrigerated transport due to extreme weather conditions. This has impacts on the physical, financial, social, and human assets of agriculture.

#### *4.1.4 Consumers*

Consumers purchase and consume food. They can affect the entire FVC to some degree through their dietary preferences, which contribute to determining what companies produce. Buyers can also influence other elements in the FVC through their choices, which comprise value improvement, for example through branding and accreditation.

Reduced commodity options, effects on transportation, and changes in the quality of food and food prices due to environmental risks have an impact on consumers, which causes food insecurity and affects physical, human, and social assets.

## **4.2. Stranding Factors and Their Impacts on Actors**

The physical and economic factors that may lead to stranding and create physical, financial, and societal risk along the value chain are shown in Table 3.

All four categories of actors positioned along the FVC may be affected. These include producers and landowners, who benefit directly from agricultural production, and leaseholders, for example those who have long-term rights to crop production, such as plantations of bananas, coffee, and tea. In the case of delayed business continuity after a disaster, to the extent that leaseholders have options to exit concessions early, the risk may ultimately be faced by the government or private landowners, as happened in the 2011 Thai floods (Anbumozhi, 2015). For smallholding farmers, who are likely to have few alternative options, or those locked into long leases, the cost of stranding will be borne directly by concession-holders. Small farmers may be particularly at risk as they lack the resources to invest in adaptation measures to manage physical and environmental risks or to diversify into alternative investments/business models in the face of regulatory risks.

**Table 3. Relationship between Actors and Impacts on Stranded Asset Risks**

	<b>Stranding Risk Factors</b>	<b>Physical Assets</b>	<b>Financial Assets</b>	<b>Societal Assets</b>
<b>Physical</b>	<p>Increased vulnerability</p> <p>Loss of natural capital</p> <p>Increased health risks</p>	<p>Degradation of food production infrastructure due to disasters</p> <p>Damage to transport infrastructure</p>	<p>Loss of value for producers and retailers</p> <p>Loss of value for both government and private infrastructure owners</p>	<p>Loss of natural capital and reduction in ecosystem services</p>
<b>Economic</b>	<p>Making resilient food value chains</p> <p>Adapting to climate change variability through technological changes</p>	<p>Change in demand for agricultural commodities at the local, national, and regional levels</p> <p>Regulations related to the Sendai Framework and COP 21</p>	<p>Loss of value for upstream and downstream producers and unsustainable food production in disaster and climate prone areas</p>	<p>Impact on national employment, tax revenues, and trade</p>

Source: Authors.

Larger scale stranding can impact actors involved in the FVCs. These include the owners of infrastructure, such as dedicated roads, railways, or port terminals, to transport logistics of food commodities that have become obsolete. Distributors and retailers may also be exposed to risks, especially if there are major changes in food production patterns over a long period. Global food commodity values are dominated by a small number of large corporations that may well be able to absorb the impact of individual risks and maintain market dominance by adopting diversified portfolios. Nonetheless, there may be impacts on company values if production and consumption patterns shift as a result of disasters and climate change. Given the FVC progresses from the producer via the distributor, the risk of a significant impact from stranding is likely to diminish the closer the position is to the consumer. This applies not only to private companies but also to shareholders and investors in publically traded

companies. The scale of risk to the financial and insurance sectors may be determined by the same factor.

Stranded assets along the FVC could be influenced by natural capital. Natural capital is not currently included in farmers' income and corporate balance sheets, and hence the role that natural assets play in underwriting financial value and the risk associated with these assets is often insufficiently recognised. Caldecott et al. (2013) identify that there is a 0.5% chance and annual natural capital losses of US\$6.3 trillion, US\$8.7 trillion, and US\$11.2 trillion in the current, moderate, and extreme scenarios, respectively. Regulatory efforts may be forthcoming, aimed at giving more weight to natural capital considerations in determining financing value and therefore increased risk values of those stranded assets.

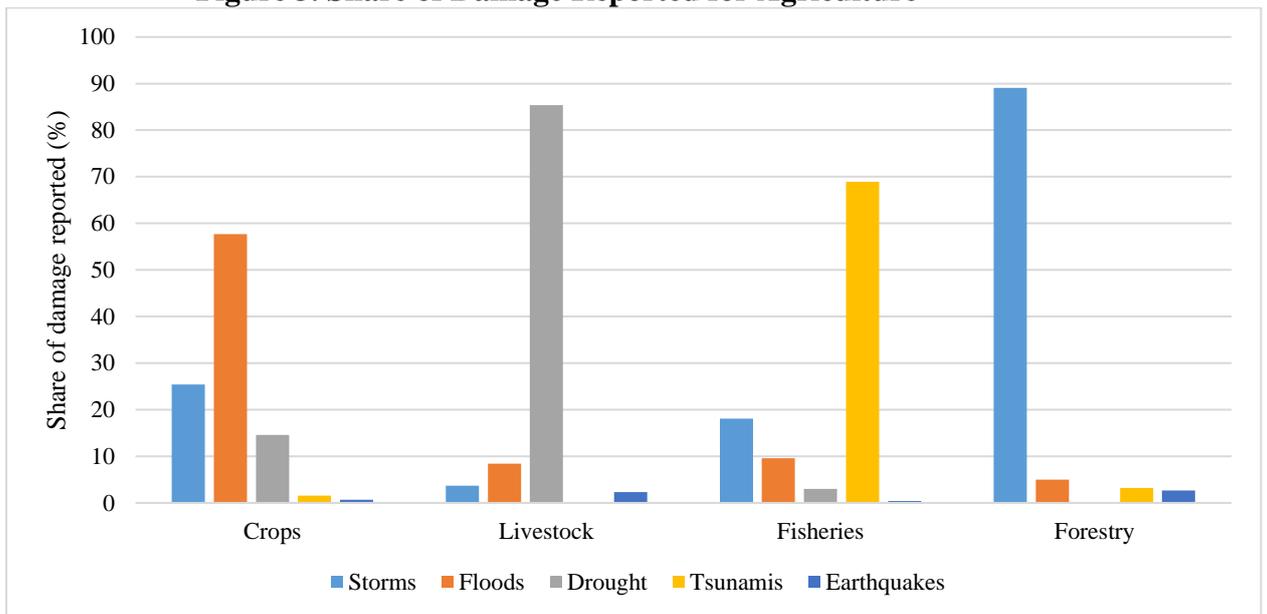
#### **4.3. Disaster Risk and Stranding in the FVC**

