Vulnerability of Agricultural Production Networks and Global Food Value Chains Due to Natural Disasters

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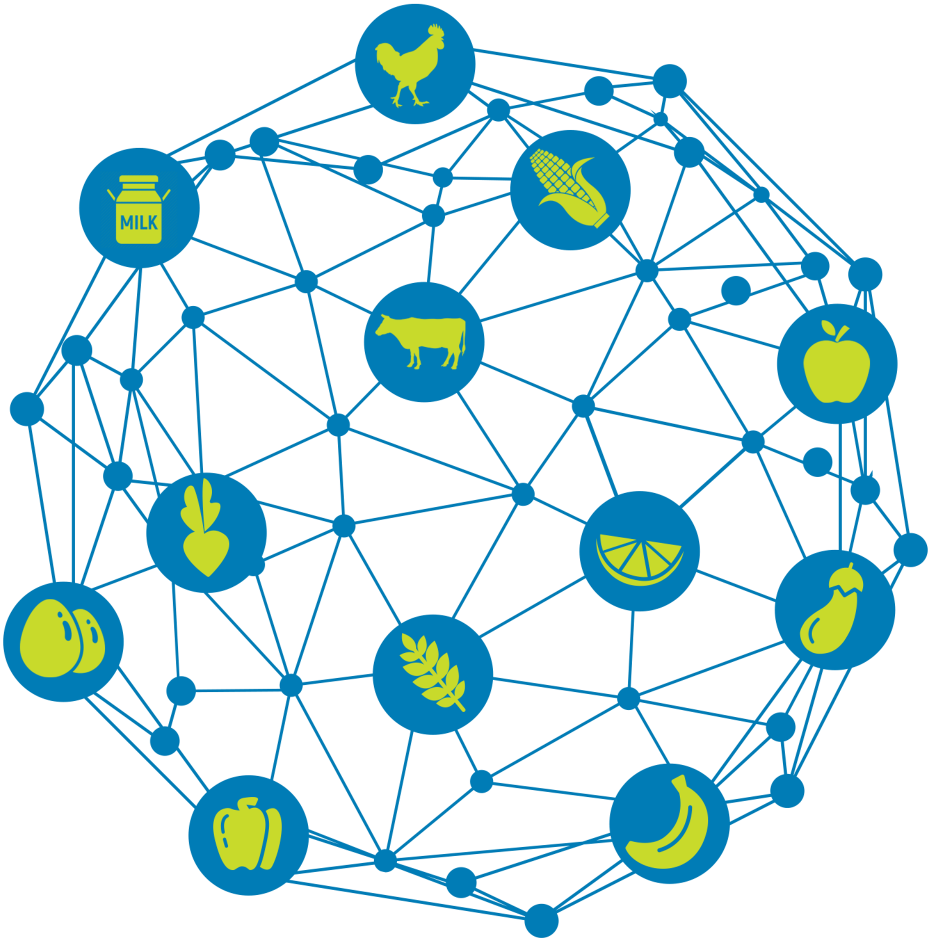

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FOREWORD

In 20–24 June 2016, 33 scientists and policymakers from the United States, Asia, and Europe met in Vienna, Austria, for a conference called 'Vulnerability of Agricultural Production Networks and Global Food Value Chains Due to Natural Disasters'. The conference was organised by the Economic Research Institute of ASEAN and East Asia in cooperation with the Technische Universität Wien, and supported by the OECD Co-operative Research Programme: Biological Resource Management for Sustainable Agricultural Systems.

The host country of the conference has increasingly been experiencing more extreme weather events including storms, floods, frost, hail, snowfall, and droughts. The annual damage in various economic sectors increased from less than €100 million annually during the 1980s to over €700 million during the first decade of this millennium. For a long time, agriculture and food value chains were spared major damage. The year 2016, however, brought serious challenges for the agricultural sector and damage amounting to several hundred million euros in the first half of the year alone. I welcome the initiative of many distinguished international scholars to shed more light on this topic.

Global food production will need to increase by 80% before 2050 to guarantee the appropriate supply of food for the expected nine billion people on earth. We face challenges in food quantity, food quality, increased natural hazards due to climate change, a deterioration of the natural resource base such as productive soils or fresh water resources, and an increasingly globalised food market with value chains that are both more efficient and more fragile.

Agricultural value chains have become more sophisticated and larger in scale with more stakeholders. Due to the increased complexity and dependences, the vulnerability of agricultural production networks is increasing. More disasters coincide with higher levels of vulnerability. These increase damage and loss in individual units of the agricultural value chain and demand sophisticated countermeasures even at places not hit by disasters. Increases in prices for agricultural products and higher premiums for insurance against extreme climate events are just two perceivable consequences.

The wide perspective of related topics discussed in Austria and outlined in this report will help create an appropriate awareness on this issue and support planning for benign actions in many countries. For our sector to prosper, we must ensure that all actors – producers, intermediates, and consumers – face a secure future and are given the perspectives they need to continue their valuable work in uncertain times.

Andrä Rupprechter
Federal Minister of Agriculture, Forestry,
Environment and Water Management

Economic Research Institute for ASEAN and East Asia

FOREWORD

The global interdependence of food supply chains is well known. When one part of the agricultural production network is affected by natural hazards or climate-induced disasters, the consequences reverberate globally: supply decreases and food prices increase. In agricultural production systems, food supply, supply chain infrastructure, and transport to and from local markets are vulnerable to natural hazards. These reduce the availability and affordability of food in the region.

In the developing countries of Asia, for example, 22% of the total economic impact of natural disasters was in the agriculture sector: crops, livestock, fisheries, and forestry. Data, however, are scarce, so little is known about the substantial impact of natural disasters and climate change on the agricultural value chains and the disproportionate burden placed on people who rely on agriculture for their livelihood. No consistent accounting for direct and indirect agriculture losses from natural hazards exist in any of the primary global hazard databases, although some national databases separately record losses in agriculture.

To further understand the vulnerability of global food value chains and to assess policy implications from this understanding, the Economic Research Institute for ASEAN and East Asia (ERIA) co-organised with TU-Wien (the University of Technology Vienna) an international workshop on 20–24 June 2016. This event was sponsored by the Organisation for Economic Co-operation and Development (OECD) Co-operative Research Programme on Biological Resource Management for Sustainable Agricultural Systems. The workshop brought together leading academics from OECD countries and other international organisations to describe several approaches in building resilience to food value chains, share knowledge, and understand risk reduction more from different disciplinary perspectives. ERIA is happy to collaborate in that knowledge initiative.

I acknowledge the support of the Government of Austria's Federal Ministry of Agriculture, Forestry, Environment and Water Management and OECD for their efficient organisation and helpful support in planning and running the workshop. The essence of this joint effort can be captured in the recommendations that follow each chapter. These are collected in the summary section.

This book is based on papers presented and discussed in that workshop. It comes at a critical time as we are looking for innovative approaches to support the implementation of the Sendai Framework for Disaster Risk Reduction and the ASEAN Community Vision 2025. The chapters assist in clarifying resilient pathways in the vital process of disaster risk management and adaptation to climate change. As the authors continue to research, debate, analyse, and propose an enabling environment to food value chain resilience, new publications like this bring fresh insights into policy development.

Here we emphasise the need for holistic actions: for improved resilience of global food value chains rather than narrowly drawn sectoral approaches, for innovative disaster risk management measures rather than reliance on established patterns, and ensuring that governments and the private sector take the powerful lead in implementing robust institutional frameworks rather than entrusting the task to communities and international agencies. I am confident that this book will contribute to policy development and academic understanding in an area where new acumen is urgently needed.

Hidetoshi Nishimura
President
Economic Research Institute for
ASEAN and East Asia

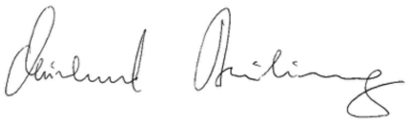
PREFACE

‘Vulnerability of Agricultural Production Networks and Global Food Value Chains Due to Natural Disasters’ was a conference organised by the Economic Research Institute of ASEAN and East Asia (ERIA), a Jakarta-based international institute, and TU Wien, and supported by the Organization for Economic Co-operation and Development Co-operative Research Programme: Biological Resource Management for Sustainable Agricultural Systems. It was attended by 60 participants and involved specialists in economics, natural resource management, and risk research from academia, industry, and public administration, as well as local stakeholders from the Wachau Region in Lower Austria, a rural wine-producing region some 80 km west of Vienna, Austria. Just a few weeks before the conference, the stakeholders had been affected by late frost events that damaged almost the entire 2016 harvest. This meant that nobody needed to be convinced about how timely the topic on our agenda was. However, perceptions of the problem by the participating individuals can be different for many reasons, including their professional orientation, country of origin, practical or theoretical approach, and kinds of risks and disasters experienced.

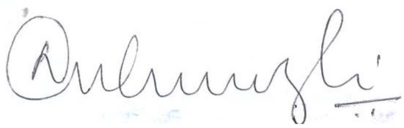
The topics of the four scientific sessions were: 1) the nexus of agricultural production networks and global food value chains and natural disasters; 2) natural disasters and agricultural production: numbers, models, measures, and current policies; 3) lessons to be learned for agricultural production networks and food value chains; and 4) decreasing vulnerability to natural disasters in agricultural production networks and food value chains. There were 30 contributors for the conference, 24 scheduled in the programme, two bus lectures during study tour, and two ad hoc presentations during session 4 by policymakers from Austria. In addition, there were four stakeholder presentations during the study tour in the Wachau Cultural Landscape.

In particular, the conference shed light on the fact that we are still at an initial stage with our subject and that it will occupy us much more during the coming years or even decades. Concerning agricultural production networks and global food value chains, our speakers referred to three polarities: a) having food or not; b) having expensive, high-quality food or inexpensive, high-quantity food; and c) generating higher value through organic food or high-tech food production strategies. In the first, we have yet to find a value chain. Here, the satisfaction of basic demands is in focus and there is no choice of strategy. The second case takes us further to the level of decision making. When basic demands are met, we can aim for just food or set our targets on quality food. It becomes additionally important that food is healthy and free from chemical residuals; tastes good; and has fresh appearance, a special aroma, a certain content mix (such as low fat, sugar free, amino-acid rich, etc.), and in general, standards that consumers request and producers can fulfil. The third case relates to different philosophies on how one can reach quality food standards, either by kinds of organic (or integrated) agriculture with less inputs of pesticides and industrial fertilisers and more human inputs, or with technology-driven innovations where growth conditions and resource consumption are optimised. Regarding the value chain, the second case represents the start of an agricultural value chain while the third is the alteration and multiplication of the food value chain in different strategic directions.

With regard to disasters, the three cases can be seen as follows: a) historically, in the first case investigated, hunger or lack of food was thought of as a natural disaster but was actually more indicative of limitations in the food supply networks; b) producing high quantities and food surpluses means both robustness against famine as deficits can be balanced by food imports and limitation due to decreased soil fertility or less availability of good-quality water; c) greatly reduced disaster vulnerability due to quality food production either by increasing local resilience through organic agriculture production methods or by decreasing the external influence of adverse factors through better information and controlling growth parameters in information and communication technology or smart farming applications.



Meinhard Breiling



Venkatachalam Anbumozhi

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KEY MESSAGES: THE NEXUS OF AGRICULTURAL PRODUCTION NETWORKS AND GLOBAL FOOD VALUE CHAINS AND NATURAL DISASTERS

Susan Cutter from the US points out the difference between food production and healthy food production. The US is a major food exporter but 7% of the US population – living in inner cities and more remote rural areas – have no adequate access to healthy food and balanced nutrition. In 2013, an unusual heat wave in Alaska related to an unusual demand in electricity caused major disruptions to the electricity grid. Deep freezers stopped functioning and large quantities of food got spoiled. Since 1960, crop losses due to disasters have accounted for US$3 billion annually or 24% of the total damage. Flooding in 2011 alone caused one US$1 billion damage in Arkansas, Mississippi, and Missouri. Additionally, the harbour infrastructure for bulk transportation of food was destroyed. In October 2015, extreme precipitation in Southern Carolina caused US$600 million losses in agriculture or 5% of the usual agricultural income. Disasters can have different impacts on different individuals. Poor and less-educated people are more vulnerable to disasters. The degree of vulnerability can be measured based on regional and local statistical information with what is known as Social Vulnerability Index.

Margreth Keiler and Sven Fuchs analyse agricultural production networks in relation to the mountain environments of Austria and Switzerland. They provide definitions of risk and hazard and point towards an underrepresentation of mountain risks in international outlines like the Hyogo Framework for Action and the subsequent Sendai Framework. Reducing the vulnerability of agricultural production networks and food value chains is an emerging field of science and is essential in ensuring the resilience of the regional, national – and sometimes also global – food systems. Loss estimation in food value considering the energy balance proposes that 48% of the total calories produced (edible crops, yields, and animal products, including slaughter waste) is lost across the whole food value chain. Infrastructure is an important part of the food value chain. Strategic or critical infrastructure may include, but are not limited, to energy, irrigation, transportation, and telecommunications.

Stefan Anderberg discusses how far organic agricultural production can contribute to an increase in the agricultural value chain and thereby create more employment and reduce poverty. In recent decades, organic agriculture has attracted increasing attention from governments, non-governmental organisations, and development agencies. Organic production has grown and organic products today are traded not only locally but nationally and internationally as well. Anderberg cites examples from four agricultural value chains: cotton, coffee, cacao, and oil seeds, products that belong to global food value chains where producers originate in the south while intermediates and consumers are primarily found in the north.

CHAPTER 1

THE PERILOUS NATURE OF FOOD SUPPLIES: NATURAL HAZARDS, SOCIAL VULNERABILITY, AND DISASTER RESILIENCE

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Food insecurity is a problem in developing and developed countries alike where deficits in the quality and quantity of food lead to hunger and malnutrition, impairing the health of millions. Reduction in global hunger was a key element of the United Nations Millennium Development Goals process (2000–2015). With a target to reduce the proportion of undernourished people by 50% by 2015, substantial progress was made. Today, however, 805 million people still remain undernourished, the majority of them living in developing countries (FAO, 2014). The new Sustainable Development Goals are more ambitious and set targets to end hunger and all forms of malnutrition by 2030. They also include goals to ensure sustainable food production systems through resilient agricultural practices and adaptations to environmental changes (United Nations, 2016). The success or failure of such goals will not be known for a decade.

Food security is a complex and intertwined problem of reliability, quantity, and affordability of nutritious food. The global interdependence of food supply chains alters availability of food. When one part of the food production chain is affected (e.g. on contamination, poor harvests, natural hazards, conflict), the consequences reverberate globally with reductions in supply and increase in prices. As most countries import at least some of their food needs such as staples like grains or tropical products such as tea, coffee, or fruits, this creates some dependence on global food chains. Moreover, global patterns of urbanisation are fundamentally altering food systems and, more significantly, food preferences, thus reducing the food security of the planet's 6.5 billion urban dwellers (Seto and Ramankutty, 2016).

Self-sufficiency in food means that a country can meet its own food needs from domestic production, one way that nations reduce food insecurity. In 2013, 77 countries were dependent on international imports to meet their basic food needs, an increase of 57% since 1961. More than 51 countries are more than 50% dependent on imports, while

13 are totally dependent on imports to meet their food needs (Gardner, 2015). The increased dependency on imports is related to population growth, loss of fresh water, loss of fertile agricultural land, and land conversion from food crops production to other uses. Land conversion is especially problematic in the developed world, especially near cities where farmland is rapidly being converted to urban uses such as housing, industry, and transportation infrastructure. For example, urban transformation of farmland in the US is significant, with nearly 4.1 million hectares of land (an area roughly twice the size of New Jersey) converted to urban-related land uses in 1997–2012 (Farmland Information Center, 2016) As part of the global food system, importing countries are highly vulnerable to natural interruptions in supplies (weather-related shocks such as droughts or floods, crop pests, or pathogens) and increased prices as supply and demand fluctuates (Puma et al., 2015). Even food-exporting countries experience growing constraints on production related to water availability, yields, fertilisers and pesticides, and prices. In many regions, farmers make more money on their crops when sold as biofuels or feed for animals rather than as food for people. The most significant, however, is climate change and its potential to negatively influence crop yields in many food-exporting countries, especially Brazil, Russia, and Australia (IPCC, 2014), and globally alter the patterns of food security.

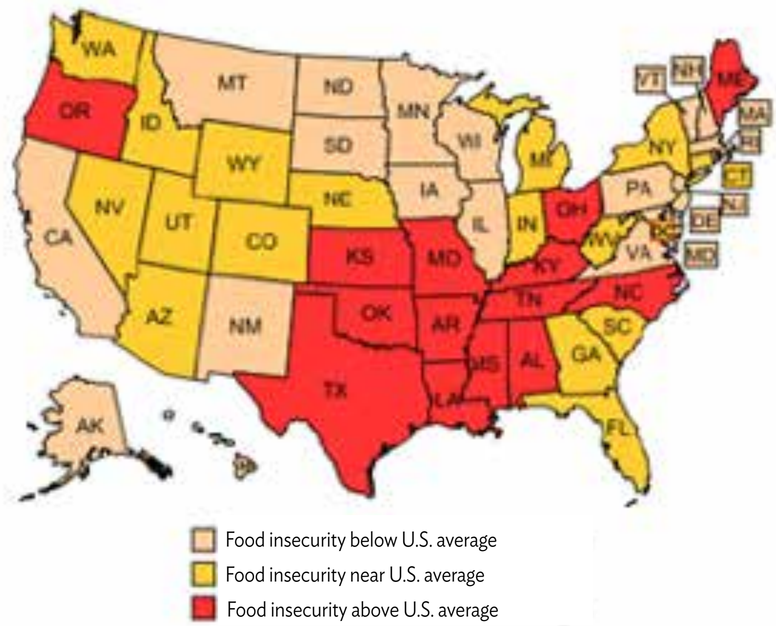
Within national or regional food supply systems, natural hazards can cause disruptions not only in the food resource supply itself but also in the supply chain infrastructure and transportation to and from markets (Reddy et al., 2016). A recent analysis found that within developing nations, 22% of the total economic impact of hazards and disasters was from the agricultural sector: crops, livestock, fisheries, and forestry (FAO, 2015). However, global data are scarce so little is known about the sub-national impacts of hazards on the agricultural sector and the disproportionate burden placed on people reliant on agriculture for their livelihoods. The primary global hazards databases (MunichRe, EM-DAT, SwissRe) have no consistent accounting for direct and indirect agricultural losses from natural hazards, although some national databases separately record agricultural losses (e.g. DesInventar, SHELDUS).

This paper examines food security and the disproportionate impact of disruptions in food supplies on vulnerable populations in a developed world context. Telling the story of where the areas are and who are disproportionately affected by crops losses due to natural hazards in the US, the paper briefly illustrates the spatial and social variability in impacts. A more detailed case study of the 2015 flood in South Carolina and its impact on the agricultural sector and associated livelihoods highlights the difficulties in assessing the true costs of agricultural losses due to natural hazards.

Food Security and Food Production

In the US, food security is mostly an economic condition where households or individuals lack money or resources to acquire food. A typical American household spends almost a third of their income on housing, followed by transportation (17%), and then food (13%) (United States Bureau of Labor Statistics, 2015). The majority of Americans purchase food at grocery stores and supermarkets or from restaurants and other food vendors. The amount of money spent on food by households is a good indicator of their relative level of food security. The US Department of Agriculture found that per capita median weekly expenditures for food of US$37.50 or less produced food-insecure individuals (Coleman-Jensen et al., 2015). Fourteen percent of American households (17.4 million households) were food insecure at some time during the year (skipped a meal, did not eat for a day or more) because of insufficient money for food. The majority of these households have single women with children under 18 years old, individuals living below the poverty line, African-American and Hispanic heads of family, and families living in inner cities and rural areas (USDA, 2016a). The highest rates of food insecurity are in the southern half of the country (Figure 1), regions with significant poverty and minority populations living in both rural and urban areas.

Figure 1: **Food Insecurity in the US, 2014**



Calculated by ERS based on Current Population Survey Food Security Supplement Data.

Source: United States Department of Agriculture, 2015.

Food is abundantly produced in the US, a food-exporting country. The US exports grains/feed, soybean, and livestock products primarily to Asia (China, Japan, Republic of Korea), the European Union, and North American neighbours (Canada and Mexico). Depending on the crop, food production in the US is highly variable, with California having the most diverse range of crops and being the largest agricultural producer in the country. Grains, grown almost everywhere, are especially prevalent in the Great Plains states. Corn (used for food, silage, and fuel), although grown everywhere, is concentrated in the traditional US Corn Belt stretching from southern Indiana west to Iowa. Peanut is concentrated in Georgia; citrus in Florida, California, Arizona, and the lower Rio Grande Valley; potatoes in Idaho; rice in Arkansas; and apples in Washington and New York.

While food is plentiful, access to healthy and affordable food is problematic for many Americans, especially those in inner city neighbourhoods and rural areas. The lack of access creates food deserts, defined as areas with limited access to affordable and nutritious food (Ver Ploeg et al., 2009). Food deserts arise due to the absence of a large supermarket within the community (within a mile or 1.6 km radius in urban areas; 20 miles or 32 km radius in rural areas); or the lack of transportation to a supermarket or large grocery store located farther away. The absence of large grocery stores or supermarkets (with lower prices and greater choice) close by coupled with lack of transportation to go there define food desert areas for more than 23.5 million Americans (7% of the population) (Ver Ploeg et al., 2009).

Short-term disruptions in food supplies exacerbate the insecurity for many households, not only influencing the availability of food supplies but also food quality and, most importantly, the prices. For example, Alaska imports nearly 90% of produce due to its short growing season, making food expensive to begin with in that state. In 2013, the summer in Alaska was particularly warm and the demand for power for cooling homes and businesses soared. As is true in many regions of this rural state, residents subsist on hunting and fishing for protein. Meat and fish (around 25% of total food consumption) are frozen for later consumption. When the power demand for home cooling soared because of the warm weather, blackouts and power shortages ensued, causing loss of refrigeration and spoilage of meat and fish (Hodges Snyder and Meter, 2015). The power shortages caused loss of protein source for many households. This was significant given that meat is prohibitively expensive and most of the Alaskan fisheries catch is exported and not available for domestic consumption. In addition to high prices for produce, Alaskans also had to pay for meat and fish, thus stretching many household budgets beyond their breaking point. While the example points to a singular heat event, the food insecurity of the indigenous populations in the state is becoming dire as climate change – coastal erosion, thinning sea ice – is not only destroying traditional livelihoods and food systems but also displacing entire coastal communities.

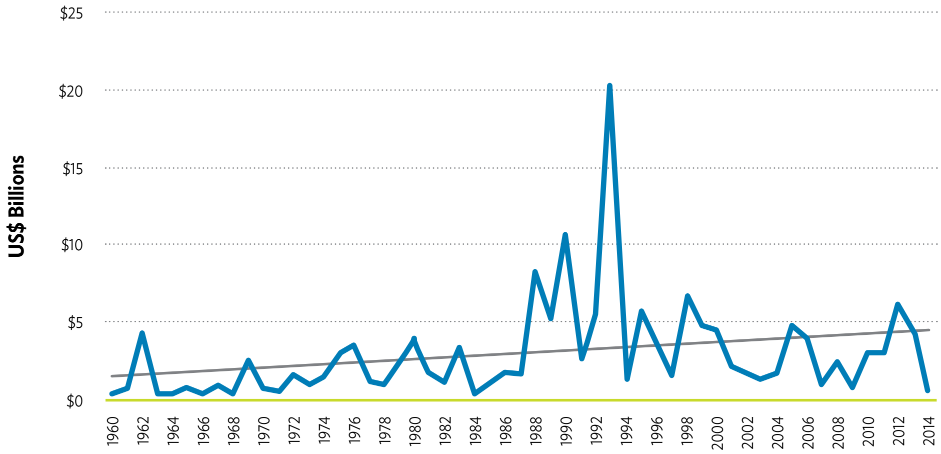
Another example is the 2012 drought that affected nearly 60% of US farms, primarily those devoted to production of corn and soybean used in livestock feed. Within the US, there were short-term increases in prices the following year especially those of beef and dairy and poultry products (Crutchfield, 2013), although the 3% average increase was well below the inflation-driven increases of the past. Locally, farmers and ranchers reduced their herds as a mitigation measure to reduce costs in the short-term. However, with the increasing global demand for meat, the reduction in herds has increased the price of US-exported beef and dairy products. The demand for meat is increasing globally especially in cities and this creates greater food insecurity for importing countries because of higher meat prices. Local changes in farming practices are occurring in both importing and exporting countries where agricultural land is increasingly being used to produce food for animals rather than food for people (Stoll-Kleemann and O'Riordan, 2015).

Losses from Disasters in the US

Since 1960, crop losses in the US due to natural hazards have averaged US$3.0 billion annually (SHELDUS, 2016). This represents roughly 24% of the total losses from natural hazards over the same time period. Crop losses due to natural hazards have steadily increased, along with property losses even when adjusting for inflation and population growth (Gall et al., 2011). As crop losses are weather-dependent, the increasing frequency of more extreme weather events produces greater losses. Coupled with better documentation of such losses, we see a steady upward trend (Figure 2) in crop losses over the past 50 years.

Crop losses were highest in 1993 as a consequence of the Mississippi Floods of 1993 (Missouri and Mississippi basins) where nearly 20 million acres (8 million ha) were flooded and not harvested of or planted (Changnon, 1996). Damage to the Mississippi River shipping infrastructure was also recorded. Flooding in the same region in 2011 also resulted in more than US$1 billion in agricultural damage in Arkansas, Mississippi, and Missouri alone. Major drought episodes in 1989, 2006, 2011–2012 in the mid-western and Plains states occurred with significant losses in corn, sorghum, and soybean crops. Freezes in December 1998 affected fruit and vegetable crops in California, and again in 1990. In 2005, Hurricane Katrina not only damaged crops but also the ports in New Orleans and in Gulfport, Mississippi. The Port of New Orleans is the terminus of the inland waterway system for the US and the primary transportation infrastructure for transporting bulk cargo such as grains, timber, cotton, and rice. The Port of Gulfport was completely destroyed by Hurricane Katrina and has been slow to rebuild. The agricultural significance of the Port of Gulfport is its being the gateway for fruits and vegetables from Latin America, especially bananas, to markets in the eastern half of the country.

Figure 2: Crop Losses (Adjusted to US$: 2014), 1960-2014



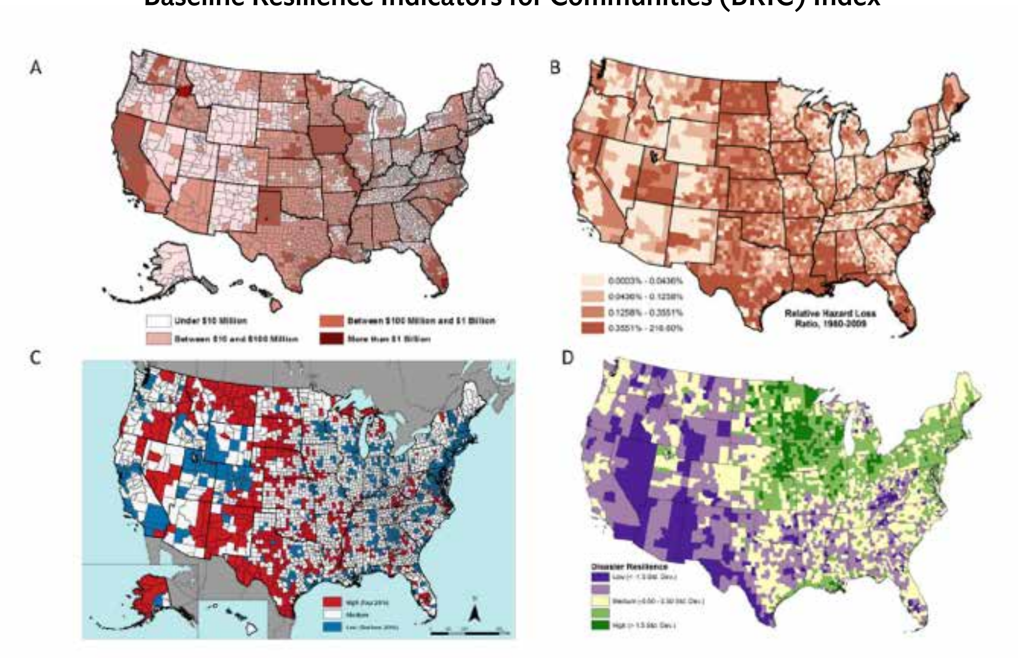
Source: SHELDUS.org.

The spatial patterns of crop losses are quite variable, but again are concentrated in the central US in the largely rural areas (Figure 3A). Droughts and floodings are the primary perils influencing crop losses in the central US, followed by severe storms including hail. Freezes and extreme cold are regionally important in California and Florida.

Measuring Social Consequences: Impact, Vulnerability, Resilience

The social consequences of hazard losses are a function of the exposure and the sensitivity of the populations to those losses. Exposure is the degree to which property (including crops) is at risk of damage from hazards and can be viewed as the pattern of losses in individual places as well as the relative impact of such losses on the economic base of the local area. Data for such assessments are scarce globally but the US has reasonably good data for such computations. The ratio of hazard losses to gross domestic product (GDP) or its equivalent affords the opportunity to refine impacts beyond simple dollar damage. For example, the effect of a million-dollar loss in one locale that has a robust and large economic base is very different from the same million-dollar loss in a place with a smaller and struggling economy. As a larger percentage of GDP, the impact is greater and not only reduces the capacity to absorb and recover from the disaster but may require an influx of external aid to assist in recovery. For the US as a whole, the average relative loss ratio is 0.15% of GDP in 1980-2009 (Ash et al., 2013). Even with costly events such as Hurricane Sandy, the overall impact on the country is minimal as there is sufficient capacity to absorb and recover from the event at the national scale. Regionally and locally, however, it is another story. The mean annual relative loss for the central US, for example, is slightly more than 4% of the county GDP, well above the national average. The relative impact is largely driven by recurring losses from flooding and severe weather (Ash et al., 2013) (Figure 3B). In the hurricane coast along the northern Gulf of Mexico, losses represent 3% of county GDP, largely attributed to periodic tropical cyclones; again, a relative loss significantly above the national average. The relative impact ratios account for the temporal and geographic differences in economic capacities of places, which in turn influence the overall social consequences of hazards at sub-national scales.

Figure 3: Spatial Patterns of Damage, Social Vulnerability, and Community Resilience, A) Total Crop Losses, 1960-2014 (in US$); B) Relative Property Loss Ratio; C) Social Vulnerability Index (SoVI®); D) Baseline Resilience Indicators for Communities (BRIC) Index



Source: SHELDUS.org; sovius.org; Ash et al., 2013; Cutter et al., 2014.

Social Vulnerability

Social vulnerability examines the susceptibility to harm from disasters. It permits the examination of the abilities of individuals and places to prepare for, respond to, recover from, mitigate, and adapt to hazards. The Social Vulnerability Index (SoVI®) is a county-based analytical tool that comparatively assesses social vulnerability for the US (Cutter and Morath, 2014). Based on 29 social and demographic variables that the research literature confirms as contributors to reducing a community's susceptibility to hazards, SoVI® provides an empirically based measure of social vulnerability. When mapped, SoVI® scores graphically illustrate the geographic variability in social vulnerability, highlighting those places where additional resources might be necessary to reduce vulnerability and, more significantly, areas where hazard recovery might lag. In disaster response and emergency planning in the US, SoVI® is used by 17 state governments in hazards mitigation plans, and recently became part of the suite of geospatial products used in federal response to disasters. The most recent utilisation of SoVI® was in the determination of targeted areas for disaster recovery resources in the aftermath of the 2015 flooding in South Carolina. Replications of the SoVI® algorithm using customised local data have been done for a number of countries and regions including Norway, Indonesia, Brazil, and the Yangtze River Delta region in China.

Regionally, levels of high social vulnerability are concentrated in the middle of the US, stretching from Texas in the south to the Canadian border, the Great Plains states. Other agricultural areas also exhibit high levels of social vulnerability, such as the lower Mississippi Valley and southern Florida (Figure 3C).

Community Resilience

Enhancing community resilience is one mechanism designed to reduce the impacts of natural hazards on people and places. Resilience as a concept has a variety of meanings and applies to many different sectors and components of communities: economic, infrastructural, social. This paper uses the definition of resilience proffered by the United States' National Research Council: 'the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events' (2012:1). Many different approaches to assessing resilience exist, ranging from qualitative to quantitative approaches. Some focus solely on assets or baseline conditions while others look at characteristics or capacities. There is no dominant methodological approach to resilience assessment and no geographic scale preference (local to global) (Cutter, 2016). The lack of a core set of resilience indicators has defined disaster resilience research to date, especially in the US.

Notwithstanding the lack of consistent methodologies or core indicators, one empirically based measure of resilience, the Baseline Resilience Indicators for Communities (BRIC), has gained some traction as a policy prescriptive approach. BRIC assumes that communities are systems of systems with different components working individually and collectively to produce the pre-existing (or inherent resilience) within places. In other words, BRIC measures the baseline of disaster resilience existing within a community before the hazard event occurs, and is useful for taking stock of capacities and assets. Using a sub-index structure, six different components are measured: social, economic, institutional, infrastructural, community, and environmental. Each sub-index has a number of variables used as proxies, and these variables are normalised and then averaged to create the sub-index score. Each composite sub-index score is then summed to produce values ranging from 0 (low resilience) to 6 (high resilience) (Cutter et al., 2014). The BRIC scores can then be mapped to display the spatial distribution or dis-aggregated to examine the specific drivers of disaster resilience for individual study areas. The latter is significant as it can highlight where investments could be made to improve baseline conditions in disaster resilience.

Resilience and vulnerability are related concepts but they are not the inverse of one another. In testing the association between the two as measured by BRIC and SoVI®, Cutter et al. (2014) found that SoVI® only explained 25% of the variability in the BRIC scores. A similar finding by Sherrieb et al. (2010) found only 14% of the variance between SoVI® and their measures of community resilience – economic development and social capital - were shared. While social vulnerability most closely tracks with social and economic resilience, these factors are only part of what constitutes disaster resilience for communities.

The geography of disaster resilience in the US shows an interesting pattern, with the highest levels of disaster resilience in the central US in the Northern Plains and Midwest states (Figure 3D). High levels of disaster resilience are also found along the Gulf Coast extending from Texas to Louisiana. A second concentration is in the urbanised Northeast. What is interesting about the pattern of disaster resilience is the focus on rural America, especially in the food production region in the central US. These are the same areas that have significantly vulnerable populations and major crop losses from natural hazards, and that experience the greatest relative impact of hazards on the local economy (Figure 3).

Case Study: October 2015 Flooding in South Carolina

As noted earlier, the SoVI® methodology was utilised by the state disaster recovery office in the post-event recovery from the October 2015 flooding in South Carolina to identify target areas across the state that would require assistance to lessen the impacts of the flooding. It was used to illustrate an 'apolitical' approach for recovery resource allocations that reflected both the worst affected areas and the most vulnerable populations who could not bounce back on their own from this disaster.

Background and Context

South Carolina, located in the southern US, is one of the original 13 colonies and the eighth state to ratify the US Constitution. It has a varied political history that explains some of the present-day social and economic patterns within the state. For example, in the colonial period (18th century) South Carolina was a wealthy state, known for its natural harbour, Charleston, and the fertility of the coastal soils. The cultivation of indigo and rice, fueled by slave labour from West Africa, made South Carolina one of the most prosperous states in the US at the time. Intolerance for slaves by the northern states and the 1860 election of President Abraham Lincoln, who opposed the expansion of slavery, led to South Carolina's secession from the United States, and the beginning of the American Civil War (1861-1865). After being soundly defeated, South Carolina never regained its economic dominance and continues to be amongst the poorest and most disadvantaged states in America.

With a land area of 32,020 square miles, South Carolina is roughly the size of Austria. Its 4.8 million inhabitants are located in the three major metropolitan centres: Columbia (the state capital), Charleston (along the coast), and Greenville-Spartanburg (in the Upstate). Most of the state retains its rural character, the remnant from its agrarian past. The state population is 64% white, 28% African-American, 5% Hispanic, 2% Asian, and 1% mixed race/ethnicity. The coastal counties contain the greatest disparities in wealth and racial makeup. Along the coast, wealthier and white residents maintain vacation and year-round homes with recreation and tourism as the dominant economic drivers (along with manufacturing and shipping in Charleston, and the military in Beaufort). Further inland is the coastal plain and the historic cotton-growing region. Still largely agricultural, these counties contain significant African-American populations and are amongst the most economically disadvantaged in the state. The Central Midlands (where Columbia is located) and the Upstate are more diversified in terms of economic livelihoods and racial makeup, although the percentage of African-Americans in the Upstate is the lowest of all the regions. The private sector contributes 83% of the total economic output for the state followed by the government at 17%, the latter including several large military bases and federal facilities in addition to state and local governments.

Despite its agrarian past, agriculture only contributed 0.8% of the state's GDP of US$190 billion (or US$1.52 billion) in 2014 (SC Department of Commerce, 2016). Regionally, however, agriculture is significant. The most important commercial crops grown in terms of acreage are soybean, corn, cotton, and wheat. Most of the farms in the state are family owned and operated. The average size of farms is 180 acres (73 ha), but the majority of farms are smaller than this (10-49 acres in size; 4-20 ha). For 62% of the farms, direct sales are less than US$5,000 annually (USDA, 2012). There is ample food production in locally based farming on small plots and backyard gardens. With an average growing season of 220 days (between first and last frost), both cool-season and warm-season crops are grown, with surpluses sold in local farmers markets or roadside stands.

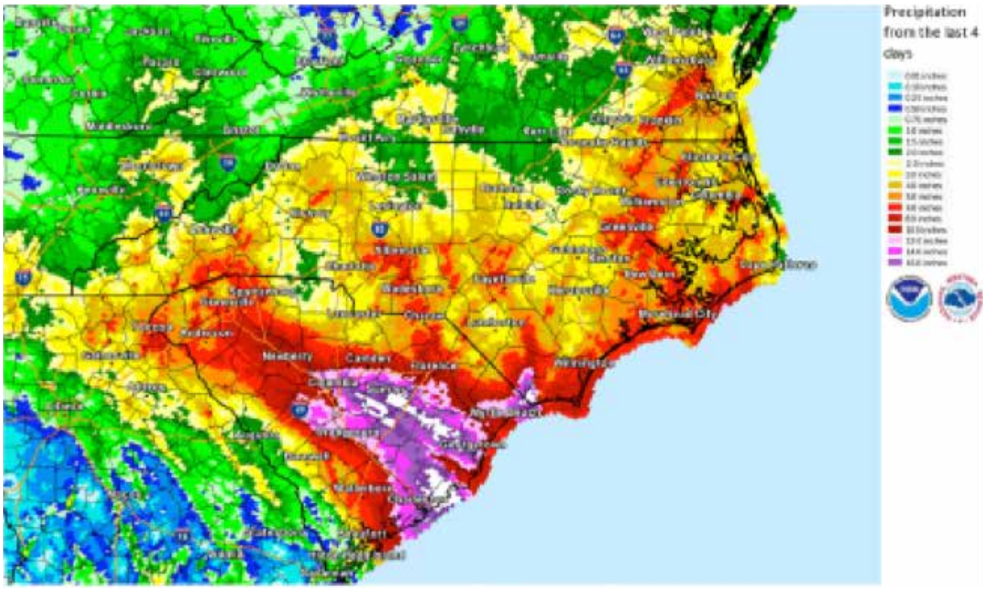
The Event

An unprecedented rainfall event in 1-15 October 2015 resulted in more than 27 inches of rainfall along the coast and inland of South Carolina. A combination of a stalled cool frontal system and a slow-moving low-pressure system to the south brought tropical moisture from the Caribbean into the state and this, in turn, interacted with moisture from Hurricane Joaquin hundreds of miles away to the southeast. These two streams of moisture coalesced into an atmospheric river of moisture that continually dumped rainfall into South Carolina over 4 days (Figure 4). During the most intense period of rain, 16.6 inches of rain were recorded, breaking the 24-hour records throughout the state. The atmospheric river of moisture resulted in catastrophic flash flooding in the urban areas and riverine flooding downstream, affecting many of the rural agricultural counties. The state received a Presidential Disaster Declaration which included 75% of the state's counties (35 out of 46 counties).

Economic Impact

Flood losses were over US$1.2 billion (Collins, 2015; O'Connor, 2015), less than 1% of the state GDP in 2014, well within the range of low relative impact, based on national averages. Estimates of agricultural losses were in the US$600-million range or about 5% of the annual cash receipts for all agricultural commodities. Agricultural crops were already stressed by a summer drought with harvests expected at half of normal before the flooding. Forestry was also depressed due to the decline in the paper market, but was on the verge of recovery after a long recession. Beyond direct crop damage and loss, additional losses were incurred as a result of soggy fields, prohibiting the fall and spring planting of winter wheat, vegetables, and fruits. The major crops affected were peanut, soybean, corn, and wheat and the cash crops of cotton, tobacco, and timber. Cotton, peanut, corn and soybean are planted in April and harvested in early October. The timing of the flood right before harvesting resulted in lower yields for all four crops (Table 1). Preliminary estimates of 2016 planted acreage compared to 2015 plantings illustrate the effect of the floods: corn (up 8%), cotton (down 19%), peanut (down 2%), soybean (down 7%), and winter wheat (down 47%) (USDA, 2016b). Geographically, the most affected counties contained some of the most socially vulnerable populations (Figure 5A).

Figure 4: **Rainfall Totals for October 2015 Rainfall and Flood Event**



Source: National Weather Service, 2016.

As most of the farmers did not have any type of agricultural insurance as they were too small, the state allocated US$40 million to help them recover from the flood. No other sector received such support from the state in the aftermath of this disaster.

Table 1: **Agricultural Production, 2014-2015**

	2014			2015			Percent Change 2014/2015		
	Acreage Planted (acres)	Production	Yield/ acre	Acreage Planted (acres)	Production	Yield/ acre	Acreage Planted (acres)	Production	Yield/ acre
Cotton	280,000	528,000 bales	912 bales	235,000	155,000 bales	547 bales	-16.1	-70.6	-40.0
Soybean	450,000	15,400,000 bushels	35.0 bushels	475,000	9,805,000 bushels	26.5 bushels	+5.6	-36.3	-24.3
Peanuts	112,000	410,400,000 pounds	3,800 pounds	112,000	262,400,000 pounds	3,200 pounds	0	-36.1	-15.8
Corn	295,000	32,760,000 bushels	117.0 bushels	295,000	24,180,000 bushels	93.0 bushels	0	-26.1	-20.5

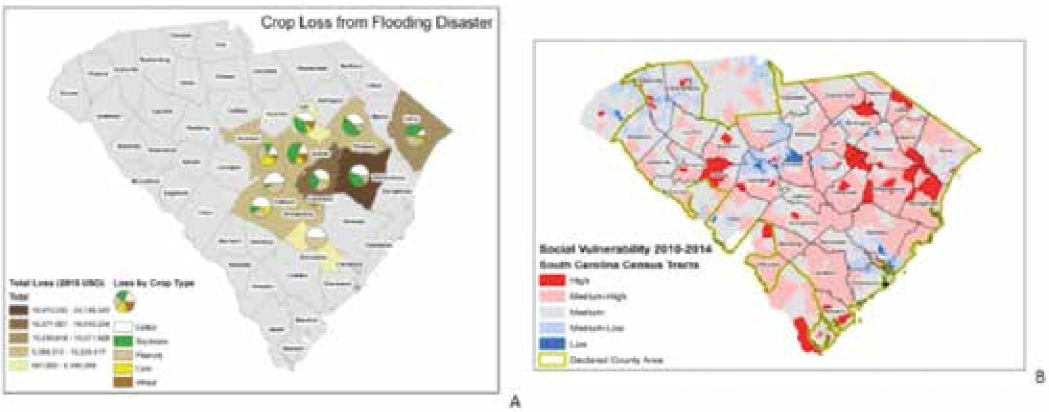
Source: USDA, 2016b.
https://www.nass.usda.gov/Statistics by State/South Carolina/Publications/County Estimates/index.php

In addition to crop damage, the transportation infrastructure damage was significant for most of the state. In the immediate aftermath of the flooding, more than 365 roads closed and 166 bridges damaged. This included more than 90 miles of interstates including Interstate 95, the main corridor for commerce along the US east coast. The funding to repair publicly owned infrastructure came from federal resources under the federal disaster declaration. Many of the secondary roads were also damaged, delaying harvesting of crops that were not directly affected by the rainfall and flooding.