FVCs represent an essential part of the global food system. Exposure and susceptibility of agricultural value chains to external shocks and natural hazards can have cascading and far-reaching effects on global food security. The discussion of disaster risk on agricultural assets in this paper is framed around the FVC. Between 2003 and 2013, natural disasters, such as storms, floods, drought, tsunamis, and earthquakes, caused an estimated loss of US\$1.53 trillion, affecting 2.02 billion individuals and causing 1,159,925 deaths (CRED, 2015). Markets are additionally affected by disasters through food prices. For instance, the food price index in 2011 was more than double its value in 2002, signifying the longest sustained cyclical rise in actual agricultural commodity costs over the last 50 years. This was due to factors such as the three droughts in Australia between 2001 and 2007, a heat wave during the summer of 2010 in central Asia, and other calamities (FAO, 2013). Also, economic losses connected with land degradation have recently been estimated at US\$490 billion per year, equalling 5% of total agricultural GDP (UNCCD, 2013).

FVCs are vital to focus on when studying disaster risk because of the risk of significant asset value loss. Disaster risk additionally poses the threat of the disintegration or destruction of agricultural value chains. In the case of extreme disaster risk events, elements of the value chain may become disengaged, leaving other components potentially more susceptible. An outline of disaster risk and vulnerability

in the FVC is listed in Table 1. Most of the literature has concentrated on disaster risk merely at the level of production, as it is a critical component of the FVC. Disasters can cause considerable damage to the physical assets of agriculture, such as farmland, crops, irrigation systems, livestock shelters, and aquaculture equipment, which affects production. Disasters strand natural assets through ecosystem degradation and loss, including increased soil erosion, declining rangeland quality, salinisation of soils, deforestation, and biodiversity loss. Accumulative ecosystem loss or degradation reduces the availability of commodities and opportunities to producers (FAO, 2013), thus affecting the human assets of agriculture. Reduced production of crops, livestock and aquaculture, and forestry causes significant economic losses to farmers (Figure 3), which frequently includes a ripple effect on the FVC (FAO, 2013). The data are from a total of 75 disasters, including storms and floods, which occurred between 2002 and 2011.

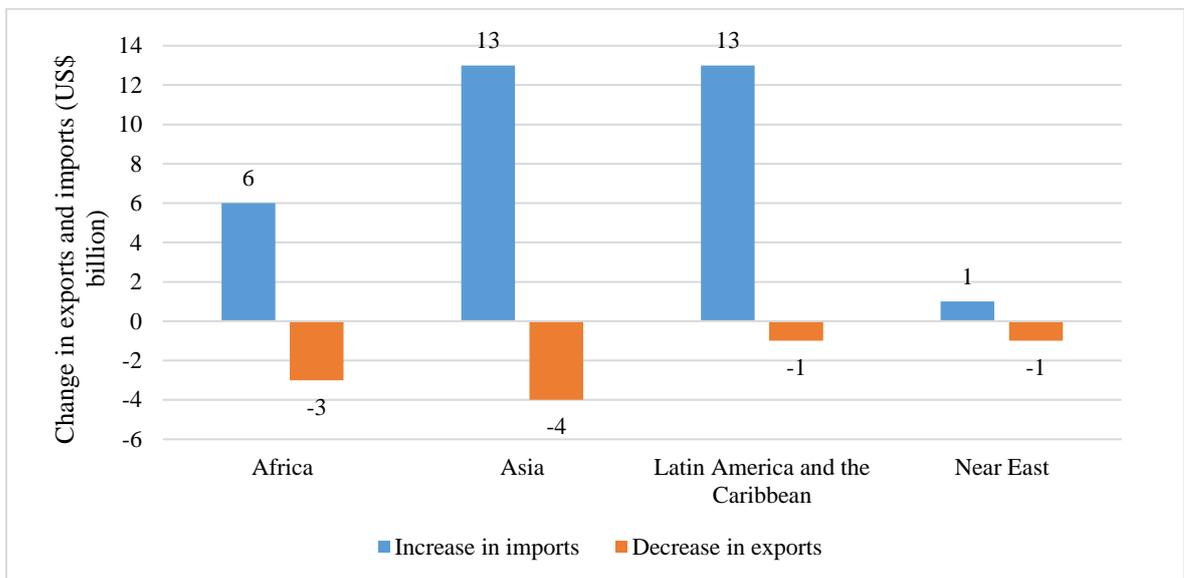
**Figure 3. Share of Damage Reported for Agriculture**



Source: FAO (2013).