Social Impacts

The flooding resulted in 17 fatalities, most due to drowning while trying to drive through high water, especially in the urban areas. The largest social impact was damage to homes. In the Columbia metropolitan area, flash flooding and small dam failures created a geographic concentration of damage to houses that disproportionately affected moderate to higher income communities (selected areas shown in blue in Figure 5B). Downstream riverine flooding was the cause of housing damage in the rural agricultural areas, and disproportionately affected lower-income and African-American residents (shown in pink and red in Figure 5B). Most of the damaged houses did not have flood insurance, so recovery progressed slowly, especially in the rural counties. While nearly 100,000 households had applied for federal assistance for housing and home repairs, only 27% of those applications were approved. Because of the unmet need, the state established the South Carolina Housing Trust Fund Flood Initiative (using private, non-profit, and state funding) to assist low-income residents with the highest need to begin repairs. To date, at least US$1.7 million have been spent to repair such houses for the most socially vulnerable populations.

Figure 5: Impact of 2015 Flooding: A) Crop Losses and Commodity, B) Location of the Most Socially Vulnerable Residents, Many Living in the Rural Agricultural Counties with Significant Flood Losses



Lessons Learned and Relearned

Direct losses to agriculture and food supply systems due to natural hazards happen everywhere. Some events produce catastrophic and longer-term damage both nationally and globally, such as persistent droughts, while other events create short-term variances in supplies that have little impact beyond local to regional scales. Food security is a challenging problem in and of itself, but when natural hazards are added to the mix, the global food system can become compromised and unreliable, exacerbating hunger conditions in many countries.

At present, there is no consistent accounting of agricultural losses due to natural hazards nor any systematic accounting by specific peril. Disaster loss accounting is more of an art than a science at this point. Not all losses are included (crops, for example), and many are not counted the same way. Until the time that a global full-cost accounting of natural hazards losses is in place, we will not know the true extent of the impact of natural hazards on agriculture and global food supply chains. To develop mitigation (and longer-term adaptation) strategies, such loss-accounting information is vital so actions can be taken to lessen the adverse impacts.

The social consequences of natural hazards are often experienced by the most socially and economically disadvantaged populations and this is true in both the global North and the South. Empirically based measurement of social vulnerability and community resilience help to geographically distinguish the likely burdens of disasters, and that also illustrate the differential capacities to respond to and recover from natural hazard events, including disruptions in food supplies. As illustrated by the 2015 flooding in South Carolina, there is considerable variability in the capacity of local places to prepare for, respond to, and recover from natural hazards.

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CHAPTER 2

LOSSES, RISK, AND VULNERABILITY INDUCED BY NATURAL DISASTERS TO AGRICULTURAL PRODUCTION NETWORKS AND FOOD VALUE CHAINS – EXAMPLES FROM THE EUROPEAN ALPS

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Introduction

Taking into account that the international community as a whole is affected by considerable damage to infrastructure and property as well as loss of lives, the United Nations General Assembly designated the 1990s as the International Decade for Natural Disaster Reduction (IDNDR) (United Nations General Assembly, 1989). Within the associated international framework of action, the objective was to promote concerted action to reduce loss of life, property damage, and economic disruption caused by natural hazards not only with a particular focus on developing countries but also with respect to most developed countries. Initially, IDNDR was largely influenced by scientific and technical interest groups. However, a broader global awareness of the social and economic consequences of natural disasters developed as the decade progressed (White, 1994). Based on this framework, which was continued by the International Strategy for Disaster Reduction (UN General Assembly, 2000), the primary focus on hazards and their physical consequences was shifted to emphasise the processes involved in physical and socio-economic dimensions of vulnerability and risk into the wider understanding, assessment, and management of natural hazards. This highlighted the integration of approaches for loss and risk reduction into the broader context of sustainable development and related environmental considerations. The main challenge of risk reduction is rooted in the inherent connected systems dynamics driven by both geophysical and social forces, calling for an integrative risk management approach based on a multi-disciplinary concept, taking into account different theories, methods, and conceptualisations. As a result of the outcomes of the IDNDR, the need to deal with the adverse effects of natural hazards was continuously emphasised by multiple institutions at various national and international levels. This was addressed in the 'Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities', a global document that addresses disaster risk reduction issues in all types of environments and settings. Mountains remain a marginal element in this document as well as in the succeeding document of Sendai 2015. Environmental issues were, in general, given more space (Zimmermann and Keiler, 2015).

Multiple definitions of the term 'disaster' exist, which is rooted in different conceptualisations by authorities, scientists, and journalists and the context in which these definitions are used (Keiler, 2013). The UN defines disaster within the IDNDR as 'a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources' (UN General Assembly, 1989). This definition provides the base for different worldwide databases on natural disasters. The Centre for Research on the Epidemiology of Disasters, for instance, declares more precisely when the local capacity is exceeded by 'necessitating a request to a national or international level for external assistance' (CRED, 2010).

Following Varnes (1984) and Fell et al. (2008a), a hazard is, in general, a condition with the potential for causing an undesirable consequence. A natural hazard is defined as a phenomenon rooted in the natural environment and endangering any elements at risk. Therefore, a natural hazard represents the potential interaction between humans and their environment (Tobin and Montz, 1997). With respect to natural processes, the description of hazard should include the location, volume (or area), classification, and velocity (or pressure), hence, information on its probability of occurrence within a given period of time for a specific location, referred to as frequency, and on a given magnitude. Frequency is the number of occurrences within a given period, and magnitude refers to scientifically based measures of the strength of physical processes. If measures of magnitude concern impacts of an event on the human-use system (such as elements at risk to natural hazards), intensity is used instead. With respect to mountain hazards, assessments are repeatedly based on intensity estimates that incorporate human variables as indices of destruction since direct measurements of process magnitude are not regularly available.

Elements at risk refers to the population, buildings and engineering works, economic activities, public services utilities, other infrastructures, and environmental values in the area potentially affected by natural hazards. If elements at risk are monetised, the term 'values at risk' is used (Fuchs et al., 2013). Vulnerability is considered by taking an engineering approach (Fuchs, 2009; Papathoma-Köhle et al., 2015), and refers to the susceptibility of elements at risk. Vulnerability is the degree of loss to a given element or set of elements at risk resulting from the occurrence of a natural hazard of a given frequency and magnitude. It is expressed on a scale from 0 (no damage) to 1 (total loss). Risk is a measure of the probability and severity of an adverse effect to health, property, or the environment (Fell et al., 2008b). This is often estimated by a function of probability of a phenomenon of a given magnitude times the consequences. In general, risk results from an interaction between hazards and vulnerable conditions (United Nations, 2004), and is conceptualised in this paper by using the engineering definition of an expected degree of loss due to a particular natural phenomenon. Consequently, risk is expressed by the product of hazard times vulnerability times values at risk (Varnes, 1984), initially neglecting any responsibility related to the structure of society or any other human dimension (Wisner et al., 2004).

In recent years, increasing numbers of natural hazards and associated losses have shown to the European Commission and the member states of the European Union the paramount importance of the natural hazards issue for the protection of the environment and the citizens (Barredo, 2007), and therefore also of food value chains. There is a strong scientific evidence of an increase in mean precipitation and extreme precipitation events, which implies that temperature extremes and associated weather phenomena might become more frequent across Europe (Keiler et al., 2010; Kundzewicz et al., 2010). The major increase in both number of disaster events and associated losses was related to meteorological hazards (tropical storms, winter storms, severe weather, hail, tornados, and local storms) and hydrological hazards (storm surges, river floods, flash floods, mass movements, and landslides). The reasons for this, apart from the increase in major weather-related hazards due to climate change processes, were assumed to be a result of socio-economic developments in hazard-prone areas, such as increasing concentrations of values, rising population figures, and the settlement and industrialisation of exposed areas (Jongman et al., 2014; Fuchs et al., 2015). Combined with business activities such as those associated with the agricultural sector, vulnerability and risk become focal points in managing natural hazards throughout Europe.

However, according to the International Panel on Climate Change (Field et al., 2012), loss estimates of the available national or global database are lower bound estimates for two main reasons: (a) some impacts are less reflected because it is difficult to value and monetise the losses (e.g. loss of human lives, cultural heritage, and ecosystem services), and (b) impacts on the informal or undocumented economy as well as indirect economic effects are generally not counted in reported estimates of losses. This is especially true for the agricultural sector, which is additionally highly dependent on the climate and weather-related events, but the damage and losses on global and regional scale provide no information on the impacts disaggregated to the different economic sectors (FAO, 2015). Thus, a clear understanding on how the hydro-climate hazards and the increase of extreme events (Field et al., 2012) impact the agricultural sector, the food production, and food value chains is essential to protect the investments for food security and to strengthen the community resilience to disasters. Yet, focusing on mountainous (alpine) regions in this context adds further challenges since risk from natural hazards and mountain development are inherently linked (Zimmermann and Keiler, 2015).

Mountains – Characteristics and Challenges for Agricultural Production and Food Value Chains

Many mountain settlements and agricultural land are located on alluvial fans, which were created over a long period of time by debris flows, mud flows, or floods. Especially, meadows and special crops are located on floodplains in the valley bottom. Hazard processes, although occurring only episodically, constitute a major threat for people's lives, livelihoods, and assets. In addition, snow avalanches, landslides, or rock avalanches are menacing life in mountains. Beside these hazards types, hail, storms, and late frost have main effects on the agricultural sectors as well as, depending on the region, droughts, and heatwaves.

Mountain areas are characterised by high geodiversity, steep gradients, and high variability in the hydroclimate systems, topography, and ecosystems. The main drivers for natural hazards are the high relief, the hydroclimate, and human activity. Socio-economic factors, particularly demographic changes, influence vulnerability and exposure of mountain communities. There are a number of other particularities of hazards, risks, and risk reduction that challenges sustainable mountain development (Zimmermann and Keiler, 2015):

- A multi-hazard environment prevails in many places in mountain areas and exhibits its specific footprint. Communities can be affected in the same location by floods, debris flows, and snow avalanches, and may influence each other (Kappes et al., 2010).
- The proximity of safe and hazard-prone areas is very typical for mountainous settlements. In the European Alps, for example, the old village centre with the church is often located in a relatively safe place whereas new housing estates and agricultural land can be often found around this centre in locations where hazards occur.
- Climate change may intensify hazard conditions in mountainous areas (Haeberli and Whiteman, 2015) as it causes glaciers to melt or permafrost to degrade, thus altering the sources for rock avalanches, landslides, or debris flows. It may even create hazard conditions without historic parallels, like the formation and potential outbreak of

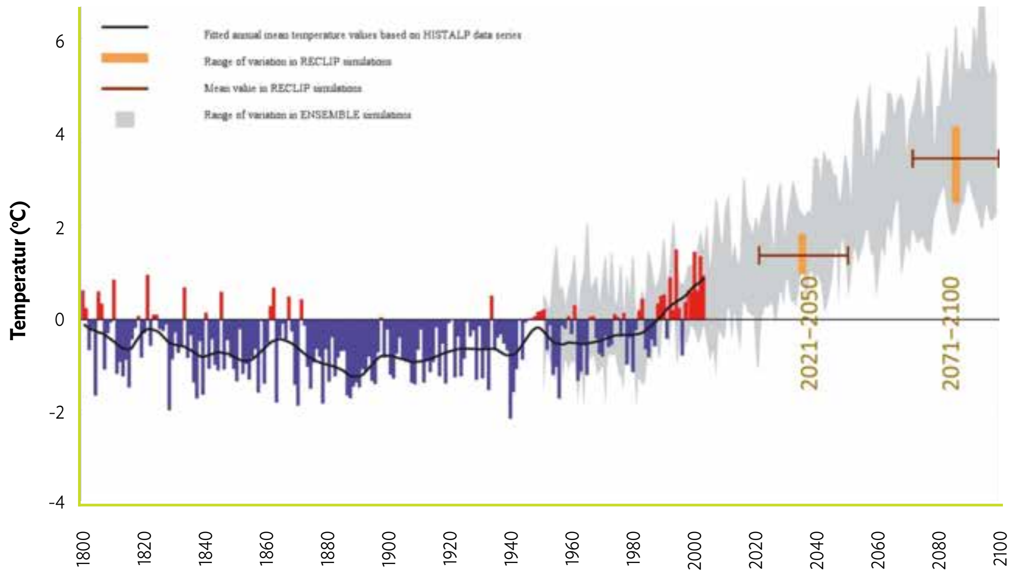
glacial lakes or the development of debris flows of unparalleled size originating in a periglacial environment as already observed in the European Alps since the 1987 flood disasters.
- Space for living is extremely limited in mountainous areas. According to Tappeiner et al. (2008), only about 17% of the total area of the European Alps are suitable for permanent settlement. Overall, the mountain population has more than tripled in the last 3 decades (Slaymaker, 2010) and urbanisation trend is as well visible in mountains. In Switzerland, 60% of mountain populations concentrate on bigger settlements. Therefore, inevitably many settlements, infrastructure, and agricultural land are exposed to natural hazards. Notably on a global perspective, from 1950 to 2010, the majority of urban population growth occurred in hilly or mountainous areas between 500 m and 1,500 m (Kohler et al., 2014).
- Highland–lowland system: In mountainous areas, the interfaces between highland and lowland have a high relevance. Very often, the highland is seen as the main source for intensified hazardous conditions in the lowland. On the other side, highlands provide important ecosystem services as drinking water, special food products, and recreation. However, such interdependences are not always obvious and sometimes also misinterpreted.
- Remoteness of mountain communities: Mountains are often physically remote spaces with difficult access due to the natural relief, which is an additional challenge to build up food value chains. Furthermore, these communities are more often cut-off from the outside during disasters for a longer period of time than lowland areas.

A sustainable use of mountain areas must include the analysis, assessment, and management of natural hazard risk due to the relative scarceness of utilisable areas. Taking countries in the European Alps as an example, only 38.7% of the territory is suitable for settlement and arable production purposes in Austria, while in the western part of the country (Federal State of Tyrol), it is only 11.9% (Statistik Austria, 2008). In Switzerland, 26% of the territory is classified as non-productive and approximately 37% of the territory is classified as area for agriculture and 31% for forestry purpose. As a result, only around 7% is suitable for settlement and infrastructure purposes (Hotz and Weibel, 2005).

In the following, an overview on agricultural production and food value chains in the European Alps (Austria and Switzerland) will be given. Mountain areas cover around 40% of the total land area of Europe, where almost 20% of the total population live (Nordregio, 2004). European mountain regions, therefore, provide a significant proportion of human settlements and areas used for economic purpose and recreation. However, mountain regions are exceedingly prone to changing environmental conditions. Thereby, mountain geosystems are not exceptionally fragile but they show a greater range of susceptibility to disturbance than many landscapes (Slaymaker and Embleton-Hamann, 2009).

Probably the most important cause of attention towards hazards, vulnerability, and risk is the recognition that global changes of important magnitude, in particular climate and land-use change, are already taking place (Stocker et al., 2013). According to modelling exercises, the nature and magnitude of potential impacts could be dramatic (Schröter et al., 2005). The assumed global rise in temperature (Stocker et al., 2013), which is already verified at the regional scale of mountain regions in Europe by measured data and analysed proxies (Auer et al., 2007), will have impacts on both the hydrosphere and the cryosphere (Huggel et al., 2015). The rise in temperature is accompanied by an increased content of moisture in the lower atmosphere, which results in intensified dynamics with respect to precipitation events (Foelsche, 2005).

Figure 1: Mean Surface Temperature in Austria from 1800 to 2100 in Terms of Deviation from the Mean of the Period 1971–2000



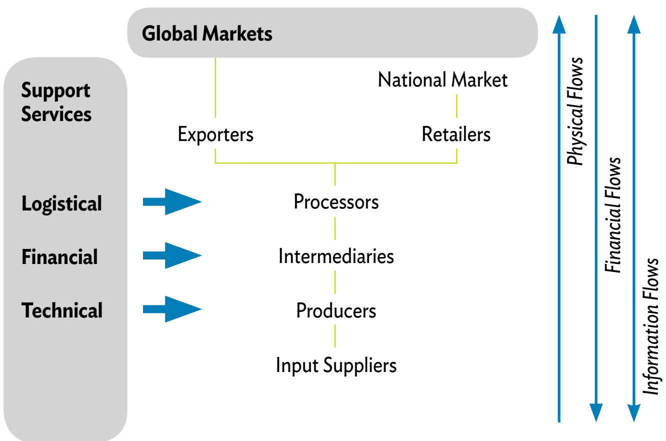
Note: A global average surface temperature rise of 3-5 °C is expected by 2100 compared to the first decade of the 20th century.
Source: APCC, 2014.

In the 21st century, an increase of precipitation in the winter months and a decrease in the summer months is to be expected for the European Alps (CH2011, 2011; APCC, 2014). Due to the expected accentuated precipitation regime, the frequency and magnitude of geomorphologic processes such as landslides or torrent processes may increase. Additionally, drought phenomena and temperature extremes are most likely to increase (Olesen et al., 2011) (see also Figure 1). In addition to extreme events, gradual temperature and precipitation changes also have economic ramifications such as the shifting potential yields in agriculture, in the energy sector, or on snow-reliability in ski areas with corresponding impacts on winter tourism. The impacts of climate change on agriculture vary by region. In cooler, wetter areas, e.g. in the northern foothills of the Alps, a warmer climate mainly increases the average potential yield of crops. In areas with poorer precipitation, such as north of the Danube in eastern and south-eastern Austria or in southern Switzerland, increasing drought and heat-stress reduce the long-term average yield potential, especially of non-irrigated crops, and increase the risk of failure. The production potential of warm-tolerant crops such as corn or grape will expand significantly (CH2011, 2011; APCC, 2014).

Agricultural Production Networks and Food Value Chains

Agricultural value chains are vulnerable and exposed to hazards due to the disaster risk of each of its components. Value chains operate as economic systems, and risks at certain nodes or of certain components have implications for other nodes and components. Resilience is a property of the value chain as a whole and is related to the vulnerability of each value chain component (United Nations, 2013). Reducing the vulnerability of agricultural production networks and food value chains is an emerging field of science, and is essential to ensuring the resilience of the regional, national, and sometimes also global food systems. Food is produced, distributed, and consumed in an increasingly complex system, where threats and hazards in one part of the system can have significant implications in others. Taking a systemic risk approach, we will present the challenges associated with the exposure of food value chains to mountain hazards based on evidence from the European Alps.

Figure 2: **Agricultural Production Chain**



Source: Jaffee et al., 2010.

Agricultural production networks are integral components of the food value chains. As such, the vulnerability and exposure of agricultural systems to hazards can have far-reaching and cascading effects for food security (United Nations, 2013). These value chains have different components, as shown in Figure 2. They can be conceptualised as having the following entities (Jaffee et al., 2010): input suppliers (i.e. groups or businesses that supply producers with fertilisers, chemicals, seeds, and other inputs), producers (i.e. individuals or businesses involved with primary agricultural production), intermediaries (i.e. commodity buyers or brokers who act as middle people), processors (i.e. businesses that are involved with the secondary production of food goods from commodities), marketers (i.e. businesses that aim to sell the food goods), and consumers (i.e. those that eat the food). At every step of the chain, transport and associated infrastructure can be at risk of direct damage from hazard events, meaning that interruptions at critical points or nodes can ripple through the supply chain. It is therefore important to focus on key supply chain participants, flows, and transaction points and to identify appropriate levels of analysis. Supply chain analyses can be carried out at different levels of analysis (Croom et al., 2000), including the dyadic level (the two-party relationship, such as between input supplier producer, producer and buyer, producer and financial institution), the sub-chain level (a set of dyadic relationships, such as input supplier and producer, and buyer), and the chain or network level (the entire supply chain and network of operations, i.e. backward and forward linkages, horizontal linkages, and enabling environment).