A reduction in agricultural production after a disaster can induce changes in agricultural trade flows, which can thus boost imports and reduce export revenue, affecting the social assets of agriculture. A comprehensive analysis conducted by the FAO of 116 disasters influencing 59 developing countries between 2003 and 2011 discloses that food imports expanded by US\$33 billion after the disasters over the period, equating to 28% of the estimated value of imports (Figure 4). Production losses can lessen agriculture value added or sector growth, vital drivers of GDP and economic development. According to an appraisal of the 125 disasters that impacted 60 developing countries between 2003 and 2013 by the FAO, a substantial fall in agriculture value-added growth occurred after the disasters.

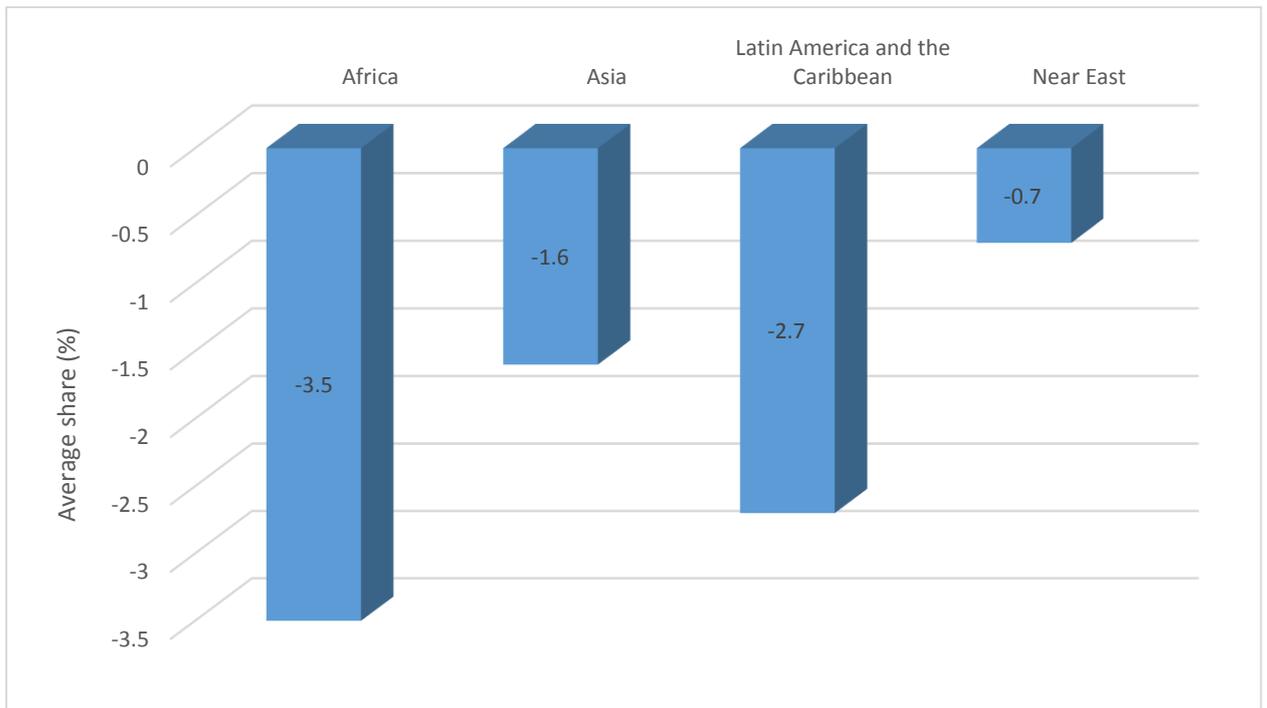
**Figure 4. Decreases in Exports and Increases in Imports after Disasters**



Source: FAO (2013).

In 55% of the events assessed, a decline in agriculture value-added growth in the year of the disasters was observed, with 1.6% in Asia disasters between 2003 and 2013 by region (Figure 5). (FAO, 2013). At the level of processing and distribution, disasters can cause destruction to infrastructure, for example facilities for storage, processing, marketing, and transport, and buildings and equipment of farms and cooperatives. Damage to transportation and storage services ultimately will have an effect on the distribution of food and on consumers. Communities will encounter an increased threat to nutritional values along with uncertain but undeniable adverse effects on food quality and quantity. More frequent disasters are already having a significant impact on the agriculture sector in developing countries. For example, severe droughts followed by flooding in 2014 caused a sharp decline in the palm oil sector in Indonesia (Falatehan and Setiawan, 2016).

**Figure 5. Average Share of Agriculture Value Added Growth Lost after Disasters**



Source: FAO (2013).

From an investment perspective, such declines are not necessarily problematic in the medium term. In mid-2015, for example, it was predicted that production would decrease by 6% in the event of a moderate El Niño in Southeast Asia and would drop by 15%–20% if the occurrence was extreme. However, while the initial impact might be a downturn in business, price increases usually follow. El Niño events in 1997–1998, 2006–2010 and 2010–2014 contributed to price increases of 75%, 40%, and 22%, respectively (Malay Mail, 2015). This would suggest that awareness of risks in the business community needs to be enhanced to manage the impacts along the value chain.

#### **4.4. Climate Change Risk and Stranding in the Food Value Chain**

Rising temperatures, altered precipitation patterns, and recurrent extreme weather events are occurring due to climate change across the globe, and all have significant negative effects on the world economy (Olesen et al., 2004). Climate change impacts typical temperatures as well as extreme temperatures, raising the likelihood of

environment-related natural disasters. Climate change is among the key factors influencing the agro-food production and farming practices globally (KPMG, 2013).