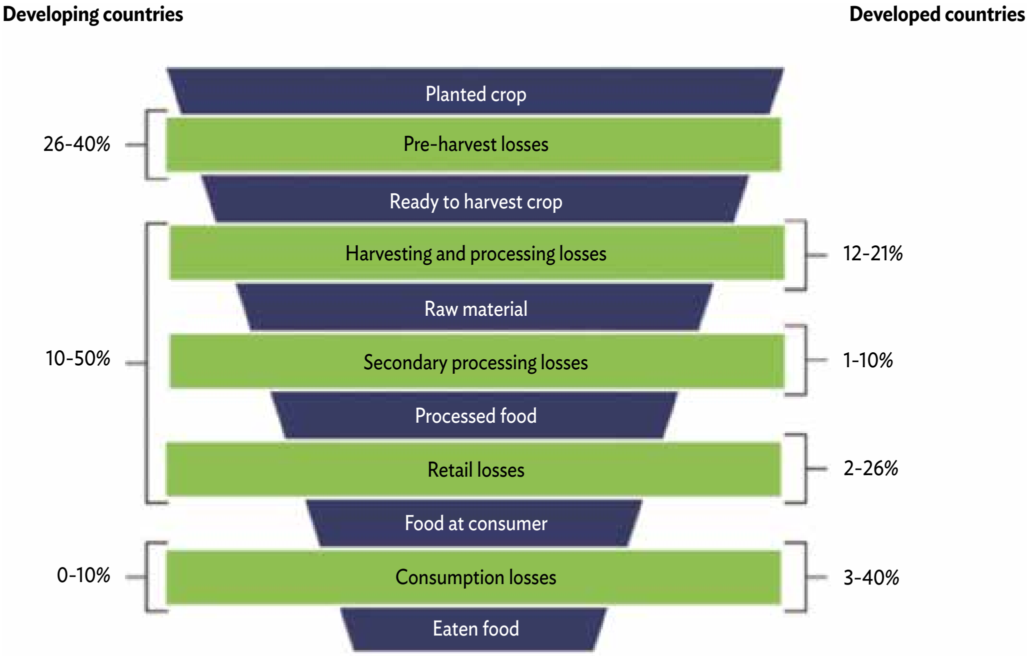
Subdividing the supply chain into dyadic and sub-chain components can make it easier to identify joint interests and potential synergies for risk management, as well as for finance. Those investing in agricultural production, processing, and trade, therefore, have a vested interest in the uninterrupted functioning of this infrastructure and in reducing damage owing to disasters (Jaffee et al., 2010).

Following this definition, agricultural disasters are one type of risk that limits the ability of the food system to provide complete food and nutritional security. Others include effects on transportation and supply infrastructure, to production facilities other than building of the primary sector, and to suppliers. In recent years, numerous assessments have been made of individual supply or value chains in developing country agriculture (United Nations, 2013) as well as for agriculture sector in Europe (e.g. Olesen et al., 2011), frequently as antecedents to investments by governments, donor agencies, or private enterprises.

Losses and Vulnerability of Individual Components of the Food Value Chain

Estimation of loss in food value chains is concentrated on waste loss (e.g. Figure 3). A study for Switzerland indicates that considering the energy balance, 48% of the total calories produced (edible crop, yields at harvest time, and animal products, including slaughter waste) is lost across the whole food value chain (Beretta et al., 2013). In this estimation, losses due to disasters are not included.

Figure 3: Total Loss in Food Value Chain



Source: Deloitte, 2013.

For the agriculture sector, typical losses due to disasters include the decline in production of agriculture, livestock, fisheries/aquaculture, and forestry, and possible higher costs of production, lower revenues, and higher operational costs in the provision of services (FAO, 2015). These losses include changes in economic flows arising from the disaster which continue until full economic recovery and reconstruction have been achieved. However, most available loss data due to disasters and regarding agriculture sector are estimations of direct costs deduced from reconstruction efforts without applying a standard approach. This includes mainly the economic impact on the physical damage to crops and livestock, agriculture, or transport infrastructure or supplier (FAO, 2015). Furthermore, indirect costs of agricultural production and food value chains imply further challenges because the evaluation of all effects has to be estimated. The end result is that the full consequences of disasters on the agriculture sector are not well understood at the global, regional, national, or subnational levels (FAO, 2015). Thus, approaches to estimate the losses are also missing for the European Alps.

One first step in the assessment of vulnerability is to investigate. With respect to agricultural production and food value chains, the concept of vulnerability is central and is supported by multiple disciplinary theories underpinning either a technical or a social origin of the concept and resulting in a range of paradigms for either a qualitative or quantitative assessment of vulnerability (Fuchs, 2009). However, efforts to reduce susceptibility to hazards and to create disaster-resilient communities require intersections amongst these theories, since human activity cannot be seen independently from the environmental setting. Acknowledging different roots of disciplinary paradigms, issues determining structural, economic, institutional, and social vulnerability should be combined to be able to prepare for climate change and necessary adaptation. Boruff and Cutter (2007) remarked on the lack of agreement and understanding concerning the methods or techniques for comparing hazard vulnerability within or between places, and stated that a refinement of vulnerability assessment methods and the delineation of highly vulnerable hotspots (e.g. strategic infrastructure) may support stakeholders interested in reducing vulnerability and using their resources more efficiently.

By applying the concept of risk, the definition of vulnerability plays an important role in agricultural production and food value chain within mountain environments. Hence, considerable areas in European regions are vulnerable to natural hazards. This is repeatedly stated in studies related to losses due to natural hazards (e.g. Rougier, 2013; Fekete and Sakdapolrak, 2014), and is therefore also valid for European mountain regions. Hence, this topic is addressed in the following section in more detail.

Producers are usually in the supply chain's most vulnerable position (United Nations, 2013). Agricultural production itself is vulnerable to natural hazards, whereas efforts to quantify this vulnerability in terms of a risk approach are relatively scarce. Dutta et al. (2003) produced relative stage-damage curves for residential and non-residential property and non-residential stocks exposed to flooding. Additionally, they developed relative damage curves for crops, relating flood duration to relative damage for three inundation depth classes. Merz et al. (2010) reported a review of damage functions for floods in a wider application of assessment methods for economic flood damage. They distinguished various relative (used in the US HAZUS-MH model) and absolute (used in the UK and Australia) vulnerability functions, and summarised the respective challenges in the assessment procedure. For static inundation, the depth of water may indeed be the dominating factor and is sufficient for a vulnerability and risk analysis. Merz et al. (2004), however, criticised this hazard indicator as too simplistic since a considerable variety of further parameters may still influence the quantity of losses, above all of which are contamination (due to oil spill from the heating system in case of European studies) and flood duration (e.g. Büchele et al., 2006).

Adaptation measures in the agricultural sector can be implemented at varying rates. Within a few years, measures such as improved evapotranspiration control on crop land (efficient mulch cover, reduced tillage, wind protection), more efficient irrigation methods, cultivation of drought or heat-resistant species or varieties, heat protection in animal husbandry, a change in cultivation and processing periods as well as crop rotation, protection from frost and hail, and risk insurance are seen as being feasible (OcCC and ProClim, 2007; APCC, 2014). In the medium term, possible adaptation measures include erosion protection; soil conservation practices; water retention strategies; improvement of irrigation infrastructure and equipment; warning, monitoring, and forecasting systems for weather-related risks; breeding stress-resistant varieties; risk distribution through diversification; increase in storage capacity; animal breeding; and adjustments to stable equipment and to farming technology. The shifts are caused by a future climate and the suitability for the cultivation of warmth-loving crops (such as grain corn, sunflower, soybean).

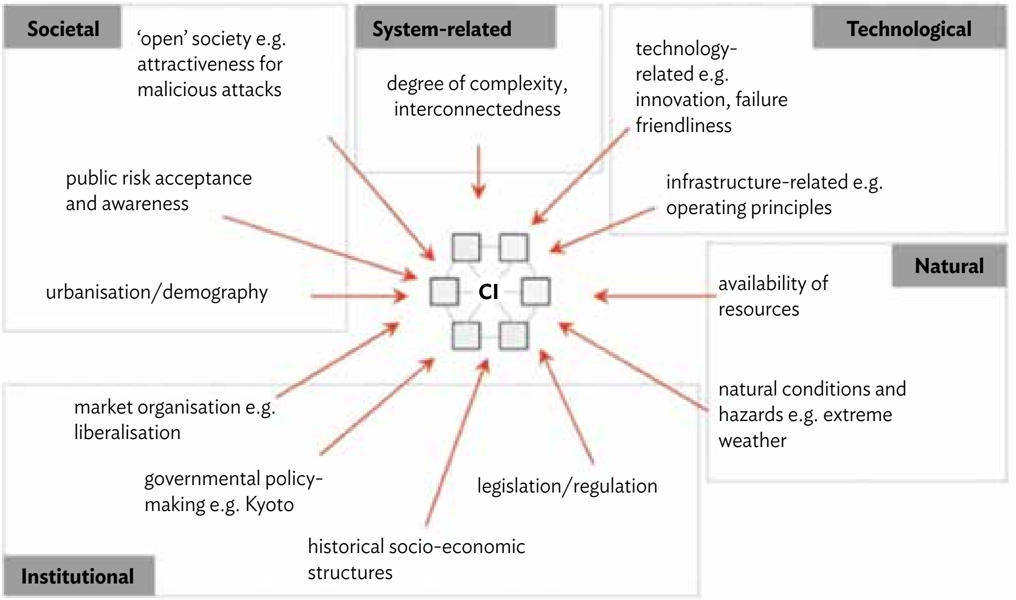
A very important component of the food value chain is infrastructure. Types of strategic or critical infrastructure may include, but are not limited to, energy, transportation, and telecommunications (Michel-Kerjan, 2003). Often, these infrastructures are interconnected and damage to one network of critical infrastructure can have cascading effects upon other critical infrastructure networks, possibly causing major damage to a country's national security and identity. The interconnectedness of these infrastructures not only extends to other types of critical infrastructure but can also be extended across political boundaries. In many cases, strategic infrastructures are dependent on international agreements and cross international borders, such as, for example, power networks and railway lines in the European Alps. Therefore, the vulnerabilities of a specific strategic infrastructure are dependent on condition and decay, capacity and use, obsolescence, interdependencies, location and topology, disruptive threats, policy and political environment, and safeguards (Grubesic and Matisziw, 2013). Strategic infrastructure networks include the highly complex and interconnected systems that are so vital to a city or state that any sudden disruption can result in debilitating impacts on human life, the economy, and the society as a whole (Cavalieri et al., 2012). The vulnerability of a system is multidimensional (Yates and Sanjeevi, 2012), a vector in mathematical terms. There are two major considerations for the efficacy of risk management in the context of infrastructure resilience and protection (Haimes, 2006). One is the ability to control the states of the system by improving its resilience. Primarily, this is the ability to recover the desired values of the states of a system that has been attacked within an acceptable period and at an acceptable cost. Resilience may be accomplished, for example, through hardening the system by adding redundancy and robustness or by simply constructing them hazard-proof if the exposure is obvious and can be assessed quantitatively. The second consideration is to reduce the effectiveness of the threat by other actions that may or may not necessarily change the vulnerability of the system (i.e. not necessarily changing its state variables). Such actions may include detection, prevention, protection, interdiction, containment, and attribution. Note that these actions (risk management options), while not necessarily changing the inherent states of the system, do change the level of the effectiveness of a potential threat.

With respect to European mountain regions, much less data are available regarding the vulnerability of infrastructure to natural hazards other than those for buildings (Fuchs et al., 2007; Papathoma-Köhle et al., 2011). In many parts of the world, however, the failure, disruption, or reduced functionality of infrastructure is likely to have a larger impact on livelihoods, production networks, and the local economy than damage to buildings (Jenkins et al., 2014). In some cases, it can act as a catalyst to existing economic, social, or agronomic decline (e.g. Wilson et al., 2012) because of high systemic vulnerability (interdependencies between physical, economic, and social systems).

The impacts of mountain hazards for infrastructure vary depending upon the hazard intensity but could include disruption of electricity supplies, contamination of agricultural processing areas, and sedimentation of surface water networks, requiring extensive and repeated clean-up (Bundesministerium für Land- und Forstwirtschaft, 2006). Even if usually manifest at local level, threats may result in cascading effects such as delays in transport times which then are likely to compound any disruption and associated impacts. Loss of transport functions due to locally deposited materials on roads can potentially be mitigated through the use of engineered channels, dams, and barriers or repeated clean-up in case of low-intensity/high-frequency events. However, the diverse range of infrastructure system designs, types, and configurations make it very difficult, perhaps impossible, to reliably create generic infrastructure vulnerability curves. Therefore, analysing interdependencies between infrastructural systems and carrying out comprehensive local inventory surveys to produce site-specific vulnerability functions are the most valid approach (Jenkins et al., 2014).

Recently, numerous studies have applied complex network-based models to study the performance and vulnerability of infrastructure systems under various types of attacks and hazards. A major part of them is, particularly after the 9/11 incident, related to terrorism attacks (Maliszewski and Horner, 2010; Briggs, 2012). Here, vulnerability is generally defined as the performance drop of an infrastructure system under a given disruptive event (Ouyang et al., 2014). The performance can be measured by different metrics, which correspond to various vulnerability values.

Figure 4: Factors Shaping the Risks Faced by Critical Infrastructure



Source: Kröger, 2008.

Focusing on the Austrian Alps, Möderl and Rauch (2011) presented a region-scale spatial risk assessment method allowing for managing critical network infrastructure in urban areas under irregular and future conditions caused by, for example, terrorist attacks, natural hazards, or climate change. For the spatial risk assessment, vulnerability maps for critical network infrastructure were merged with hazard maps for an interfering process. The result were Raster-based vulnerability maps that use a spatial sensitivity analysis of network transport models to evaluate performance decrease under the studied scenarios. Kröger (2008) identified several factors that can shape vulnerability to critical infrastructure and fall under societal, system-related, technological, natural, and institutional categories. Societal factors include attractiveness for attack, public risk awareness, and demographics. System-related factors include the complexity and interconnectedness of the network. Technological factors include failure friendliness and infrastructure-related operating principles. Natural factors include availability of resources and natural hazards. Finally, institutional factors include historic structures, legislation, and market organisation (see Figure 4).

Gaps and Challenges with Respect to Alpine Production Networks and Food Value Chains

Regarding the particular characteristics of mountains, several challenges exist for food production and development of food value chains in the Alps. To achieve sustainable development in mountain regions, natural hazards and disasters are one challenge to deal with beside socio-economic changes. However, climate change will have regional different effects on food production and food value chains. A clear gap exists on the documentation of losses due to direct and indirect impact or due to business interruptions for the agriculture sector and food value chains. Consequently, standardised and systematic approaches to estimate losses or analysis risks for this context are missing. However, such methods would help to better understand the underlying risk factors and to develop appropriated risk management.

First attempts were presented considering vulnerability assessments. Yet, most vulnerability studies are focusing on (a) physical vulnerability affecting buildings exposed to hazards and not on agricultural production itself, and (b) hydrological processes, neglecting any effects of temperature extremes, which are less-well studied. Most of the reviewed methods consider vulnerability to be the degree of loss of a specific element at risk to a hazard of a given magnitude, following an engineering approach. As discussed in Douglas (2007), there are more vulnerability curves for other geohazards, such as earthquakes, rather than for mountain hazards affecting the food value chain. These hazards usually affect larger regions than mountain hazards and have higher frequency, leading to considerable economic loss. In general, for river flooding (static inundation), there is a variety of vulnerability curves available in the literature. The majority of the studies use vulnerability curves that demonstrate the relationship between expected damage and inundation depth. The large number of vulnerability curves in flood studies can be explained by the fact that floods (just like storms which are also hazards with very well-developed vulnerability curves) damage more buildings in a single event than other hazard types (Douglas, 2007). Additionally, most of the methodologies have been applied in Europe or in countries with similar level of development, such as North America and Australia. As pointed out by Papathoma-Köhle et al. (2011), the focus of the methodologies varies significantly. While the majority of the approaches are targeted at an assessment of buildings at risk, others also include potential victims, infrastructure, and lifelines such as the road network. Very few studies focus on the vulnerability of the environment or agricultural land, or the economic vulnerability of the affected community that can include the vulnerability of businesses, employment, etc.

A very limited number of the reviewed studies address the multi-dimensional nature of vulnerability (Leone et al., 1996; Liu and Lei, 2003; Sterlacchini et al., 2007; Fuchs, 2009). As far as the scale of the study is concerned, the majority of the studies, especially the ones involving landslides, concern methodologies designed to be applied only at local level (e.g. individual torrent fans), whereas only a few (Liu and Lei, 2003; Galli and Guzzetti, 2007) are applied on a regional scale which has more predictive power in terms of food value chains affected. In the case of studies concerning river floods, the majority of them are carried out on a regional scale (Grünthal et al., 2006; Meyer et al., 2008, etc.). The regional vulnerability assessment is important for the central or the regional government to make decisions regarding funding allocations. However, as far as on-site emergency management and disaster planning are concerned in particular, local vulnerability assessment can provide decision makers with useful information. Implementing the methodologies face many difficulties, the most common of which are the non-availability of data and the fact that some methods are time-consuming due to extensive field work and detailed data required.

Many risk assessment methodologies for critical infrastructures play a major role in food production chains. In general, the approach used is rather common and linear, consisting of some main elements: identification and classification of threats, identification of vulnerabilities, and evaluation of direct impact. This is a well-known and established approach for evaluating risk and is the backbone of almost all risk assessment methodologies (Giannopoulos et al., 2012). However, there is a huge differentiation of risk assessment methodologies based on the scope of the methodology, the audience to which it is addressed to (policymakers, decision makers, research institutes) and their domain of applicability (asset level, infrastructure/system level, system of systems level). In general, the methodologies reviewed fail to incorporate the social and organisational components into the analysis of physical infrastructures. This is arguably the most significant deficiency found in the current methodological and empirical practices to measure vulnerability and resilience. The interdependencies amongst physical and human components in infrastructure seem to be very strong and complex.

The notion of vulnerability emphasises the exposure of a system to a hazard from the point of view of the nature of that system itself. Ideally, such an account should include some of the systemic properties, particularly from the perspective of the resilience of the human-environment interfaces of the system under consideration. Because vulnerability has often been regarded as a property and not as an outcome of social relations and technological systems (Hilhorst and Bankoff, 2004), the concept is easier to deal with than that of risk, as it does not exclusively emphasise a future event or system state, but also, and perhaps most obviously, certain actually present qualities of a system. Vulnerability assessments cannot take place without attention to the hazard and, thereby, also to risk. However, the concept puts the emphasis on what an actor can directly affect rather than a threat from the outside, or a possible development in the future.

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CHAPTER 3

ORGANIC AGRICULTURE'S CONTRIBUTION TO POVERTY REDUCTION

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Introduction

In recent decades, organic agriculture (OA) has attracted increasing attention from governments, non-governmental organisations (NGOs), and development agencies. Agricultural production has grown dramatically and today, organic products are not only traded locally but nationally and internationally as well. The number of customers has increased, particularly in Europe and North America (Willer and Lernoud, 2016). With the growing demand and expanding markets, OA is increasingly viewed as not only a more sustainable alternative to conventional agriculture in improving the environment and mitigating climate change but also as an economic opportunity for farmers and people in rural areas all over the world (Nandwani, 2016). In the development context, OA has been increasingly promoted because of its potentials to improve rural livelihoods through increased incomes via premium prices and reduced costs for inputs such as fertilisers and pesticides (UNCTAD, 2006; UNEP–UNCTAD 2008), and it may provide a route out of poverty for rural people (Forumue, 2005; SSNC, 2013; Setboonsarng and Markandya, 2015). As an agricultural approach based on traditional knowledge, local resources, and low-cost technology, the prospects of integrating less resourceful small farmers in organic production seem good. However, does OA really live up to its promise of improving the conditions of people living in poverty in marginal rural areas?

This paper addresses the effects of OA in terms of income and of poverty alleviation in rural areas in developing countries. The central questions are: What is the status of OA today? Does it provide the expected premium prices and benefits? Does it contribute in raising the standards of living of farmers living in poverty? What are the most important entry barriers and problems related to OA? What are its development prospects?

The paper is based on an extensive inventory and review of data and literature. Although this analysis focuses on two value chains – cotton and coffee – the project also includes other products such as cocoa and oilseed, The two value chains are selected because they involve smallholders in marginal rural areas in developing countries, their market in Europe is a major buyer, and they represent different patterns in terms of value chains, geographical importance, and development of different certification schemes Several different certification schemes exist for both crops. Many of the studies evaluating the effects of certification amongst smallholders are focused on both organic and other types of certifications.

The paper first introduces OA and its relevance to sustainable rural development in developing countries, and provides a brief introduction to the analysis of global value chains. The current status and development of OA are then briefly addressed based on the recent W*orld of Organic Agriculture 2016* (Willer and Lernoud, 2016). This overview is followed by the analysis of organic cotton and organic coffee production, with particular focus on their effects on the livelihoods of smallholders. In the final section, the findings are discussed and conclusions are drawn.

Theoretical Background: Organic Agriculture and Sustainable Rural Development in Developing Regions

Organic Agriculture

'Organic farming' and 'organic agriculture' are terms used to describe different farming methods that avoid the use of chemical fertilisers and pesticides as well as seeds of genetically modified organisms (GMO) (SSNC, 2013). Instead of chemical inputs, OA focuses on avoiding loss of nutrients through recycling; using manure, compost, and green manure; and varied crop rotations or agroforestry systems. Based on traditional farming methods from before the introduction of chemical inputs, OA has progressive ambitions. To reach its goals, OA seeks to combine the best of traditional methods with new scientifically based knowledge.

The organic farming movement emerged in Europe and the United States (US) after World War I, but 'organic farming' as a concept was first coined by Lord Northbourne in 1940 (Paull, 2014). It took a long time, however, before the terms became widely used, and even longer before they received attention in academic research. This can be illustrated by the results of searches over time for the terms 'organic agriculture' and 'organic farming' in scientific literature in the database of a Swedish university library (Table 1). It was not until the 1970s that the term 'organic farming' became widely used and only during the last two decades has the interest of academic research grown remarkably. As well, 'organic agriculture' was seldom used before the 1970s, but has since gained importance. Today, these terms are often used interchangeably and in parallel although 'organic agriculture' is often preferred in more formal contexts, e.g. in connection with international organisations, policy documents, and legislation.

Table 1: Number of Article Hits in Scientific Journal and Books per Decade, 1940—2016

	Organic farming	Organic agriculture
1940s	7	
1950s	27	1
1960s	10	
1970s	187	28
1980s	388	112
1990s	1,828	966
2000s	13,419	8,416
2010s	19,072	10,515

Note: 2010s end with May 2016.

Source: UniSearch/Linköping University Library, 2016.