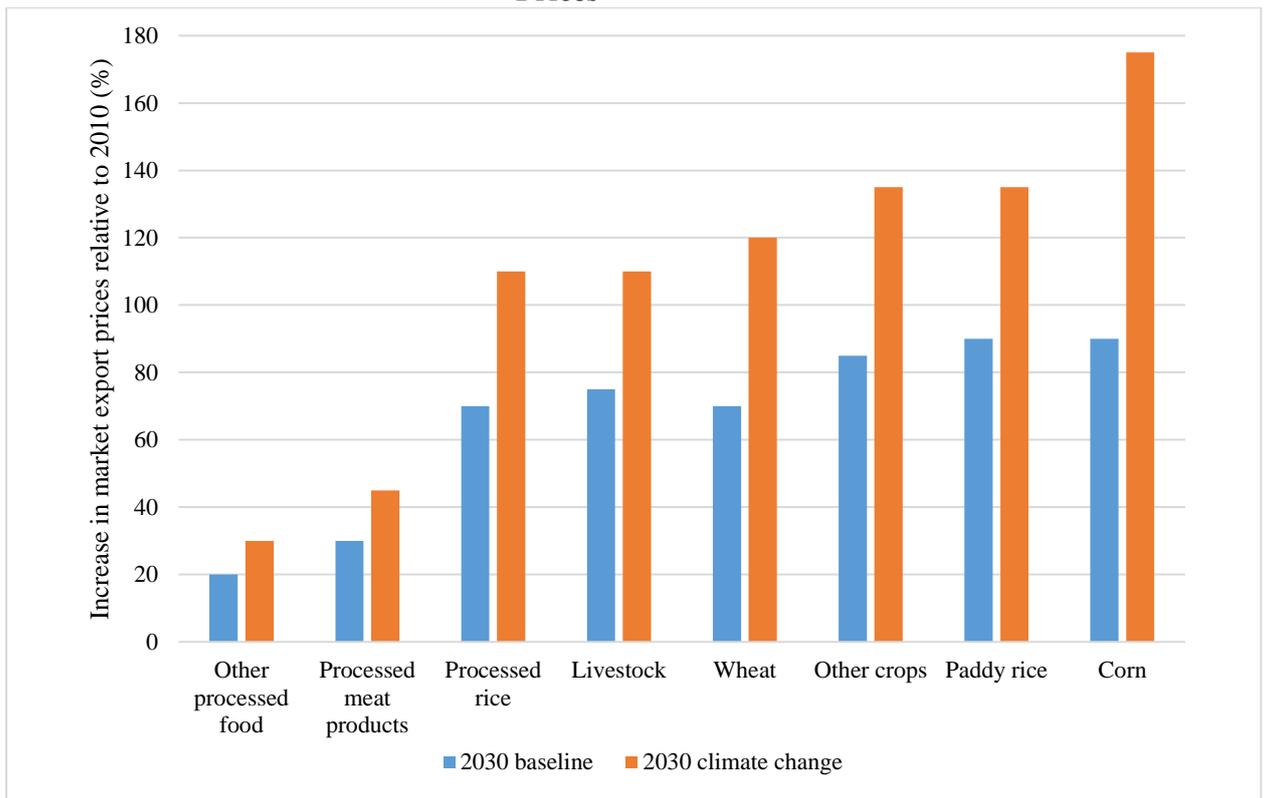
Climate change affects FVCs notably at the production phase because farmers are the least prepared to adapt (KPMG, 2013). Climate change risks are important and extend from production to additional elements in the FVC. Over the past several centuries, rapidly expanding human-induced emissions of greenhouse gases have triggered changes in rain patterns, increases in worldwide average temps, and rising sea levels. Altered rainfall patterns, greenhouse gas emission, and increasing temperatures have immediate effects on crop yields (IPCC, 2013). For example, yields of maize and wheat are sensitive to heat. For each day the temperature rises above 30°C in the growing period, the final yield will fall by 1% under optimum rain-fed conditions and by 1.7% under drought conditions (Lobell and Field, 2007). Not only do crop yields diminish as a result of high temperatures, but growth rates, including dairy production, meat from animals, and fisheries, decrease in extremely warm or cold scenarios (OECD, 2009). Therefore, the physical assets of agriculture, for example multi-year plantation harvests, have been designated as exceptionally susceptible to changes in annual precipitation patterns and amounts (OECD, 2009).

Processing, packaging, and storage are liable to be influenced by altered temperatures that could raise spoilage and prices. Rising sea levels and changing rainfall patterns change water levels in lakes and rivers, and severe heat can obstruct railroad, water, and street transport. This has an impact on producers, distributors, and retailers. Rising temperatures can also make utilisation more challenging by raising food safety risks and may be a concern for consumers and human assets of agriculture (Caldecott et al., 2013).

Social assets, such as agricultural cooperatives, networks for distributing and marketing produce, and finance relationships between farmers and agribusiness, are less vulnerable to climate change. Financial assets, including farm loans from banks and other financial organisations, can handle and are also less susceptible to stranding (Caldecott et al., 2013). Climate change is additionally affecting the water supply in some regions. Large volumes of water are required for pumping and treating water, and moving expansive volumes of water requires a lot of vitality. This will be a huge problem for the world's food producers, who need to overcome the challenges of

climate change. Climate change appears to have increased interest in agricultural exports from regions that experience production problems yet have sufficient finances to purchase imports, and it is likely that improved export demand will be met in the near term. Figure 6 shows the data predicted for 2030 calculated relative to 2010 for both the 2030 baseline and 2030 climate change scenarios.