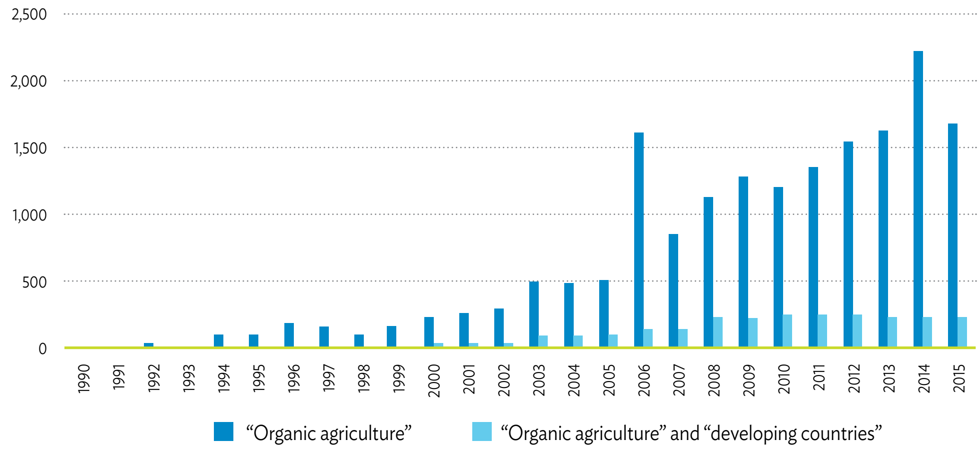
Not only has OA a longer history than other concepts and schools under the broad category of sustainable agriculture but has also a stronger base of established standards for production and processing. These standards have been integrated in legislation in many countries and form the basis for certification schemes and quality control. By 2011, 101 countries had OA regulations in place or were developing policies for it. Amongst these countries were 15 (out of the 54) African countries (SSNC, 2013). Since 1991, importing organic products has been regulated by EU legislation.

OA can be certified or noncertified (Setboonsarng, 2015a). Certified OA typically refers to third-party certification, where an independent certifier reviews the production process to ensure that it complies with national and international standards. Such certification plays a central role in the organic supply chain by guaranteeing that the products meet the standards (Haas et al., 2010). The standardisation of OA has contributed in creating confidence in organic food. It excludes by default, however, organic farmers (Farnam, 2001; Bennett and Franzel, 2013), who represent a large majority of smallholders in Africa that hardly or very irregularly use or have access to chemical inputs. Although the products from these non-certified producers live up to the basic organic standards since they are produced without chemical inputs, their production rarely incorporates the progressive objectives and practices of OA.

Organic Farming and Developing Countries

For so long, OA was not perceived as an option for the developing world as it did not seem desirable in regions that desperately needed increased food production. This attitude was reflected by the lack of interest from academia, which seldom mentioned organic agriculture in the developing context before the year 2000 (Figure 1). The introduction of organic farming in developing countries became an issue in the 1990s when the EU organic market was established and opened for imports of organic products. Also, some development aid organisations started to support the introduction of organic farming in Africa (e.g. Forss and Sterky, 2000).

Figure 1: Number of Article Hits in Scientific Journals and Books per Year, 1990—2015



Source: UniSearch/Linköping University Library, 2016.

The 'breakthrough' after 2000 was related to a changed view on the prospects for OA in the traditional South, and increasing critique against the long-term results of the green revolution. The modern, mechanised, and chemical agriculture, introduced in developing countries via the 'green revolution', has been successful in raising production levels and increasing the food supply for a growing population. However, it has also brought severe risks and problems such as environmental degradation via pollution of ground and surface waters, erosion problems, and loss of biodiversity in agricultural landscapes (Nandwani and Nwosisi, 2016). The use of antibiotics and pesticides has had negative consequences for animals and farmers and led to the quality of the products being questioned from health perspectives. Conventional farming is also related to high costs of investments in machinery and infrastructure, and purchase of fossil fuels, chemical fertilisers, and pesticides as inputs. Overproduction has often led to decreasing prices which, in combination with stable or increasing input price levels, have led many deeply indebted farmers into bankruptcy (Pattanapant and Shivakoti, 2009).

OA is the most widely recognised alternative farming system that decreases its environmental effects. Reduced use of pesticides and chemical fertilisers decrease health impacts as well as ground and surface water pollution. It enhances biodiversity that helps control pests and diseases and produce healthy crops, and contributes to climate mitigation via reduction of fossil fuel use and increased build-up of soil carbon through use of animal manure, compost, and green manure (Schader et al., 2012).

Additionally, researchers, NGOs, development agencies, and UN organisations have increasingly viewed OA as a way for creating a more sustainable development in rural regions in Africa, Asia, and Latin America; reducing negative effects of agricultural modernisation; improving local food supplies; increasing employment; and reducing poverty in rural areas. It can contribute to poverty reduction and food security through market premiums, reduced costs for purchased agrichemicals and seeds, and improving the productivity and yields of the farm system. OA most often involves diversification of farm and its outputs. This may involve inter- or multi-cropping of annual crops or a shift to longer-term rotations including shrubs or trees (agroforestry), which may contribute to more stable and higher incomes. It may also make better use of the local labour force.

It was long assumed that OA had a general yield disadvantage compared with conventional agriculture. However, Badgley et al. (2007) found that, in general, organic systems in developing countries have higher yields than conventional systems. In a similar meta-study, Seufert et al. (2012) showed that conventional farming most often has higher yields, but that organic systems can match conventional farming under certain conditions, including good management practices, crop types, and growing conditions. Where little or no fertiliser has been used, the introduction of organic fertilisers often increases yields. Although yield decreases during conversion to OA, this can be quite temporary (Setboonsarng, 2015b). In practice, one of the main challenges of organic farming remains the yield and limited productivity due to lack of nutrients, ineffective weed control measures, and limited possibilities to improve the nutrient status of infertile soils (Kirchmann et al., 2008; Nandwani and Nwosisi, 2016).

Value Chain Analysis and Farmers in Developing Countries

Value chain analysis is a method to study the value created in a product from raw material to the final product. Most often, it has been used in an industrial-corporate context for analysing the system of producing a particular product. In recent decades, however, this approach has been increasingly used by development researchers to examine the interrelationships between the various actors involved in different stages of global supply or value chains (e.g. Mitchell and Coles, 2011). Development practitioners have also used this kind of analysis for identifying opportunities to improve the conditions of farmers (e.g. Donovan et al., 2013).

Value chain thinking has its roots in both the supply chain and business strategy analysis and the commodity chain analysis connected to world systems theory (Raikes et al., 2000). The supply chain literature in the 1980s stressed the importance of mutually beneficial business partnerships. Michael Porter (1985) introduced the concept of value chains within firms and between a firm and its suppliers. The term was introduced in the development literature in the 1990s, where it partly replaced 'commodity chain' (Donovan, 2011).

'Chain' suggests a focus on 'vertical' relationships between buyers and suppliers and the movement of a good or service from producer to consumer (Bolwig et al., 2010). The global value chain analysis has mostly centered on flows of material resources, finance, knowledge, and information in value chains, and has addressed related power relations and governance issues. Global value chain studies have analysed the structure, actors, and dynamics of value chains, including the development of functional division of labour along the chain and its changing shape, the dynamics of inclusion and exclusion, the distribution of value-added, and the roles of standards and policies in facilitating or hindering participation (Poulton et al., 2004). Currently, more local, 'horizontal' dimensions such as poverty, gender, and environmental aspects have been included in the value chain analysis (Riisgaard et al., 2010).

To smallholders in developing countries, these analyses of global value chains have shown the inequities in power relationships in connection with different supply chains and the difficulties of upstream farmers to influence and change the terms of their participation. Smallholders have often experienced worsening terms of trade and economic hardships due to low and unstable prices for their products and high costs of inputs. There are, however, also examples where integration in international value chains has brought opportunities for farmers to acquire the skills and resources needed to 'upgrade' their participation by reducing costs, increasing the level of processing, or producing new types of goods or services.

In recent decades, there has been less focus on the question whether farmers in the developing countries should participate in global trade and value chains. Instead, questions on how the terms of their participation can be improved are now being addressed by researchers, NGOs, and development agencies. In this context, value chain analysis has proved valuable because it helps to identify problems, weaknesses, and strengths in different value chains, and to identify new opportunities. Research has, in the context of different value chains and regions, more often addressed the prospects for upgrading and how this upgrading can be supported (Kumar et al., 2011).

OA offers a package that potentially can bring to farmers all four types of upgrading typically mentioned in the literature (e.g. Gereffi, 1999; Donovan, 2011):

- Product upgrading through the production of higher priced organic products;
- Process upgrading by developing higher resource efficiency and lower input costs;
- Functional upgrading by develping varied skills for OA and innovative use of resources; and
- Intersectoral upgrading where successful organic transformation will make it possible to enter the organic value chain for both traditional cash crops and potentially new products.

However, realising such potentials and the connected benefits is difficult particularly in the context of smallholder communities in developing countries. In contrast to large commercial farmers who have access to capital, information, finance, and technology and can supply larger quantities of products and guarantee product quality, smallholders are generally disadvantaged (Kumar et al., 2011). They are often illiterate, lack management and technical skills, and have poor access to information (e.g. quality assessment, buyer demand, and standards). Their organisation and access to markets are often poor due to poor infrastructure and communications.

Methods and initiatives to facilitate value chain integration and upgrading of smallholders include efforts of increasing smallholders' capabilities by education and creation of farmer organisations and restructuring value chains by, for example, reduction of the number of intermediaries, and direct company contracts shortening of the value chains (NRC, 2010). Smallholders' capabilities can increase through training, information, and financial services. (Fayet and Vermeulen, 2014). Contractual arrangements can help reduce risk and farmers' vulnerabilities (Proctor and Digal, 2008). Contracts allow farmers to foresee volumes and quality requirements, predict prices, and determine what kind of support would be valuable. Branding allows product differentiation and increased profit and negotiation power along the value chain. Even if branding is rarely associated with small farmers, it can help to better position products of developing regions in both local and international markets by adding value and positive image building (Boomsma and Arnoldus, 2008).

Organic Production and Consumption in the World

The Research Institute for Organic Agriculture and the International Federation of Organic Agriculture Movements – Organics International regularly publish *World of Organic Agriculture*, an overview of the status and development of OA in the world. In the spring of 2016 appeared its 17th edition (Willer and Lernoud, 2016), with data for 2014. The data presented in the following sections are from this overview.

The 2016 report illustrates the dynamic development of organic production and consumption, and the generally expected fast growth of organic market. So far, the traditional North dominates the world of OA in terms of both consumption and production.

Organic Agricultural Land

The total organic agricultural land area was, in 2014, 43.7 million ha (including land in conversion). It has grown by 300% since 1999 and corresponds now to 1.0% of the global agricultural land. Additionally, there are also non-agricultural areas, mainly for wild collection, beekeeping, aquaculture, and occasional grazing. Approximately 40% of the organic agricultural land is in Oceania (Australia) and 30% in Europe. Oceania (4%) and Europe (2.4%) have substantially higher than the world average share of agricultural land, while the two largest continents – Africa and Asia – together have only 11% of the total organic agricultural area in the world. More than half the area is in Australia, Argentina, the US, and China. The growth of the organic area has been quite steady in Europe and Africa, while development has been much more irregular in other continents.

Consumption of Organic Products

In 2014, the global market for organic food and beverages was estimated to be US$80 million (Sahota, 2016). The turnover has had a five-fold increase since 1999. The US (43%) and the EU (38%) have together more than 80% of the total purchases of organic products, while China is the only traditional developing country with a significant share of the global organic market. The countries with the highest per capita consumption of organic food and beverages are Switzerland and Luxembourg, while the organic market share is highest in Denmark (7.6%), Switzerland (7.3%), Austria (6.5%), Sweden (6%), and the US (5%).

Organic Producers

In 2014, a total of 2.3 million organic producers were reported. While the market since 1999 has grown five times, the number of people involved in organic production has grown more than 10 times according to workforce estimations. Despite some double counting in the FiBL survey, this number is probably an underestimation due to incomplete reporting by certifiers (Willer and Lernoud, 2016). While consumers of organic products and organic agricultural land are predominantly located in the traditional North, more than four-fifth of organic producers are located in Asia, Africa, and Latin America. Forty percent of producers are in Asia and 26% in Africa, despite the fact that only 3% of the global organic agricultural land is located there.

The Value Chains of Organic Cotton and Coffee

The labour-intensive cultivation of cotton and coffee is widespread and their value chains involve smallholders in developing regions and growing organic markets. They differ in terms of structures and geographical patterns. The value chains of cotton are complex and include uncountable final products while coffee beans are only produced to make coffee as beverage. There are several different certification schemes for both crops, and the total certified area is considerably larger than the organic area. Europe is not an important producer and relies on imports, and its expanding organic market is already an important, if not dominant, buyer of these organic products from the traditional South.

Cotton

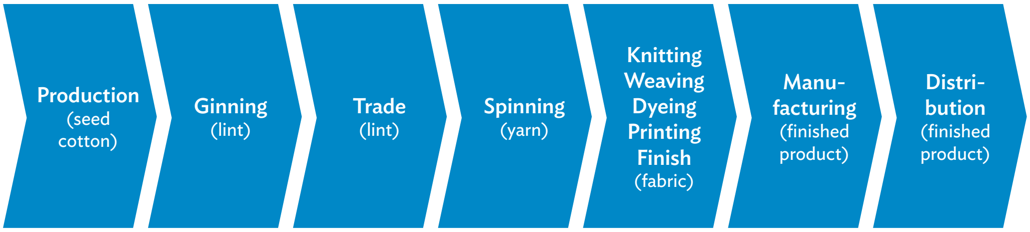
Cotton, cultivated in more than 75 countries (FAO/ICAC, 2015), is mainly used for textile production and is amongst the most important non-food crops in the world. In 2013, the total cotton area was 32 million ha, which corresponds to 0.7% of the global agricultural land (ITC, 2015). According to Better Cotton Initiative, 90% of cotton is produced by small farmers with less than 2 ha of land (Forum for the Future, 2013). It provides livelihoods for 100 million farmers and 250 million people working in various cotton-based industries (FAO/ICAC, 2015). In 2013, the largest cotton-producing lands were in India with almost 12 million ha, China with 4 million ha, and the US and Pakistan, each with 3 million ha (ITC, 2015). Globally, 73 million tonnes of seed cotton and 25 million tonnes of cotton lint were produced. The two largest producers are China and India, each with about a quarter of the world production. Most of their production is used by their textile industries that export to the whole world, but China is also the leading importer with about one-third of the global imports. Other large producers are the US, Pakistan, Brazil, Uzbekistan, and Turkey. The US, with approximately one-third of the global exports, India, Australia, and Brazil are the most important cotton exporters (ICTSD, 2013).

Cotton needs a lot of water and is sensitive to drought and insect infestation. Inefficient irrigation combined with inappropriate use of fertilisers and pesticides can lead to water shortages, reduced soil fertility, water contamination, and increased human health risks (Fayet and Vermeulen, 2014). Low market prices, high input costs, and delays on high interest rates have often led small cotton farmers into vicious cycles of debt (Makita, 2012).

The Cotton Value Chain

Since cotton is a raw material with widespread use, it is part of uncountable value chains, which most often consist of numerous steps. Figure 2 is a crude illustration of the typical cotton value chain of farmers in India. Studies of organic cotton cultivation and the organic and certified cotton value chains have mainly focused on India. It is most common to include at least seven steps in the cotton value chain: farming, ginning, spinning, weaving, dyeing, manufacturing, retailing. But the different steps can be combined or further divided. The ambitions of different cotton certification schemes or company initiatives are most often to reduce the number of intermediaries along these value chains.

Figure 2: Basic Structure of Cotton Value Chains



Source: After Nelson and Smith, 2011.

There are many varieties and types of cotton that are adapted for different uses and have different price implications (Nelson and Smith, 2011). Longer, finer, and more resistant cotton lint most often commands a higher price. Contamination with organic matter or other foreign materials such as plastics can be a serious problem to smallholders in both India and Africa since it negatively affects the price. Improving the quality by eliminating contamination can be a way to receive a higher price for the produce.

Organic Cotton Production

The social and environmental conditions of cotton cultivation and related environmental problems got attention early. Since the 1980s, actors in the cotton and clothes value chains have experienced increasing pressure to introduce more sustainable practices. The first certification schemes were launched in the US and Europe in the early 1990s (Hortmeyer, 2010). Although the market for organic clothes and organic cotton remained very limited and unstable in the 1990s, organic cotton production was introduced in India and some other Asian and African countries with support from NGOs and development agencies. Since the early 2000s, there has been a renewed and rising interest in sustainable methods, and a rapid increase in the number of voluntary certification and labelling initiatives addressing environmental and social supply chain issues (Gruère and Plastina, 2010). Companies, pushed by media and increasing consumer expectations, have increasingly joined these certification schemes to improve their market positions and increase control over their supply chains to make it possible to reduce costs and enhance quality control. The nine-fold growth of organic cotton production in 2005-2010 (Truscott et al., 2016) can, to a large extent, be attributed to this trend as supported by NGO and government programmes.

According to the Organic Cotton Market Report 2014 (Truscott et al., 2016), 117,000 tonnes of organic cotton were produced in 2014 by 148,000 farmers on 221,000 ha. India, with 115,000 ha, dominated organic cotton cultivation with 74% of the production and 78% of the producers. Other important cotton-producing countries are China, Turkey, Tanzania, and the US. There are large differences between these major countries in land productivity (Table 2)as indicated by the relationship between production and land area. The most notable differences, however, are the scales of production (production per farm).

Table 2: Organic Cotton Production in the Five Largest Producing Countries, 2013-14

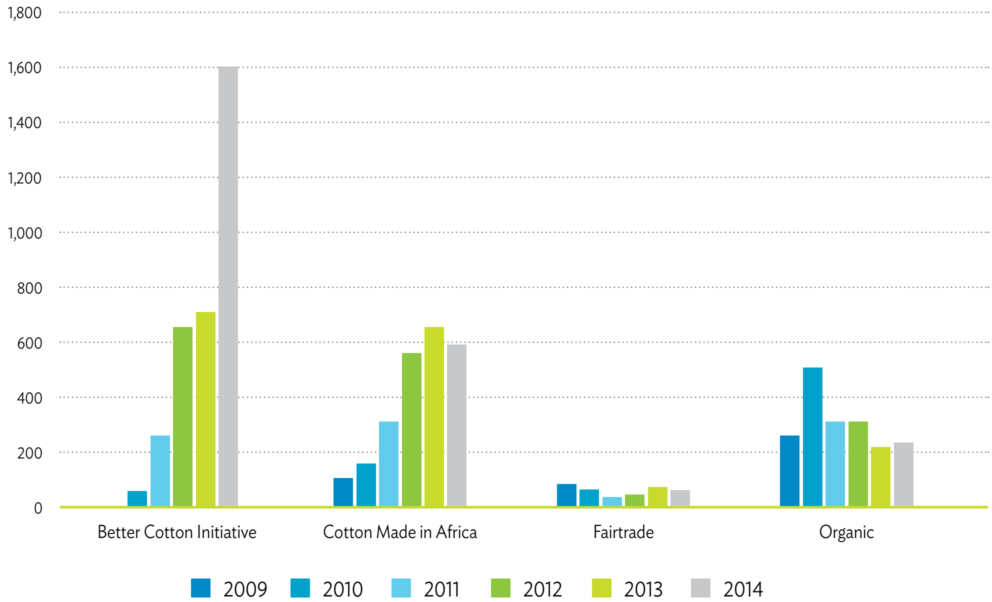
	Farms	Area (ha)	Cotton lint production (tonnes)	Production/farm (tonnes/farm)	Production/area (tonnes/ha)
India	114,863	172,295	86,583	0.8	0.5
China	34,02	5,957	12,231	3.6	2.1
Turkey	258	4,240	7,958	30.8	1.9
Tanzania	4,179	17,218	3,752	0.9	0.2
US	38	4,189	2,315	60.9	0.6

US = United States

Source: Truscott et al., 2016.

Organic cotton production grew rapidly until 2009, when it was the dominant certification scheme for cotton (Figure 3). However, the cultivated area has since then decreased by half. Truscott et al. (2016) explain that this fall was due to very low price levels after the financial crisis, difficulties related to chain management, and limited supplies of high-quality non-GMO seeds. A shift towards less demanding and less costly sustainable certification schemes can be observed. Particularly, the Better Cotton Initiative has grown fast amongst farmers in India as well as in Latin America and Africa (ITC, 2015). This certification is a general sustainability benchmarking scheme without most of the organic requirements, and it accepts the use of GMO seeds. In 2014, the Better Cotton Initiative was the dominant cotton certification with 1.6 million ha (Figure 3).

Figure 3: Development of the Certified Cotton Area in the World According to Different Voluntary Sustainability Schemes, 2009-2014, in Thousands of Hectares



Source: Adapted from ITC, 2015.

Coffee

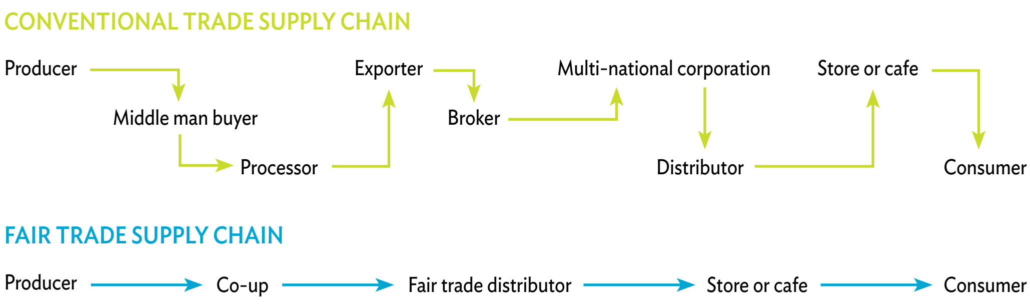
Coffee is grown in more than 10 million ha of land (ITC, 2015), which corresponds to 0.2% of the agricultural land in the world. The largest coffee cultivation areas are located in Brazil (2.1 million ha), Indonesia (1.2 million ha), Colombia (0.8 million ha), Mexico (0.7 million ha) and Viet Nam (0.6 million ha). Together, these countries have 53% of the total coffee area. In 2013, almost 9 million tonnes of coffee were produced in the world (ITC, 2015). The world's leading producers are Brazil with more than one-third of the production, Viet Nam (1.5 million tonnes), Indonesia (0.7 million tonnes), Colombia (0.7 million tonnes), and India (0.3 million tonnes).