**Figure 6. Predicted Impacts of Climate Change on World Market Food Export Prices**



Source: Oxfam (2011).

In graze farming that is intensive, climate change risks can result in a significant reduction in the forage that is available to livestock. Particularly, famine may cause decreased rate of the herd or in extraordinary instances the liquidation of gain (Stockton et al., 2007).

In summary, the stranding of assets from change climate is already occurring. Inertia in the climate change system means that decision makers and investors need to seriously think about the adaptive measures and mitigation options along the FVC.

However, research and public debate have not yet made the connection between climate-induced impacts and stranded assets.

## **5. Regulatory Risks of Stranded Assets**

As discussed earlier, the impact of disasters and climate change has been largely studied and to some extent quantified. A lack of detailed data along the FVC and modelling means that it is not possible to state in detail the potential financial losses. Nevertheless, the timeframe in which certain policies are implemented is also likely to have an impact on investment, shares, and assets.

At the global level, the Sendai Framework for Disaster Risk Management, the Sustainable Development Goals (SDGs), and the Paris Climate Agreement possess both regulatory risks and opportunities for increasing the value of stranded agricultural assets. The Sendai Framework is a 15-year, voluntary agreement that recognises that the state has the primary role in reducing disaster risk but that responsibility should be shared with other stakeholders, including local government, the private sector, and other stakeholders.

The framework set out seven targets to (i) substantially reduce global disaster mortality by 2030, aiming to lower the average per 100,000 global mortality rate in the decade 2020–2030 compared to the period 2005–2015; (ii) substantially reduce the number of affected people globally by 2030, aiming to lower the average global figure per 100,000 in the decade 2020–2030 compared to the period 2005–2015; (iii) reduce direct disaster economic loss in relation to global GDP by 2030; (iv) substantially reduce disaster damage to critical infrastructure and the disruption of basic services, among them health and educational facilities, including through developing their resilience by 2030; (v) substantially increase the number of countries with national and local disaster risk reduction strategies by 2020; (vi) substantially enhance international cooperation to developing countries through adequate and sustainable support to complement their national actions for implementation of the framework by 2030; and (vii) substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments for the public by 2030.

The Sendai Framework along with other international goals and agreements reached in 2015, such as the SDGs and the COP21 Paris Agreement, represent another source of change that may affect investment in the FVC. The SDGs will influence international development priorities in the period 2016–2030, i.e. in a period that is highly relevant to stranding. SDG 2.4. by 2030 aims to ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production; help maintain ecosystems; strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters; and progressively improve land and soil quality.

In addition to the SDGs, the ratchet mechanism in the Paris Agreement, whereby pledges will be revisited every 5 years to close the gap with the below 2<sup>0</sup>C trajectory, should result in increasingly ambitious mitigation targets. If resources are adequate, the Sendai Framework, the SDGs, and the Paris Agreement could have a significant impact not only on agriculture production systems through regulations that do not support sustainable development targets but also investments in those systems.

It is difficult to assess the extent to which investment mechanisms as a part of FVC resilience have the potential to cause stranding. Much depends on whether active markets for such instruments are created and international financial flows come to developing member countries in Asia. Another concern is the time lag between ratification of the Paris Agreement and its scheduled targets in 2020. This means that the necessary incentives for FVC resilience may not be in place for some time to come.

Other domestic disaster risk management and climate adaptation policies could increase the risk of stranding, e.g. government aims to mainstream climate change and disaster management in agricultural sectoral planning. Regulations that affect future food production through domestic policy aimed at actions to limit unsustainable agriculture could result in stranding risks along the FVC.

## **6. Principles of Enhancing Food Value Chain Resilience to Disasters**

The degree to which disasters cause disruptions along the FVC and create food insecurity changes depend on several variables, including the nature, location, scale, timing, and size of the disaster, the vulnerability of the populations to shocks, as well as the strategies introduced by governments to alleviate the effects of disasters.

Disaster risk reduction strategies may be executed on several levels. FVC resilience to disasters and protecting agricultural assets relies upon various factors, such as prior experience, perception of danger, studying of the characteristics, and understanding the value of the risk. A number of disaster strategies are discussed below, centred on previous studies and various factors.

### **6.1. Disaster Profiling and Preparedness**

Strategies to implement disaster risk reduction should be established through evaluation and prioritisation of the risks that people face, as well as their ability to adapt and resist the effects of those risks and protect their assets. Assessment of a disaster incorporates typology, recurrence, and severity of the hazard. It should also recognise the geographical communities and areas that are most exposed to disasters and evaluate the functions of livestock, agriculture, fishery, and forestry in disaster risk management and their linkages with other associated institutions (FAO, 2008). Involving communities in disaster management and transforming them into disaster resilient communities includes understanding the risks and creating response plans that are appropriate.

Disaster management relies upon the source of information and early warning (Eiser et al., 2012). Preparedness measures should be taken immediately before an estimated or introduced risk to reduce the possible impacts. Essential elements of disaster preparation include forecasts, the issuing of warnings and alerts, contingency planning for post-disaster scenarios, protective infrastructural actions, and household-level readiness actions. Nonetheless, to be able to be effective and assure disaster risk reduction in agriculture value chains, alerts must be linked to information on the possible impacts on the agriculture market and precautions to reduce the hazard. Risk-related measures in agricultural value chains include raised seed beds, proofing of storage facilities, livestock shelters, and strategic animal fodder reserves, which ensure the protection of physical agricultural assets and their value.