More than 6 million tonnes or two-thirds of the global coffee production were exported in 2013 (Kaffeemarkt, 2013). The largest exporters were Brazil (27% of world exports) and Viet Nam (20%). The EU stood for 42% of the world imports, while the leading import countries were the US (23%), Germany (9%), Japan (8%), Italy (6%), and France (6%). Finland has the highest coffee consumption with 12 kg of raw coffee per person and year, followed by Austria, Norway, and Denmark.

The Coffee Value Chain

Compared with cotton, the value chain of coffee is rather homogenous, consisting of several value-adding steps, which may be organised in different ways, and include different numbers of actors. The chain can be divided into two major steps: farming stage consisting of production and processing in developing countries, and industrial stage consisting of roasting, milling, solubilising, lyophilization, packing, and distribution, normally in high-income countries, where most consumption takes place (Caffagi et al., 2012). The ambitions of fair trade and other sustainable coffee initiatives emphasise radical shortening of the value chain through reduction of the number of middlemen and creation of more direct links from farmers to consumers, bypassing large corporations (Figure 4).

Figure 4: Conventional Coffee Supply Chain vs Fair Trade Supply Chain



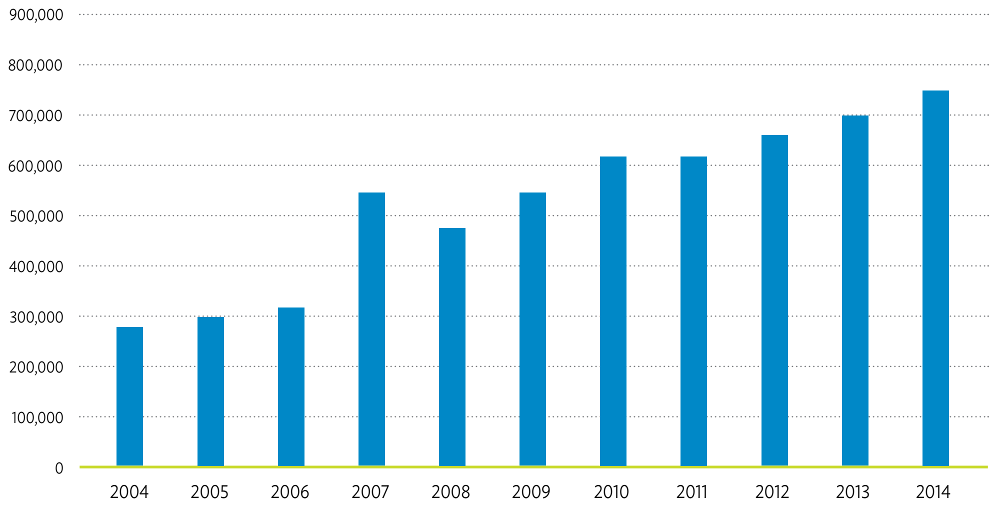
Source: Adapted from Urban Conserve.

Organic Coffee Production

In 2014, the organic coffee cultivation areas consisted of 763,000 ha, which corresponded to 7.7% of the world's harvested coffee. The largest areas were found in Mexico (243,000 ha), Ethiopia (154,000 ha), and Peru (89,000 ha), while Nepal had the largest share of organic cultivation area (46%), followed by Timor-Leste (45%), Bolivia (37%), and Mexico (35%). More than half of the world's organic coffee areas are in Latin America, 27% in Africa, and 15% in Asia. Since 2004, the organic coffee areas have shown a steady growth and more than quadrupled in size (Figure 5).

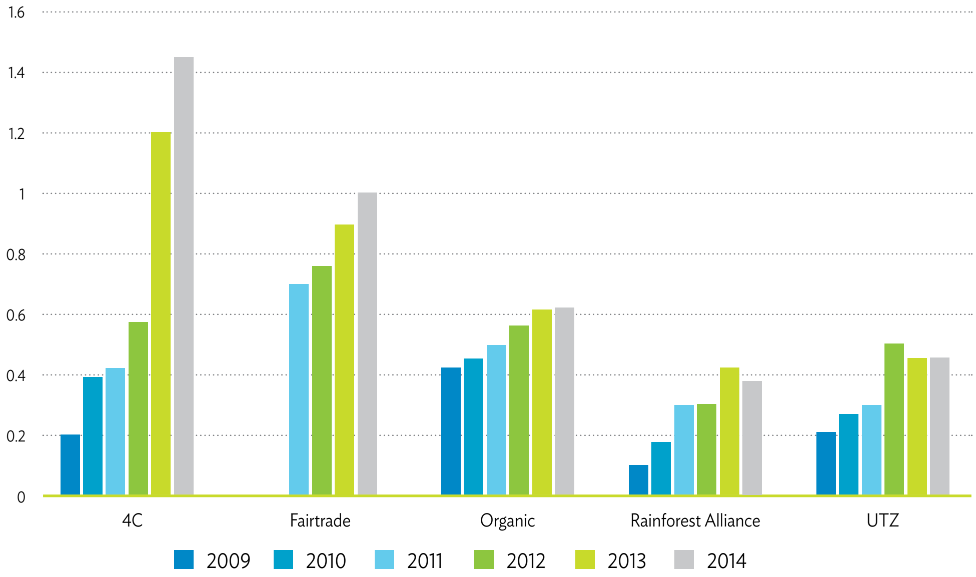
Coffee has a long history of standardisation, and organic coffee is just one out of several certification schemes. Besides organic coffee, also sold as 'certified coffee' are Fairtrade, Bird Friendly, Rainforest Alliance, and Utz Kapeh, all generally accepted as ecological or sustainable coffee even if standards and control may differ. 4C is a relatively new certification scheme, which demands gradual compliance of the production to certain standards. There are also other sustainability labels developed by the industry. As shown in Figure 6, all the major voluntary certification schemes have grown in the past few years, including, most importantly, 4C. In 2014, the different schemes together covered 4 million ha or 40% of coffee areas. The geographical patterns of the different certification schemes differ. While Fairtrade coffee certification is widespread in African countries, 4C has mostly attracted coffee farmers in the most important production countries such as Brazil and Viet Nam.

Figure 5: Development of the Global Organic Coffee Areas, 2004-2014, in Hectares



Source: Adapted from FiBL Survey, Willer and Lernoud, 2016.

Figure 6: Development of the Certified Areas of the Most Common Coffee Certification Schemes, in Million Hectares



Source: Adapted from ITC, 2015.

Effects of Organic Conversion on Smallholders' Livelihoods

Many studies have focused on organic cotton farming amongst smallholders particularly in India, although there are also some studies from Africa and Latin America, with most of them often focused on Latin America. Increasingly, organic cotton and organic coffee are addressed together with other certification schemes, particularly Fairtrade which, to some extent, also encourages organic production. Only few studies systematically assess the full range of effects of organic conversion from yields, incomes, and costs to the economic situation and food security of households. Many studies focus on very particular projects, but there are also some overviews and efforts of a more general evaluation of impacts. A general problem of these efforts to evaluate the impact of organic production is that they often rely on rather crude methods that may result in biases (Blackman and Rivera, 2010) and it often remains uncertain if observed differences between certified and non-certified farmers can really be attributed to certification (Chiputwa et al., 2015)

Cotton

Most studies addressing the effects of organic cotton production amongst smallholders are focused on India. But there are also some examples of studies from other parts of the world, e.g. Tanzania (Altenbuchner et al., 2014), Mali (Nelson and Smith, 2011), Burkina

Faso (Bassett, 2010), Senegal (Nelson and Smith, 2011), Cameroon (Nelson and Smith, 2011), Kyrgyzstan (Bachmann, 2011), Turkey (Adanacioglu and Olgun, 2010, 2012), Uzbekistan (Franz et al., 2010), and Paraguay (Martin et al., 2010). Studies from Africa more often focus on organic cotton together with Fairtrade cotton that is often combined with organic production.

Most assessments of Indian organic cotton production show positive effects and potentials. The implementation of organic cotton farming has generally brought reduced production costs and positive health effects. In a review of nine case studies, Fayet and Vermeulen (2014) conclude that implementation of organic farming and other certification schemes has generally improved the situation of smallholders growing cotton. The yields have usually been maintained and, in some cases, increased. The most widespread and strongest positive effects are reduced production costs and improved health, but in most cases, market access has significantly improved and better payments have been achieved. Riepke and Singh (2010) analysed the value chain from organic cotton in India to retailers in the UK, and found that the use of organic cotton can add value at all stages of the production process, both to farmers and intermediaries. Although farmers' shares of the value additions are small, these price increases are still important. Price premiums of 10% seem to be common, but organisations can also offer increases of 20% or more (Panneerselvam et al., 2010).

Food insecurity amongst smallholders in India is often a result of indebted farmers not having enough money to buy food. The combination of lower input costs and higher incomes have great potentials to increase food security amongst Indian small farmers by reducing indebtedness without affecting farm production (Panneerselvam et al., 2010). Panneerselvam et al. (2014) suggest that even with a 3%-5% reduction of food production, organic conversion of cotton production would improve the economic situation of smallholders. However, the prospects of organic conversion may be dependent on regional conditions. Patil et al. (2014) show that profits of organic production (including cotton rotations) are higher in a dry area of Karnataka and risks are lower due to lower input costs than in a wet area, where profits and risks are more similar to conventional farming since inputs such as organic fertiliser have to be purchased.

In Africa, almost all studies point at positive environmental and health impacts of introduction of organic cultivation. Improved yields are most common in low-intensity agricultural areas. There are also cases where it is very difficult to observe any development due to very low and highly variable production, e.g. amongst smallholders in Mali (Bassett, 2010). Some studies have documented other positive social impacts such as improved education, organisation, and position of women. According to some studies (e.g. Bassett, 2010; Nelson and Smith, 2011), participation in Fairtrade programmes has made it possible for women to increase their household status, be active in organisations, and directly benefit from their cultivation of cotton plots and other work incomes. Other studies perceive greater difficulties in achieving changes in gender relations (e.g. Altenbuchner et al., 2014).

Outside India and Africa, evaluations of economic outcomes are mixed. Organic cotton production is less often connected with yield increases but more with decreases. Turkey has been a leading producer of organic cotton, but premiums and profits have not been upheld, hurting many small farmers who had converted to organic production. Adanacioglu and Olgun (2012) reported that in Turkey, the profits per hectare of organic cotton production were less than half of the conventionally produced cotton due to higher production costs. The low premium prices, lack of conversion support, and dim possibility of achieving long-term contracts do not compensate for the high production costs and risks related to organic cotton cultivation in terms of, for example, production variability. Bachmann (2011) found a completely different situation in Kyrgyzstan, where despite 10% lower yields, much lower input costs in combination with organic and Fairtrade premiums led to 27% higher average gross margin from organic cotton cultivation. In Paraguay, organic cotton production is well established and yields seem comparable, although Martin et al. (2010) found that continued reliance on conventional industry for seeds; difficult certification processes; and problems with logistics, marketing, and payment make it difficult for farmers to obtain premium prices. They often sell large parts of their organic cotton to traditional buyers.

Various studies in India have shown that the initial introduction of organic farming programmes to small farmers presented an important challenge (Fayet and Vermeulen, 2014). Pilot projects with pioneer farmers can be an efficient means to overcome the general skepticism amongst farmers. In a study based on interviews with farmers in three Indian states, Panneerselvam et al. (2012) found that conventional farmers perceived the lack of technical knowledge, organic inputs, institutional support, and access to organic markets as land fragmentation as the major barriers to organic conversion, while price premium, health benefits, and reduced costs are factors that could motivate them. Organic farmers associated the conversion with reduced input costs, higher incomes, and sometimes, higher yields after the conversion period. However, for both conventional and organic farmers, yield levels and insect control remained a challenge.

The outcome of organic conversion may depend on the implemented standards and who is implementing them (Fayet and Vermeulen, 2014). Company-based projects have often better and more direct access to markets while NGO projects supported by development agencies often are better at adapting to local needs but may experience challenges in assuring market access. Market price fluctuations create difficulties, particularly for NGOs who may not be able to make long-term commitments. The most positive multi-sided effects of conversion to organic agriculture are reported from a company project in the Meatu district in the north of Tanzania (Altenbuchner et al., 2014). The smallholders in this district have benefitted from higher yields and increased incomes due to lower costs, more stable markets through long-term contracts, and access to loans, which made it possible to invest in farming and buildings, and diversify incomes with new crops and off-farm activities. Increased productivity has also brought increased food security. However, many of the positive developments concerning education, extension services, and other infrastructures are dependent on the company bioRe Tanzania and its resourceful organisation. bioRe Tanzania has been initiated by the Swiss company Remei AG, which provides the link to the market together with the Swiss retail company Coop. bioRe purchases organic cotton in the region with a 15% price premium on actual local market prices.

Despite the rather positive evaluations of organic cotton cultivation in India, the reduction in number of organic cotton farmers and organic cotton areas during the few last years points towards important barriers for the further development of organic cotton farming amongst smallholders. Lack of supplies of non-GMO seeds and lack of technical skills together with unstable prices for farmers without company contracts seem to have contributed to the rather dramatic shift towards less costly and demanding certification schemes (Truscott et al., 2016). In 2010-2011, there was a substantial fall in cotton prices and premiums of organic cotton, and a majority of producers only received about 3%-5% premium for organic fibre (Chandak et al., 2014). Furthermore, organic cotton cultivation is quite demanding compared with other certification schemes.

Coffee

Similar to the studies on the organic cotton chain, assessments point towards gains all along the value chains of organic coffee and other ethical/ecological certified coffee. Studies from many countries and regions – Mexico, Nicaragua, Guatemala, Colombia, Ethiopia, Uganda, Kenya, and India - have evaluated the effects of organic and Fairtrade coffee certification amongst smallholders.

Most studies have found positive environmental and health effects, and have evaluated yield as higher or unchanged after organic conversion, and that premium prices for organic or other certified coffees have been realised. However, only few studies have been able to find important income increases or prove tangible effects in terms of reduced poverty and increased food security (Bennett and Franzel, 2013).

Most early studies (before 2009) claimed that yields had increased and that organic coffee had great potentials to bring economic benefits to and reduce poverty amongst smallholders if premium prices were realised, chemical input costs reduced, and incomes from farming became more stable. Recent studies have increasingly questioned the economic benefits of certified coffee production or viewed them as highly context dependent.

Case studies and literature related to projects and programmes in Africa have more often claimed positive economic effects in connection with organic certification and other certification schemes. Bolwig et al. (2009) found that organic certification contributed to higher farm revenues in Uganda. Chiputwa et al. (2015) concluded that coffee farming households in Uganda connected to Organic, Fairtrade, and UTZ certification schemes had substantially higher incomes and living standard than those that sell via uncertified market channels, and that Fairtrade certification, in particular, had significant effects on poverty. However, Jena et al. (2012) and van Rijsbergen et al. (2016) only found rather insignificant economic effects in Ethiopia and Kenya, respectively, and that positive effects sometimes remained as potentials due to poor organisation.

In Latin America, studies have generally found that although certified farmers receive higher prices, this does not necessarily result in higher incomes nor reduced poverty. Arnould et al. (2009) looked at impacts of Fairtrade certification in Peru, Guatemala, and Nicaragua and found limited effects on household welfare despite higher prices. In Mexico, Barham et al. (2010) found in a large survey that Fairtrade/organic producers received higher prices than conventional producers, but that the differences were relatively small and that the yield mattered more than the price difference for the income. Yields are often maintained or even increased after organic conversion, but the decline during the transition period and related losses of incomes are major barriers for farmers converting to organic coffee (Bravo-Monroy et al., 2016). Weber (2011) found a 5%-income gain amongst Mexican Fairtrade/organic farmers. Such difference, however, is hardly sufficient to cover all expenses related to organic conversion, extra labour, and higher standards of living. Valkila (2009) did not find any benefits from organic and Fairtrade production in Nicaragua, and argued that these certification schemes contribute to poverty traps through their prolonging of obsolete low-input agricultural systems. Bacon (2005) and his collaborators (2014) have, in a series of studies, addressed food security amongst Fairtrade and organic-certified small farmers in Nicaragua and found that households suffered from seasonal hunger due to weather conditions and hazards, rising maize prices during lean periods, and coffee harvests and prices that do not provide sufficient income. In Colombia, Ibanez and Blackman (2016) observed many positive outcomes of certification and organic production from an environmental point of view, but were unable to identify any economic benefits.

A major difference between smallholders in Latin America and Africa is that farming only makes up a minor part of the Latin American smallholders' incomes, which dominantly come from work outside the farm, and remittances. Higher crop prices do not automatically make much difference for the standards of living nor make farmers put in extra work and resources into developing their farming. Vellema et al. (2015) found in Colombia that increasing incomes from coffee did not make households increase their income because the time and efforts spent on coffee cultivation made farmer give up other income-generating activities. Donovan and Poole (2014) concluded that few of the poorest households in Nicaragua invested in coffee farming and are still depended heavily on seasonal off-farm incomes and subsistence farming. Their results indicate that improved market access with higher prices have uncertain impacts on rural poverty. Several of these studies recommend a broader focus that addresses the underlying constraints on household assets and investments.

Discussion

OA has expanded dramatically in recent decades in the global South and in smallholder communities. Studies generally point out that OA can have certain potentials for rural smallholder communities in the global South. It is, however, difficult to overview and generalise as conditions may differ dramatically between regions and local contexts. There have been numerous programmes, initiatives, and projects to introduce organic, Fairtrade, and other certified cultivation schemes in rural smallholder contexts in Latin America, Africa, and Asia. 'Success stories' are very common, particularly in connection with various NGO-supported programmes and UN reports (e.g. UNEP–UNCTAD, 2008). The emphasis in various evaluation efforts, however, is most often on rather immediate effects, while more long-term evaluations and overviews are rare. Evaluating the development of the emerging organic sector is also hampered by difficulties on data and related uncertainties. These difficulties do not only concern organic production in the Third World context but also the consumption data in Europe, where different 'ecological' and certified coffees, for example, are often clumped. There exist for both coffee and cotton a wide flora of certification schemes and sustainability initiatives that confuse and bring difficulties to consistent evaluation. Few studies make systematic efforts to assess the broader effects of organic certification of cotton and coffee, and these assessments most often rely on rather crude methods that may have brought biases in the results.

The existing evidence point to organic conversion very often bringing farmers the promised price premiums, reduced input costs, and improved health. The effects on yields are more context dependent. They may depend on how much fertilisers were used previously, and available labour. But often, the long-term effect of organic conversion can be higher yields in Asia, Africa, and Latin America. Recent reviews of organic conversion in Sri Lanka and Thailand point towards important yield increases in rainfed and marginal lands, where smallholder communities reside (Setboonsarng, 2015b).

In terms of value chain upgrading, the studies on organic coffee and organic cotton show in general that farmers who converted to organic production achieve product upgrading. The certified organic production receives premium prices over conventional production and value chains are shortened via more direct and stable market linkages provided by NGOs or companies. There are also indications of process upgrading in numerous cases through reduced needs of external inputs and lower costs of production. The need to purchase manure and to increase labour, and to reduce non-farm incomes may, however, counterweigh these gains. Functional upgrading can often be perceived as a challenge; the necessary skills for organic farming, and pest and weed control, for instance, are not easily achieved. A limitation of this study and several studies that focus on single product is that it becomes difficult to approach inter-sectoral upgrading. Some of the positive economic effects in terms of income, employment, and decreasing vulnerability may lie in new combinations of products introduced by organic conversion. There are, however, indications in some studies that a more diversified production may reduce vulnerability (e.g. Bacon et al., 2014).

To what extent the positive effects of organic conversion contribute to an improved economic situation amongst smallholders is very context dependent. It can be related to the role and importance of farming incomes for the rural households and to the local organisation. The effects may also depend on the implemented standards and who is implementing them. It seems as if company-based initiatives often are able to provide more stable and more long-term markets, while NGO projects supported by development agencies are often better at adapting to local needs but may experience challenges in assuring market access. However, the development of new and better market conditions is seldom adequate to combat poverty amongst the least resourceful smallholders who do not have resources nor incentives to develop their farming. It has to be supplemented by other policies/initiatives.

Both coffee and cotton exemplify that other less demanding certification schemes have gained even importance. In the case of cotton, this expansion has been at the expense of organic production as the number of organic producers has decreased in recent years. These alternative ecological and ethical certification schemes often reward farmers more directly and more significantly in terms of premium prices and better access to market (Setboonsarng, 2015a), and do not require a transition period with yield decreases and other uncertainties. On the other hand, these alternative certifications are less connected to all the potential benefits of OA such as reduced input costs, improved health, and in improving local land and resource productivity. There is a need to further investigate and address the entry barriers to OA in different regions.

Reaching the full potentials of OA is quite challenging and probably very seldom realised. It is dependent on assistance not only in terms of market connections, non-GMO seeds, basic methods, and temporary financial support, but also on development of advanced capacity for managing, experimenting, and learning how to improve the farming system and making better use of local resources. There is a risk that organic conversion and developments would become very dependent on external support from government agencies, aid organisations, NGOs, and businesses from the global North. To develop and improve education, local organisations and national infrastructures are central challenges for the further development of OA in Asia, Africa, and Latin America.