### **6.2. Diversification**

Diversification is considered an important aspect of disaster risk reduction. Fundamentally, diversification in agriculture is adding new crop varieties and new

strains of livestock. Diversification is a vital resilience strategy for agro-value chains and is required to preserve ecosystem functioning (Lin et al., 2011) and the natural assets of agricultural systems. This essentially entails research and development to produce new varieties that can withstand natural disasters. National and international research organisations have produced many tolerant varieties and are continuing to produce many more. This strategy minimises susceptibility by increasing the commodity choices for producers. This, in turn, allows a manufacturer to improve its versatility and control uncertainties (Hallegatte, 2009). Crop diversity using locally adapted varieties is widely used as a method for supporting adaptive capability (Muller and Niggli, 2013).

A project of the USAID office of US foreign disaster aid executes the disaster risk reduction Hyogo framework programme to target disaster-prone areas in southern Africa. In the programme, through crop diversification, communities have increased the diversity of their plots with more drought-tolerant legume species and types. Diversification has improved soil fertility, increased the consumption of proteins, and diversified the inhabitants' diets (Heady and Kennedy, 2012). Diversification also consists of the ability to obtain different markets or aspects, such as the ability to alter livestock or cropping choices quickly and with minimal consequences. Overall, diversification can offer resilience to agricultural systems by protecting natural, physical, and human assets of agriculture.

### **6.3. Risk Transfer**

Risk transfer refers to the transfer of the potential financial consequences of particular risks from one party to another, saving the financial assets of agriculture. It has been a critical component of disaster risk reduction management in agriculture around the globe. Resources commonly include insurance, government-managed contingency, financial devices, and subsidies. These enable the poor, smallholders, and the most vulnerable farmers to make investments that increase their profitability (Hill and Pittman, 2012).

Insurance is employed to reduce hazards by pooling the regular payments of several clients and paying out to those affected by disasters. Payment schedules are set according to statistical information on loss occurrence and offset the loss from natural

disasters for farmers in the value chain. Another initiative is micro-financing to promote investments for producers for the value of micro-credit that allows the safeguarding of potential disaster shocks to production (Johnston and Morduch, 2007). With the safety of risk transfer, when an adverse event like a drought or flooding hits, farmers receive automated insurance pay-outs so they do not have to consider desperate measures, such as attempting to sell off their physical assets, such as land or livestock, or take their children out of school.

For example, impact evaluation by the Horn of Africa Risk Transfer for Adaptation (R4/HARITA) project in Ethiopia shows that insured farmers save more than twice those without any insurance, and they invest more in seeds, fertiliser, and productive assets, such as plough oxen. Farmers in one cluster of villages tripled their grain reserves compared with uninsured farmers. Women, who often head the poorest households, achieved the largest gains in productivity through investing in labour and improved tools for planting (Oxfam, 2014).

#### **6.4. Sustainability Intensification**

Sustainability options in the context of the disaster risk reduction direction in FVCs deliver disaster reduction that is cost effective, aids biodiversity conservation, and enables progress in economic livelihoods and individual well-being, especially for vulnerable and poor producers (Hill and Pittman, 2012). Adaptation strategies for sustainable intensification based on ecosystems – including crop improvements; soil conservation; conservation agriculture; forest conservation, such as mangrove conservation and sustainable forests; integrated pest management; livestock and fodder crops; and fisheries management – also minimise the scope for maladaptation in developed and developing countries (Keys and McConnell, 2005; Pretty et al., 2011). Sustainable intensification has the potential to meet future demands on agriculture to conserve the natural assets of agriculture by farmland improvement and ecosystem management.

In the past, intensification has been most successful when followed by associated institutional ability when it comes to strategies for technology exchange and risk management (Keys and McConnell, 2005; Pretty et al., 2011). For instance, integrated sustainable palm oil production projects by Conservation International have supported

the demand for sustainably produced palm oil from processors and traders, as well as manufacturers and retailers. Demand signals from companies that use and sell palm oil within their products or process palm oil can create strong incentives to producers to adopt more sustainable practices as well as fortify market-based sustainability initiatives. Conservation International is having a driving influence in the improvement of national and international policy incentives for sustainable palm oil (Conservation International, 2014).

### **6.5. Efficient Use of Resources**

Effective use of natural resources assists in reducing susceptibility to multiple natural disaster risks in several circumstances. In a broad sense, elevated efficiency typically results in lowered vulnerability through lowered dependence on essential resources and enhanced resource management. Given that 40% of global food production comes from irrigated systems and 20% of the arable land are marginally located, investment to enhance water productivity in current schemes and safely expand irrigated agriculture may be needed for long-term food security (Rosegrant et al., 2009). This requires a strong focus on procedures and new technologies to ensure maximum effective water use and protect essential natural and financial agricultural assets. This involves crop varieties that use water efficiently (greater yield per water used), drip or low pressure irrigation systems for watering crops, lining waterways (canals/pipes) to decrease water loss in delivery systems, and helping to target the water where it can be used most effectively (Pittman et al., 2011).

Micro irrigation or low pressure irrigation systems, coupled with filters to clean water and smart-metred solar utility models for irrigation pumps in Sub-Saharan Africa have helped to deliver water and nutrients directly to the roots of crops, resulting in more efficient use of resources to gain greater yields (Burney et al., 2010; Burney and Nolan, 2012). Resource-use efficiency also offers several other benefits as well as disaster risk reduction. Regarding nitrogen and phosphorous use, efficiency may assist in handling rising difficulties and externalities. Important opportunities exist for increasing nutrient-use efficiency and hence also reduce greenhouse gas emissions in the circumstance of integrated utilisation of both inorganic and organic fertilisers.