Organic production is a development path that is dependent on external know-how and support as well as foreign markets. The products are sold in niche markets in Europe and North America where consumers are willing to pay extra for products with certified qualities. Organic and other certifications may provide opportunities for quite a few small farmers but the expansion potentials still seem limited. There are certainly important growth opportunities in some market segments, but can premium prices and current arrangements be upheld when markets expand? It is also hard to imagine that cash-crop-oriented organic production will be an option for the majority, if not for the domestic markets, for these products develop, and if not, a much more autonomous and independent development of OA emerges.

Conclusions

Organic agricultue has in recent decades spread to the developing world and grown rapidly. Even if most organic producers are located in developing countries, organic production in Africa, Asia, and Latin America is still a marginal phenomenon in relation to the total agricultural land and the total number of farmers. However, in relation to some value chains with important markets in Europe and North America such as coffee and cotton, organic production has, together with other certification schemes, gained some importance.

Introduction of OA amongst cotton and coffee-producing smallholders in developing countries has often had positive effects in terms of realised price premiums, reduced input costs, maintained yields, decreased environmental impacts, and improved health. The effects on yields are more dependent on context, but organic conversion seldom results in higher yields. Better market conditions are, however, not adequate to reduce poverty and to decrease food insecurity amongst the least resourceful.

Introduction of organic production relies heavily on assistance in terms of knowledge, market connections, and financial support, and on bringing new external dependencies. The development of organic production in developing countries has so far been heavily dependent on foreign markets in Europe and North America where consumers are willing to pay extra for organic products. Certainly, although there are still market growth opportunities, the expansion potentials still seem limited, and further expansion of OA will be increasingly dependent on the development of local markets.

The entry barriers to organic markets and the need to develop and improve education, local organisation, and national infrastructures should be further addressed. Assessment of the effects of OA on rural poverty and vulnerability should focus more on local settings since important potentials of OA lie in the development of the local farming systems and new combinations of income sources.

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PART 2
KEY MESSAGES: NATURAL DISASTERS AND AGRICULTURAL PRODUCTION, NUMBERS, MODELS, MEASURES, AND CURRENT POLICIES

Pedro Chambel Leitao and colleagues present a variety of models synthesising knowledge on the interaction between plants, soil, and the atmosphere. This allows for more sophisticated soil and water management during periods of droughts and floods. Farmers and stakeholders should be empowered to assess climate and disaster risks by themselves. A challenge is to control a spatial and time-distributed high variability of properties in soil, atmosphere, and plants and the related data handling. Leitao's development team aims to establish a system of climate scenario management with easy-to-use tools.

Chris Renschler and colleagues present a method to quantify impacts of climate and land use changes on soil and water management in close relationship to community resilience and sustainable development of agricultural watersheds. The PEOPLES resilience framework they present is better suited to counter natural disasters, with its subsystems, demographics, lifestyles, infrastructure, ecosystem services, governmental services, market mechanisms, and disaster response. Each of the subsystems is an individual subject for improvements and optimisation. An entirely managed system can widely abate adverse impacts. In total, the effects and damage after a disaster can be widely minimised.

Eirik Romstad informs on the choice of policy instruments and the correlated impacts on land use and the food industry. Poverty and poorly developed political institutions are key obstacles in dealing with the negative impacts of natural disasters. Well-functioning and integrated food markets are the most important institutions for ensuring the supply of enough food under natural disasters. Crop insurance is the most important single measure to reduce the negative impacts natural disasters have on farmers while futures markets serve the same role for the food processing industry. Price support will increase commodity production volumes particularly in good years, which will lower prices but increase price variability.

CHAPTER 4

MODELLING YIELD, NATURAL RESOURCE, AND MONETARY LOSSES OF FLOOD AND DROUGHT DISASTERS

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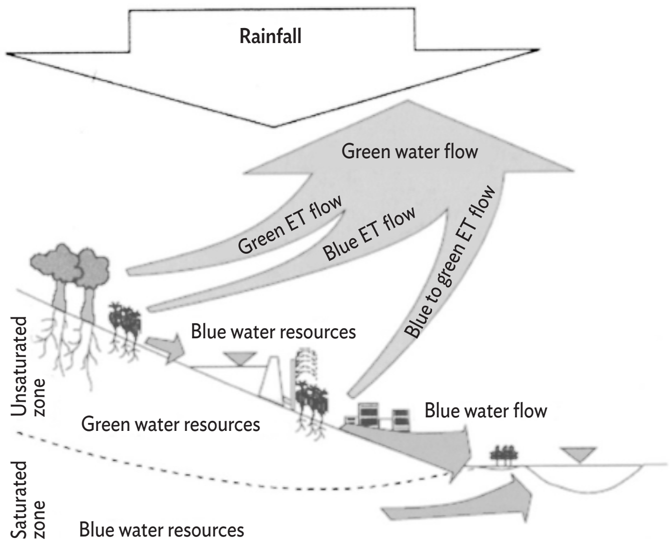
Introduction

The world is experiencing changing patterns of water use as a result of changes in land use. The occupation of natural landscapes by agriculture is a major cause in developing countries while changes in crops are being encountered by developed countries. In both cases, economic reasons pushed by the globalisation of world trade play an important role. Also, in both cases, further global changes are expected as a result of climate change. Water availability is essential for socio-economic activities, and citizens expect catchment managers to take the necessary measures to assure quantity and quality for direct and indirect human consumption. Kaufman (2012) considers the possible transformation of water into a commodity. The worldwide water budget can become a measure of the prosperity of a country whereas evapotranspiration can be considered an expense. Knowledge of the processes determining water fate, actual reserves, and the capacity to forecast water consumption are essential for a catchment manager's decision-making. Other authors have named evapotranspiration as green water flow (Falkenmark and Rockström, 2006). These authors associate green water flow with biomass production, which is paramount for food production (Figure 1). The proportion of undernourished people is 12.9% in 2014–2016, and the reduction of this is the first millennium development goal (UN, 2015). To obtain this goal, changes to the green water flow might have to happen. The green water flow has two major components: transpiration, which is a productive flow, and a non-productive evaporative flow from soil, ponded water (example: rice), and water intercepted from foliage surfaces. Green water is mostly stored in unsaturated zone. However, part of it could also be stored in saturated region due to capillary rise or deep root plants. Remaining stored water is blue water stored in aquifers, reservoirs, lakes, and streams. Blue water flows into the ocean or evaporates to the atmosphere.

Figure 1: Conceptualisation of Green-Blue Water in the Context of Water-resource Planning and Management



ET = evapotranspiration.

Source: Falkenmark and Rockström, 2006.

Based on the available data and the simulation models (catchment and reservoir), it is possible to get an early view of the possible evolution of the reservoir and then act accordingly. This way, it is possible to simulate in real time the potential effects of a decision that involves the modification of soil use (erosion, nutrient sources, etc.) or the possible effects of different outflow of reservoir management, specially in what concerns droughts and floods. An example using the Soil and Water Assessment Tool (SWAT) model is the estimation of pollutant loads in the Ardila watershed (Durão et al., 2012). Models provide forecasts and alternative management scenarios based on technical and scientific information of land use, soil type, weather, etc. In other words, the hydrologic models allow the customisation of each solution's specificities, allowing the connection between drivers and pressures (agriculture practices, climate changes, etc.) and the state of the water. Some examples include the use of watershed models with hydrodynamic models aimed at integrated coastal water management (Campuzano et al., 2013). Many hydrologic studies have been successful at the hydrographic region scale. In Portugal, where the management plans of the hydrographic region have been concluded, the Alentejo and Algarve plans used SWAT for the catchment water budget and to estimate the diffuse sources of pollution, in particular, from agriculture (Leitão et al., 2012). This approach was possible due to the availability of extensive data in the national water web portal of Sistema Nacional de Informação de Recursos Hídricos (SNIRH). Also, the existence of national-scale weather forecast models allows the implementation of water budget forecasts at the catchment level. Several watersheds in Portugal are shared with Spain, where data are not publicly available and thus makes the task of implementing and calibrating the models more difficult.

Catchment models require field data for validation and for the specification of parameters and boundary conditions. Satellite data are inexpensive and regularly collected at the catchment scale. Together with in situ point data, they can supply model data needs. The combination of these three sources of data provides a continuous spatial-temporal description of the water path and water quality that allows the forecasting capacity required by managers and optimises the cost–benefit ratio. A good example on the use of satellite data to support modelling was the MyWater FP7 project (Hartanto et al., 2015). After implementation and calibration, the model can be used to study processes and assess scenarios, and can also be run operationally to generate daily forecasts based on meteorological forecasts. This model can be validated by comparing the model solution with satellite images, whenever they are available, and can generate the data required by catchment managers to assess water availability and water requirements.

The main problems that can be addressed by these types of models are water availability in the soil for agriculture and in reservoirs for water managers, and flood dynamics for civil authorities and urban managers. One of the main challenges today is communicating to water managers uncertainty in hydro-meteorological forecasts (Ramos et al., 2010). This uncertainty can be estimated in operational systems like the ones proposed by Chambel-Leitão et al. (2016).

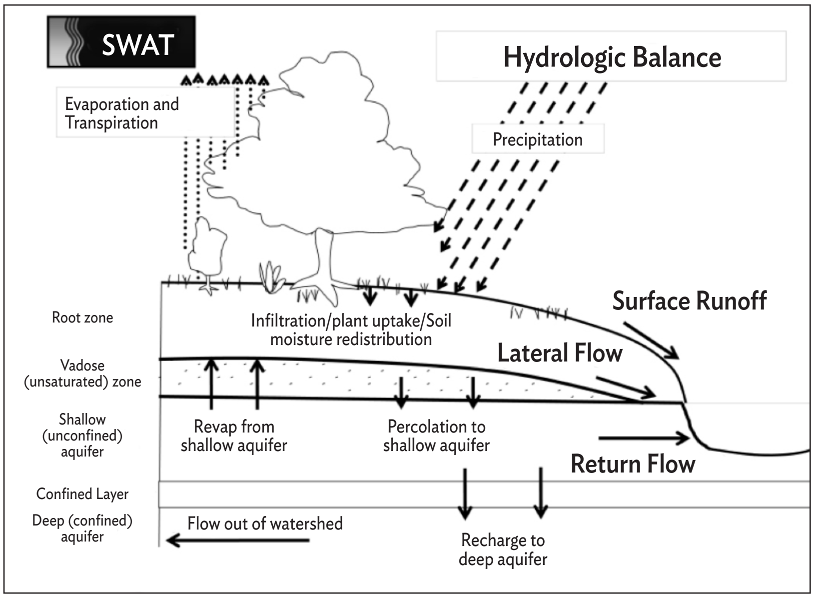
Methodology

The two models presented here are being used in Portugal (and around the world) to support water managers on flood, drought, and yield estimations, and are the ones used for the results presented below. Also shown are some examples of water information systems used by water managers.

SWAT Model

SWAT is a river basin or watershed scale model developed by the USDA Agricultural Research Service to predict the impact of land management practices on water, sediment, and agricultural chemical yields in large complex watersheds with varying soils, land use, and management conditions over long periods of time. Intended to be a model for evaluating the impact of agricultural practices at the watershed scale, it came at a time when there was a need to improve water quality. As point sources were getting more controlled, diffuse sources were set as new targets for improvements. In order to do that, the origins of the diffuse sources had to be understood using the scarce data available.
Hydrology in the watershed is the main driver for the transport of nutrients. SWAT requires specific information about weather, soil properties, topography, vegetation, and land management practices occurring in the watershed. The physical processes associated with water movement, sediment movement, crop growth, nutrient cycling, etc. are directly modelled by SWAT using this input data.

Figure 2: Water Budget Fluxes at Hydrologic Response Units



Source: SWAT course slides.

In SWAT, the simulated basin is divided into several sub-basins. Each sub-basin can either be divided into many hydrologic response units (HRU) with the same land use and soil type, or there can be only one HRU. Each HRU has soil surface as superior boundary and aquifer as inferior boundary. It receives precipitation (PRECIP) from the superior boundary, part of which is converted into runoff (SURQ_CNT) and another part is infiltrated. The part that is converted into runoff is directed to the sub-basin channel while the parcel that infiltrates – being able to evapotranspirate (ET) – is carried along the soil profile to be percolated to the aquifer or carried laterally along the soil profile until it reaches the channel (LATQ), or it can be stored in the soil (ΔS). The water that reaches the aquifer is lost to the stream (GW_Q), to the deep aquifer (DA_{RCHG}), or finally, to the atmosphere (REVAP). REVAP is in fact an indirect way of simulating capillary rise, because the SWAT soil module can only distribute water in the soil profile with a downwards flux.

The equation below summarises the water budget for each HRU:

$$PRECIP=ET+DA_{RCHG}+REVAP+LATQ+GW_Q+SURQ\_CNT+\Delta S \quad (1)$$

SWAT fluxes can also relate with the green and blue water flow mentioned:

$$GreenWaterFlow= ET+REVAP \quad (2)$$
$$BlueWaterFlow= LATQ+GW_Q+SURQ_{CNT}+DA_{RCHG} \quad (3)$$

MOHID LAND Model

MOHID Land is a newer model compared to SWAT. It started being developed in 2000 (Neves et al., 2000), reusing the code that was written for MOHID Water (Miranda et al., 2000). This model has some similarities with SWAT. For example, it enables a wide range of spatial and temporal scales, allowing the simulation of a 1 sq m plot or a 5,000 sq km watershed with time steps that can range from seconds to hours. The modular design of MOHID Land facilitates the integration of other models (Miranda et al., 2000). Different water quality modules are available for stream water. Furthermore, this approach minimises the maintenance costs and allows the development of integrated models of soil water flow and surface water flow.

Table 1: Comparison Between MOHID Land and SWAT Characteristics and Features

Model	MOHID Land	SWAT
Suited Applications	Wide range of spatial and temporal scales; modular design facilitates integration of other models; advanced capabilities for water quality and water budget analysis	Watersheds; excellent for calculating total maximum daily loads and simulating a wide variety of conservation practices and other best management practices; successfully applied across watersheds in several countries
Main Components	Hydrology, weather, soil properties, crop growth, nutrients, pesticides, agricultural management and channel routing, overland/channel flow, unsaturated/saturated zone, snowmelt; aquifer/rivers exchange, advection/dispersion of solutes, geochemical processes	Hydrology, weather, sedimentation, soil temperature and properties, crop growth, nutrients, pesticides, agricultural management, and channel and reservoir routing
Runoff on Overland	2-D diffusive wave and dynamic wave equations	CN for runoff

Model	MOHID Land	SWAT
Subsurface Flow	3-D groundwater and unsaturated flow	Lateral subsurface flow/ground flow
Chemical Simulation	N, P, pesticides, C, dissolved conservative solutes in surface, soil, and ground waters	N, P, pesticides, C
Spatial Scale	Distributed	Semi-Distributed
Temporal Scale	Event-based; continuous; variable steps	Continuous; daily steps
Watershed Representation	2-D rectangular/square overland grids; 1-D channels; 3-D unsaturated/3-D saturated flow	Sub-basins based on topography, HRU, ponds, groundwater, and main channel
Availability	Public	Public

1-D = one dimensional, 2-D = two dimensional, 3-D = three dimensional, C = carbon, CN = carbon nitrogen, HRU = hydrologic response unit, N = nitrogen, P = phosphorus, SWAT = Soil and Water Assessment Tool.

Source: Authors.

Water Information Systems

Platforms that provide hydrologic data are very important to water resources managers. In Portugal and Spain, there are two examples of this type of platform: the National Information System of Water Resources (Sistema Nacional de Informação de Recursos Hídricos) and the Automatic System of Hydrologic Information (Sistema Automático de Información Hidrológica). The main activities of these systems are to measure, transmit, process, and in some cases, validate the data, which allow the characterisation of the state of rivers and some hydraulic structures. In the end, they will be a tool to archive and provide long-term series of hydrological data, which helps in the management of water resources and in the prediction and monitoring of extreme climatic events such as floods and droughts. The SNIRH system was implemented with the goal of facilitating the usage of collected data in different studies and objectives (Santos et al., 1997).

In Portugal, SNIRH was used to develop a system of flood monitoring and alert (Sistema de Vigilância e Alerta de Cheias) (Lacerda et al., 1997). Later, this system was updated with new features (Rodrigues et al., 2003), becoming the system of water resources monitoring and alert of Portugal (Sistema de Vigilância e Alerta de Recursos Hídricos de Portugal). The system is based on flow measurements and water levels measured in reservoirs and provided by National Institute of Water (Instituto Nacional da Água), Energies of Portugal (Energias de Portugal), and other entities that manage these reservoirs. However, this system does not include meteorological forecasting. Other countries, such as Brazil and the US, have similar systems. In Brazil, all hydrological information resulting from monitoring systems is available in the System of Hydrologic Information (Sistema de Informações Hidrológicas) managed by National Water Agency (Agência Natural das Águas). In the US, the corresponding system is National Water Information System, which supports the acquisition, processing, and storage of hydrological data. Both systems provide real time information, with that of the US having an alert system available to the general public.

Normally, these systems do not include modelling results as an output. On the other hand, multiple measurements of areas are scarce in these systems. The development of models applied to different spatial scales and making them operational is the aim of this paper. For that, some examples are presented on model application to different scales.

Results

Land use change drives the modification of three interdependent global variables of the watershed: evapotranspirated water, biomass production, and organic matter content of soil. Assessing the consequences of land use changes requires the capacity to study those global variables at an integrated level. Catchment models can simulate those interactions together with all the processes that determine plant dynamics, and are major tools not only for integrated studies but also for decision making. Decision makers, however, work at different scales, which sometimes make difficult the dialog to manage overall water recourses. The models presented here have a wide range of spatial and temporal scales. Three examples are provided.

i) Managing water on farm scale

In the FIGARO FP7 (Flexible and Precision Irrigation Platform to Improve Farm Scale Water Productivity – Seventh Framework Program) project, a system based on AQUASAFE platform was implemented with the objective of providing easy-to-use tools capable of gathering up-to-date data and forecasts that may advise both in what concerns the prevention (scenarios management), the actual risk (how the actual catchment conditions constrain the risk level), and the response (in the present conditions, and the short-term forecasts of what areas are being at risk in the following days). This vision goes beyond the traditional event prevention to response cycle by contributing to long-term land and water bodies management through information-rich support of the relevant stakeholders' decisions on water management towards the effective, continuous water control, and promotion of economic growth. It seeks an integrated forecast system that can simulate hydrologic, hydraulic, and soil plant air models using meteorological measurements and models results as input (Simionesei et al., 2016).

Non-specialised personnel find the AQUASAFE platform easy to use and that it can integrate any type of model and data source. As a result, the system represents an added value in what concerns the information that can be processed and integrated through ICT tools in a user-friendly way.

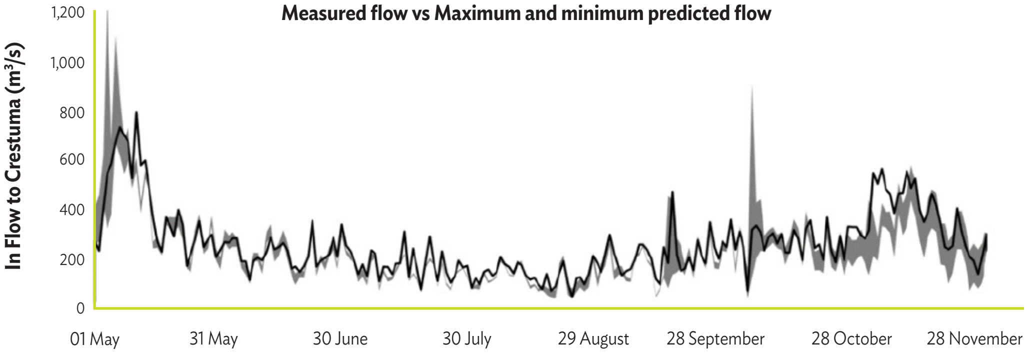
The major beneficiaries of the FIGARO platform include:

- The environment, through overall reduction in use of fresh water for irrigation and the consequent reduction in the water footprint.
- Individual farmers who, by employing the platform, fulfil their obligation to save water in compliance with the growing trend of European regulation compelling the use of managed irrigation.
- The food industry, through companies buying agricultural products grown with the FIGARO Platform. These companies will benefit twice: first, by better compliance with regulation that compels them to lower the environmental impact of their businesses, and second, by promoting themselves as environmentally friendly business by acquiring the 'environmentally friendly farming practices used in our products lowered water footprint' label.
- Policymakers and decision makers, who will gain tools for monitoring and managing agricultural practices including irrigation, fertigation, and use of saline/brackish water. With FIGARO platform, they will be able to manage natural resources such as water and energy more effectively and accurately.
- Consumers of Europe and beyond, who will benefit from healthier and higher quality food products, which have been produced with more sustainable practices, e.g. use of less fertilisers and minimal amount of water.

ii) Managing water on watershed scale

Hidromod daily provides the Portuguese Electrical Company with predictions on streamflow. This system, known as AquaSafe Douro, is divided into two main components: AquaSafe Server, which stores and allows the manipulation of data generated in the system (model results) or externally (SCADA systems, FTP, Open DAP, etc.), and AquaSafe Desktop Client, which is the user interface (Chamabel-Leitão et al., 2016). The first component lets the user schedule a range of activities such as running models, publishing reports, etc. Communication with this component is made through two web channels: an exchange data channel and an administration channel. AquaSafe Desktop Client is the interface that assures connection between user and server .This platform was designed for 'operational' scenarios, providing a range of features (SIG, graphs, reports, etc.) that can be grouped and accessed in workspaces. Each workspace can be available only for one user or for a group of users. Hydrologic models MOHID Land and SWAT were implemented in this system to provide daily predictions (Figure 3).