## **6.6. Good Governance**

Good governance will be crucial in managing the human and social assets of agriculture by supporting farmer groups, supporting private sector investment in agriculture, and implementing resources and accountability actions but also for setting clear restrictions on the unsustainable exploitation of forests, water, land, and fisheries. The governance of disasters anchored in a whole ecosystem and society-based strategy provides the basis for the successful execution of disaster risk reduction. It is essential to support cooperation between the public and private sectors for creating incentives and supporting activities and policies that encourage risk reduction. Policymakers, scientists, agricultural professionals from all sectors, and farmers are required to have the right knowledge and information. Institutional mechanisms and disaster risk reduction policies are required to support the implementation of proper actions at the local community level.

Accessibility to value chains for small-scale agricultural producers, in relation to market governance, can contribute significantly through the ability to handle disaster risks by improving access to resources used in coping or adapting. Small-scale producers in many cases are competing with altering food system dynamics, such as the development of large-scale supermarkets and shifting consumer demands. Several changes have happened through public investment, market liberalisation, urbanisation, and rising incomes in developing countries (Reardon et al., 2009). Good governance always requires linkages between traders, processors, markets, producer associations, and the R&D community to develop new market opportunities. Collaboration between traders and producers ensures the quality and quantity of production in discrete geographic areas (Thiele et al. 2011).

## **6.7. Disaster Risk Reduction Case Studies**

Resilience relates to the ability of people to absorb and recover from shocks and stresses while adapting and changing their communities and livelihoods to defy the effects of potential events and protect their assets. Resilience to disaster management and adding value to the value chain depend on communities and their environmental risks. Approaches to resilience by communities should be based on the environment and specific needs. Mbeere County in eastern Kenya is a semi-arid region that faces

frequent droughts every 18–24 months, and farmers are more dependent on rain-fed agriculture. With frequent droughts, the crop yields and vegetation produced are lost by the communities.

Catholic Relief Services (CRS), Kenya; Caritas Embu; and the International Small Group and Tree Planting Program initiated a project called the Green Gram Value Chain Project in 2009 to increase food security through innovative agricultural and livelihood diversification initiatives. Strategies have been executed in the ‘green gram value chain’ to improve the livelihood of the farmers, add value to the value chain, and protect agricultural assets. The project reinforced the green value chain through diversification by helping 2,200 farmers to plant drought-tolerant green gram over maize and beans to mitigate drought, which was essentially built upon the previous lucrative legumes project funded by the United States Department of Agriculture, CRS, and Caritas. The project additionally formed a producer advertising group to distribute the seed, construct seed storage space, and negotiate with traders for higher green gram costs. The project encouraged conservative agriculture by training the farmers to optimise water retention and minimise land disturbances. Many trees were planted to save natural assets, minimise rising temperatures, and intensify sustainability. CRS helped farmers to invest in fertilisers and seeds and also helped farmers to receive small-scale loans. The project involved small-scale farmers and motivated women to participate. The outcomes of the project included improved yields despite low rain due to drought-tolerant seeds, improved accessibility to resources, and greater savings compared to the other farmers who did not participate in the project. Farmers who participated in the producer marketing groups found the groups to be extremely useful and continue to carry out activities on their own. The region is covered with more trees, has improved soil conditions, and has better preserved natural resources (DeVoe, 2013).

## **7. Climate Resilience and Managing Stranded Assets along the Food Value Chain**

Unpredictable weather can be devastating for agricultural production, but climate change effects stretch beyond production, affecting the whole FVC from the quality of seeds through to how food is processed, transported, and consumed. A changing climate can change the whole chain of value-adding activities for agricultural commodities, from production and processing to marketing and consumption of the final product (Reddy, Singh, and Anbumozhi (2016). Sustainable FVC development can only be achieved if all actors along the value chain work together to address climate change hazards. This implies that actors must look beyond their own actions on the value chain to consider how activities and other actors may be affected by risk management choices and climate risks (Oxfam, 2014).

The need to assess climate change risks, recognise opportunities, and increase resilience is clear. The World Bank, FAO, International Institute for Sustainable Development, Oxfam America, World Food Programme, and some industries are taking the road towards climate resilience using a value-based approach. The most successful approaches to climate resilience span the value chain, integrated within core corporate strategy, projects, and endeavours. Distinct frameworks are proposed to construct paths towards climate resilience. The following are some recommended steps for building FVCs that are climate resilient and also conserve agricultural assets.

**(a) Risk evaluation.** Investigate the vulnerability of the FVC to climate and identify the areas of risk to agricultural assets across the entire value chain. Environmental risks can be evaluated based on information from different sources. Exposure can be assessed based on the understanding of preceding crop and livestock losses on account of extreme climate conditions, such as high temperatures, heat waves, and drought. This will enhance the capacity to build climate resilience FVCs and protect the value of assets.

**(b) Strategy development.** Design and execute climate change risk reduction strategies based on the identification of the main impacts of climate change on agriculture. While developing the strategies, the risks that farmers are now facing must

be considered along with the threats they may face in the future. Assemble the right team to address climate resilience involving local small-scale farmers and women who are vulnerable to climate change impacts. Raising awareness on climate change and capacity building to address the impacts along the FVC can be significant. Operations, production supply, transport and logistics, government affairs, investor relations, and regional departments should be aware of climate change problems and impacts. The strategies should be implemented in a way that reduces the value of risk to agricultural assets.

**(c) Exploring the opportunities.** Foster R&D to generate crop/livestock varieties that are tolerant to the changing climate. Recognise opportunities for new markets to help communities adjust and prospects to utilise new tolerant crop or livestock varieties to create green agriculture value chains. Partnering with private and government sectors is vital to achieving climate resilient value chains. Concentrate on extension services of agricultural research to create knowledge/helping centres that support farmers and encourage sustainable agriculture.

**(d) Strategy implementation.** Implement the strategies by prioritising the actions and testing the new varieties of tolerant crops or livestock. Attempt to use alternative water resources or new irrigation techniques to handle more varying drier climates and maximise the use of resources. Execute climate resilience actions in partnership with those who can mutually benefit from them. Assist producers to avert, cope, or recover from climate change impacts. Enhance access to finance through loans and subsidies that can support climate adaptation value chains.

**(e) Progress evaluation.** Research and track the ongoing impacts of climate change on livestock and crop production and the progress of the value chain from producers to consumers. Identify possibilities to maintain climate resilience across the entire value chain and protect the assets of agriculture. Also, assess the economic benefit-to-cost ratio.

**(f) A value chain approach to a climate resilience case study.** In a case study, Conservation International partnered with Starbucks, the largest coffeehouse business in the world, to follow a value chain method to make coffee that is environmentally sustainable, transparent, and climate resilient, and also beneficial to people and the planet. They planned and implemented a programme called Coffee and Farmer Equity, or CAFÉ, with coffee farmers to encourage environmentally sustainable growing practices, create new income flows from conservation and carbon markets, and supply loans for sustainable business development. CAFÉ practices include maintaining coffee canopy shades, which provide cover assistance to control the temperatures and extreme heat. Conserving processed water and minimising irrigation by resource use efficiency helps farmers be ready for potentially fewer water resources. Starbucks additionally supported the medium and small-scale scale farmers by supplying loans through Verde enterprises. Both partners continued their support by creating farmer support centres to provide guidance and resources to lower the price of production, reduce fungus diseases, improve coffee quality and raise the yield of superior premium coffee. The results of the project include advantages to the farmers practising CAFÉ, with improved income and higher sales in comparison with farmers not following the practices; decreased use of chemical fertilisers, pesticides, and herbicides; and greater equilibrium of local natural habitats. CAFÉ practices lead to more climate resilient coffee value chain communities and encourage economic development (Conservation International, 2012).

There are potentially significant risks of stranding, both from regulation and climate change impacts on the Starbucks value chain. In order to minimise stranding risks, corporations and communities will increasingly have to consider changes to regulatory frameworks. A focus on sustainable coffee production with the right adaptation strategies may be able to manage some physical risks.

## **8. Conclusions**

This paper discussed the effects of environmental risks, such as natural disasters and climate change, that cause asset stranding in agriculture as well as an evaluation of where and how environment-related risk factors can affect assets across the FVC

and therefore the components of it. The amount of value potentially at risk and the reduced value-added economic growth globally is considerable.

There are credible reasons why stranded assets in agriculture may result from the increased frequency of disasters and climate change. These are driven by both the physical impacts and by regulatory responses by the actors along the FVC. The plan of action to protect agricultural assets and different components of the FVC to develop disaster and climate change resilient chains have been summarised in this paper. The actors in the FVC play roles that are distinct in managing environmental risks through preparedness, as each of the elements in the FVC is interdependent and all must work in coordination to ensure an effective response to disasters. Working towards the resilience of agricultural systems can be an effective way of reducing disaster risks and protecting the assets of agriculture. As illustrated in this paper, there are a number of options for pursuing this goal. The discussions include disaster profiling and preparedness, diversification, risk transfer and sharing, maximising resource use efficiency, and good governance.

There are several benefits associated with a value chain approach to climate resilience. Climate change impacts all actors in the FVC and the value-added activities of agricultural commodities, from production and processing to marketing and consumption of the final products. The value chain approach is an integrated approach that provides important opportunities for creative collaborations to develop a sustainable value chain and protect the value of agricultural assets. This approach concentrates on local communities and the natural ecosystem as a result of their essential functions within FVCs.

Ecosystems supply services and natural products of significant economic value to businesses, for example water treatment and flood protection. These activities are recommended for climate resilient value chain improvement. Decision makers should evaluate the risks to develop the strategies, implement the strategies by exploring opportunities, and track them from time to time. They should also enhance marketing and partnerships for climate adaptation along the value chain by strengthening existing platforms. Government and financial services businesses need to develop fresh and flexible financial products to support climate resilient and inclusive agro-value chains through innovative public-private partnerships and capacity building.

Greater comprehension of the environment-associated risks that strand assets in agriculture and affect FVCs and building risk management strategies may help traders and policymakers minimise VaR and improve resilience.

It is at present difficult to precisely analyse the stranding risks in economic terms. The likelihood of stranding is subject to a range of uncertainties, among them how disasters and climate change affect geographies, how different actors respond, and how farmers and consumers adapt. Further study of the risks of stranding is greatly needed, as are the strategies for how the risks can be managed by investors and companies. This should be done through assessing the physical impacts of extreme weather events on investments, taking into account the role of the insurance industry as well as price fluctuations generated by production decline and the resulting impact on assets and their performance. Research in this area could be used to initiate discussions with key producers, retailers, and consumers along the FVC about the risks of stranding that may result from their strategies and policies.

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