Figure 3: Comparison of Simulated Flow (Grey Area) and Measured Flow (Black Line)



Source: Authors.

iii) Managing water at country scale

The perspective of managing not only water but also the potential for Portugal's biomass production by using SWAT model is the subject of a recent doctoral thesis (Chambel-Leitão, 2016). Watershed-simulated fluxes for Continental Portugal can be divided in blue water flow (Figure 1) and green water flow. Table 2 shows the accumulated volumes of water flow from precipitation, green water, blue water, and the water storage variation on the soil and shallow aquifer. The volumes result from the sum of the period 1 October 1979 to 30 September 2003, while the storage variation takes into consideration the volume available at the beginning and end of this period.

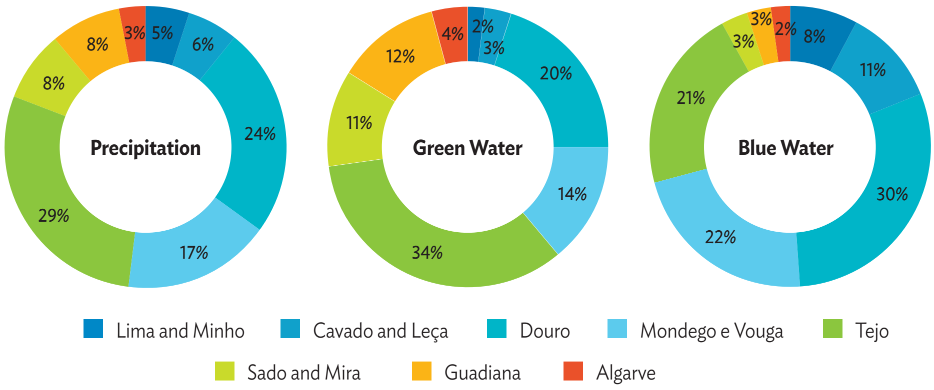
Table 2: Water Budget per Portuguese Hydrographical Region from 1 October 1979 to 30 September 2003 for Model Run with IPMA-GRID (values in km^3 in 24 years)

Hydrographical Region	Code	PRECIP	Green Water Flow	Blue Water Flow	ΔS
Lima and Minho	PTRH1	80.45	24.21	56.30	-0.13
Cavado and Leça	PTRH2	111.07	36.67	74.61	-0.27
Douro	PTRH3	411.79	206.67	205.47	-0.78
Mondego e Vouga	PTRH4	292.56	142.80	149.98	-0.75
Tejo	PTRH5	494.37	356.25	138.35	-2.08
Sado and Mira	PTRH6	140.73	118.44	22.45	-0.59
Guadiana	PTRH7	144.85	123.61	21.47	-0.58
Algarve	PTRH8	51.73	41.25	10.54	-0.18

Source: Authors.

Based on the global volumes in Table 2, the proportion of each of HR in each flow can be shown (Figure 4). For example, the area of HR 1, 2, and 3 accounts for only 35% of precipitation, but for 49% of all the blue water flow. The area of HR 6, 7, and 8 accounts for 19% of precipitation but only contributes to 8% of blue water flow.

Figure 4: Accumulated Volumes of Water Flow from Precipitation, Green Water, Blue Water per Hydrographical Region



Source: Authors.

Conclusions

Water managers work at different scales, which sometimes make difficult the dialogue to manage overall water resourses. The models presented here have a wide range of spatial and temporal scales. Three examples were presented that show it is possible to use models as integrative tool to help manage water resources. At farm scale, precision farming can allow for a sustainable growth in agricultural production. Modelling is a very helpful tool to support decision-making in precise farming. The FIGARO project is an example of model implementation. Extreme water conditions like flood and drought can result in high monetary losses. These extreme events will tend to be aggravated by expected climate changes. Again, models can help in the development of warning systems to prevent losses. An example of this type of model implementation is presented at watershed scale for Portugal. The development of centralised water information systems is very important. The Portuguese water systems do not include modelling results as an output. On the other hand, data became scarce in recent years on this system. The development of a model to country scale (Portugal) allows the possibility of a country having scale application that will provide water information to support decisions. AQUASAFE, which has been proven efficient at farm scale and at watershed scale, is then used at country scale.

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CHAPTER 5

QUANTIFYING IMPACTS OF CLIMATE AND LAND USE CHANGES ON SOIL AND WATER MANAGEMENT, COMMUNITY RESILIENCE, AND SUSTAINABLE DEVELOPMENT IN AGRICULTURAL WATERSHEDS

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Introduction

Soil erosion by water on agricultural land and naturally vegetated landscapes such as rangelands is a major current and future environmental threat to the sustainability and productive capacity of agriculture, forestry, etc. (on-site impacts). It also supplies sediment and associated chemical pollutants to vulnerable water bodies (off-site impacts). Pimentel et al. (1995) suggest that, during the past 40 years, nearly one-third of the world's arable land has been lost by erosion at a rate of more than 10 million ha per year. The off-site sediment damage is estimated to be far greater than the on-site productivity effects of erosion (Guntermann et al., 1976). Global change (i.e. climate change and associated major land use) is likely to exacerbate both the on- and off-site impacts of erosion in many locations worldwide.

Future shifts in the amount, intensity, and temporal distribution of rainfall will directly modify rates of soil loss in currently erosion-prone areas, along with rates of surface runoff (including peak flow discharge) and groundwater recharges. These shifts, along with spatial and temporal pattern changes in temperatures and precipitation, will affect rates of plant growth and crop yields as well as water use and, hence, soil-protective crop cover (Taub, 2010). In turn, these changes (in particular, shifts in the duration of time when unprotected soil is exposed before a protective plant cover is established) will also, more indirectly, modify runoff and soil loss. Faster residue decomposition from increased microbial activity may also increase erosion rates (Nearing et al., 2005) as will any changes in the timing of agricultural operations that leave even more areas with bare soil exposed to soil erosion. Finally, future climate changes will create opportunities for novel crops to be grown, which in some cases will give rise to new erosion problems. For example, maize and sunflower may be adopted in response to warmer conditions in temperate areas. However, these increase risk of erosion as both take a significant amount of time to provide adequate crop cover (Boardman and Favis-Mortlock, 1993).

The economy of Ethiopia, a country with a population of over 80 million inhabitants, is based on agriculture, especially production of coffee which is its major export crop. Ethiopia is also the leading African producer and exporter of coffee, cotton, cereal, vegetable products, and tea across the other continents, most especially Europe. According to a survey, agriculture accounts for about 83.9% of Ethiopia's export or half of its gross domestic product (GDP). About 80% of the total population of the Ethiopian economy are engaged in agriculture, making it the predominant occupation for Ethiopia's economy, with 25% of the population gaining their livelihood from the production of coffee alone (Devereux, 2000). Ethiopia depends mainly on low-productivity rain-fed agriculture for its national income.

While the Ethiopian economy is dependent on agricultural production, its crop yield is dependent on the weather condition. With such heavy dependence on rainfall, it should not be a surprise that impacts of climatic change like droughts, and decline in precipitation could lead to devastation of the Ethiopian economy and problems such as food insecurity, diseases, sickness, high poverty rate amongst farmers, and a decline in the country's GDP. Like many African countries, Ethiopia is confronted with environmental issues that are problematic for its agricultural sector (Gebremedhin Berhane, 2002). It is, therefore, imperative to study the trends in the temperature and precipitation pattern in Ethiopia. Several research studies have been conducted on temperature and precipitation around Ethiopia, the country being amongst areas of the world most likely to experience climate variations for short and long periods. Inter-annual variability of precipitation and temperature in Ethiopia is relatively large than the annual mean (Kahya and Kalaycı, 2004). As a result of climatic variations, the country's agricultural production is easily reduced.

The aim of this study is to assess the potential future temporal and spatial trend of temperature and precipitation pattern in Ethiopia as well as assess potential best management practices (e.g. soil conservation structures or non-structural vegetation cover changes in current crop rotations) to mitigate the problem of on-site soil erosion as well as the impact of off-site runoff and sediment yields.

Most developing countries like Ethiopia are experiencing degradation of land and water resources. To tackle this problem, soil and water conservation is now considered top priority to maintain Ethiopia's natural ecosystem and improve its agricultural productivity to be able to achieve food self-sufficiency (Melaku et al., 2017; Klik et al., 2017; Melaku et al., 2018). A massive effort in soil conservation strategies is being made by the government of Ethiopia. However, the effectiveness of soil and water conservation on the dynamics of the nutrient, stream flow, and sediment loading is not studied and identified clearly for long-term and short-term effects. Therefore, this project was designed to address gaps in the knowledge of the effectiveness of the soil and water structures. The study was done in two adjacent watersheds: one is equipped with soil and water conservation structures (stone bunds) while the other is without soil and water conservation structure. Streamflow, nutrient, and sediment loading will be compared based on the model output. Weather data were collected from the nearby station. Runoff was monitored with automatic cameras and flow sensors, and sediment samples were collected at the outlets of the two watersheds. The collected samples were analysed for sediment load and nutrients concentration. All collected data would be used to calibrate a simulation model and verify the same with it to compare the two watersheds to see the effectiveness of the soil conservation structures.

Objectives and Methodology

The main objectives of this interdisciplinary research were to assist in communication and collaboration between natural resources and natural hazards/disaster managers about spatial and temporal land management options in response to the need to assess potential climate and/or land use changes. To gain enhanced understanding of both disciplines, the researchers facilitated the communication to understand the spatial and temporal dynamics and variability of processes and process-based modelling techniques, utilise mapping to represent scales and foremost important agreement on core principles, such as 'sustainability' and 'resilience'. Qualitative and quantitative techniques enabled the utilisation of the new modelling approach for slow-onset and fast-onset extreme events and related unfolding disasters (e.g. climate and/or land use/cover change, flooding, etc.). This enabled the assessment of complex, interdependent system functionalities such as the promotion of wetland creation or water harvesting to increase on-site infiltration and reduce/delay off-site runoff. Assessing flood risk reduction, the potential loss of agricultural production, and investment in infrastructure are keys in evaluating sustainable development and community resilience.

This experimental study developed and tested a combined landscape-based modelling and assessment platform to investigate impacts of land use/climate changes and management options on sustainability and resilience of agricultural communities in Ethiopia. The study was performed in two adjacent watersheds: one developed by soil and water conservation structures (stone bunds) and the other one without soil and water conservation structure. Streamflow, nutrient, and sediment loading would be compared based on the model output. Weather data were collected from the nearby station. Runoff was monitored with automatic cameras and flow sensors and sediment samples were collected at the outlets of the two watersheds. The collected samples were analysed for sediment load and nutrients concentration. All collected data would be used to calibrate and verify a simulation model to compare the two watersheds to see the effectiveness of the soil conservation structures.

The Geospatial Interface for the Water Erosion Prediction Project (GeoWEPP) (Renschler, 2003), a process-based watershed model, and the PEOPLES Resilience Framework (PEOPLES) (Renschler et al., 2010), a holistic landscape-based systems assessment approach, were the foundation of this experimental study. Case studies for this newly combined model and assessment approach account for the spatial-temporal changes and dynamics of interdependent systems, enabling users to explore the impacts of likely scenarios (Renschler, 2013).

With the stakeholders from the soil and water conservation community, the researchers defined simulation scenarios to assess the impact of environmental changes and land use policy for more sustainable and resilient watershed management. The quantitative model results enabled the collaborators and stakeholders to assess on-site ecosystem service functionality (e.g. infiltration, ground water recharge, biomass production, crop yields, carbon sequestration, soil loss, etc.) and off-site impacts (e.g. return periods of runoff volumes and peak discharges at the outlet). The off-site impacts on existing and repaired downstream infrastructure were used to assess the complexity of interdependent system functionalities.

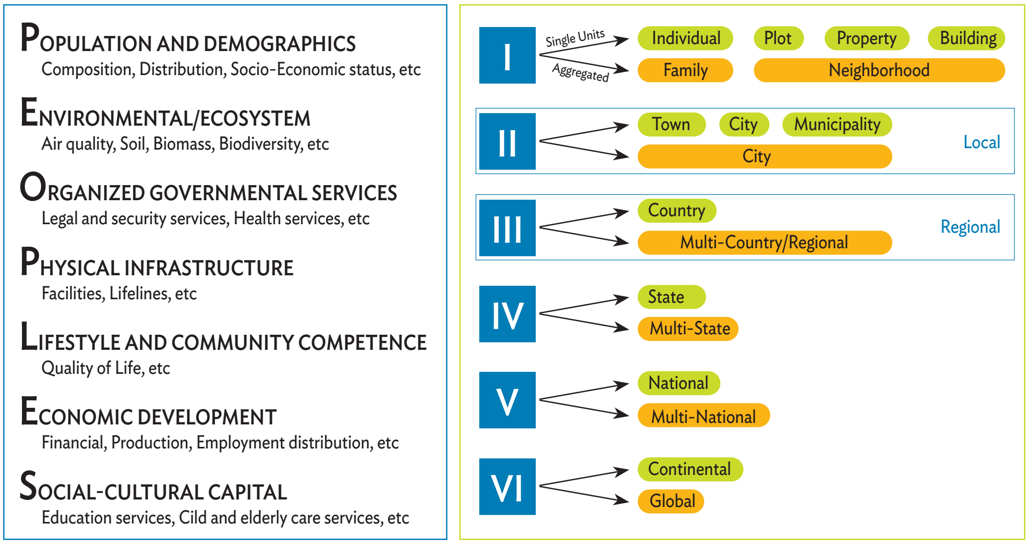
Natural Resources Modelling and Management

The model used in this study is the state-of-the-art, process-based Water Erosion Prediction Project (WEPP) model (Laflen et al., 1991; Flanagan and Nearing, 1995) and the Geospatial interface for WEPP (GeoWEPP) (Renschler, 2003; Flanagan et al., 2013). These freely available software packages simulate the effects of soil erosion by water on agricultural hillslopes and small watersheds. WEPP has been proven effective in assisting experts with the development of best management practices that aim to control soil loss and sediment export. WEPP has also been used to estimate water balances and sediment budgets under future climate and land use scenarios. However, as with any model, WEPP has its limitations such as zero representation of gully erosion or of permanent streamflow and those regarding the generation of multiple peak intensities during precipitation events. Nonetheless, it is one of the best-studied and validated soil erosion models currently available (Nearing et al, 2005; Flanagan et al., 2013) and frequently used by US agencies and researchers worldwide to develop and assess best management practices (Renschler and Lee, 2005).

Community Resilience Assessment

The PEOPLES Resilience Framework (Renschler et al., 2010) provided the platform to assess interdependencies. While PEOPLES can be used for scales ranging from individual, local, regional, and national to global, it was used in this study for watersheds of up to 100 ha. The PEOPLES acronym stands for a series of seven holistic, quantitative resilience dimensions and hierarchical lead indicators that stand for the state of functionality of systems in communities: population and demographics, environmental/ecosystem services, organised governmental services, physical infrastructure, lifestyle and community competence, economic development, and social-cultural capital (Renschler et al., 2010). This framework allows the assessment of the functionalities of each or interdependent systems using disaster or extreme events reduction measures (e.g. migration planning (P), implementing BMPs (E), disaster response and mitigation (O), reinforcing infrastructure (P), willingness for voluntary assistance (L), market development/subsidies (E), restrictive weekend activities (S), etc.). This combined assessment then uses lead indicators to assess the interdependencies between the seven defined systems for a more holistic review.

Figure 1: Seven Dimensions of Resilience and Scales of the PEOPLES Resilience Framework



Source: Renschler et al., 2010.

This review process utilises quantitative and qualitative lead indicators to compare stakeholder-defined management/hazard risk scenarios. The data formats for lead indicators consist of the respective PEOPLES dimension, functionality, and interdependency percentages at a particular time and geographical scale. Interdependencies can also be quantified by their relevance or weighted by their level of interdependencies with values between 1 (100% dependent) and 0 (0% or independent). This process was especially designed for supporting communication between both types of managers to better understand natural processes and their variability on a day-to-day-basis and to support decision-making in rapidly unfolding situations (e.g. rainfall runoff scenarios and return periods of peak runoff rates).

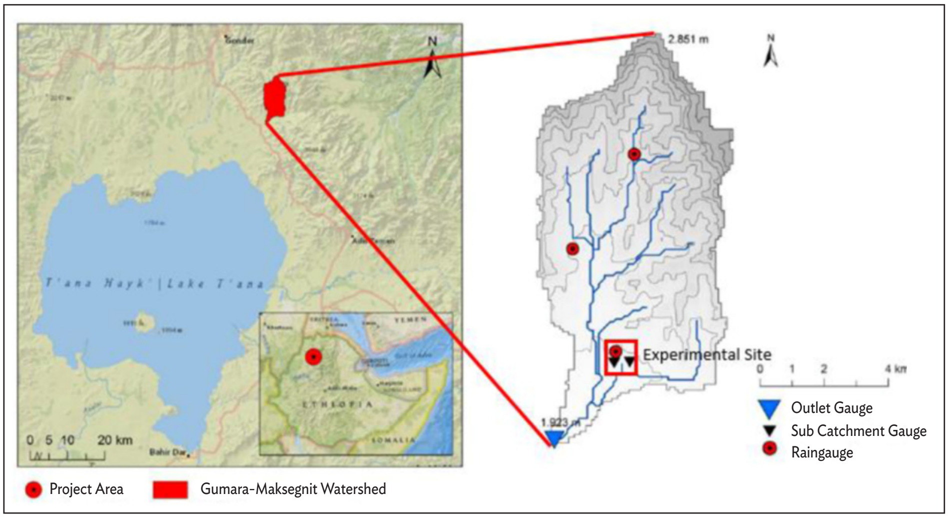
The collaborators in this experimental study worked with scientists, practitioners, and educators in natural resources management and natural hazards/disaster management. The collaborators developed the modelling approach in relative data-intensive watersheds by testing various levels of data granularity to evaluate its use with commonly available data and/or in data-poor watersheds. The project was designed to test relevant policy questions such as the implementation of best management practices (e.g. erosion control measures).

Study Area

In the Ethiopian Highlands, deforestation for crop production dramatically increased the vulnerability of the soils to rainfall-driven erosion (Nyssen et al., 2000; Melaku et al. 2017; Klik et al. 2017; Melaku et al. 2018). Intensive rainfalls during the rainy season (June to September) threaten the mountainous regions with severe land degradation especially the steep-sloped and unprotected areas (Addis et al., 2015).

The study area – the Aba-Kaloye (untreated) and Ayaye (treated) sub-watersheds – lies within the Gumara-Maksegnit watershed, situated in the Lake Tana basin in the northwest Amhara region of Ethiopia (Figure 2). The watershed is dominated by steep slopes and ranges from about 1,920 m above sea level to 2,860 m above sea level in altitude. It covers an area of 54 sq km and is located between 12°24' N and 12°31' N and between 37°33' E and 37°37' E. The watershed drains into the Gumara River, which finally reaches Lake Tana (Addis et al., 2015). The two sub-watersheds are located in the southern lower part of Gumara-Maksegnit watershed between 12°25'26" N and 12°25'46" N and between 37°34'56" E and 37°35'38" E (Figure 2). They are neighbouring each other with a distance of about 1 km between the outlets (Figure 2). The Aba-Kaloye and Ayaye sub-watersheds embrace an area of 31 ha and 24 ha, respectively, while their altitude reaches from about 1998 m above sea level to about 2150 m above sea level. They are also characterised by a mountainous topography, where 80% of the area have slopes of 10% or higher.

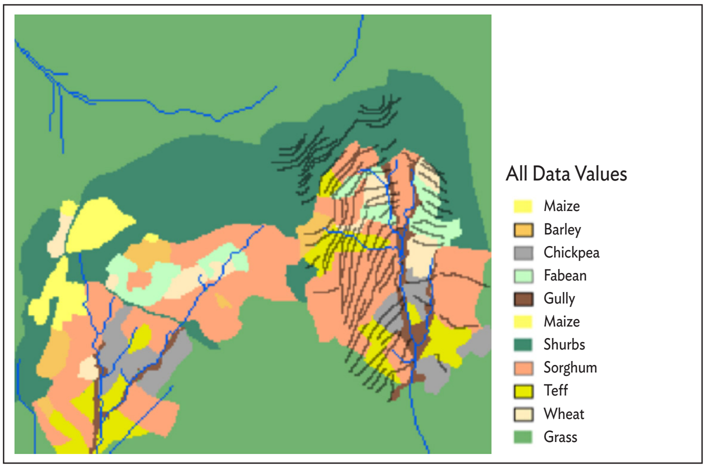
Figure 2: Map of the Study Area (Gumara-Maksegnit Watershed with Paired Sub-watersheds)



Source: Renschler et al., 2010.

The Aba-Kaloye and Ayaye sub-watersheds are involved in long-term soil erosion studies (Klik et al., 2015). Both sub-watersheds show severe soil erosion problems as manifested in the formation of deep gullies (Klik et al., 2016).

Figure 3: Sub-watersheds Abakaloye (West Side) and Ayaye (East Side), With and Without Stone Bunds as Best Management Practice, Respectively



Source: Authors.

While water and soil conservation measures are applied in the Ayaye sub-watershed through the construction of gabions within the gullies and the implementation of stone bunds, the Aba-Kaloye sub-watershed acts as a reference for gully development without measures. In the Ayaye sub-watershed, all fields at the west flake are treated with stone bunds except the southmost fields (Figure 3). According to Bosshart (1997), the potential short-term benefits of stone bunds are the reduction of slope length and the creation of small retention basins for runoff and sediments. These effects appear immediately after the construction of stone bunds and result in reduced soil loss. The major medium-term and long-term effect is the reduction in slope steepness by progressive formation of terraces through the filling up of the retention spaces with sediments. To achieve these results, maintenance of stone bunds every 3 years is needed.

Watershed Study for Stone Bunds Best Management Practice

The sediment accumulating on bunds gradually changes the original slope of the plot, making it more suitable for cultivation. Stone bunds of 20 cm to 50 cm high embankments built in shallow trenches along contour lines use large and medium-sized rock fragments from neighbouring fields for construction (Morgan, 2005, 2012; Nyssen et al., 2007; Melaku et al. 2017; Klik et al. 2017; Melaku et al., 2018). Construction of stone bunds requires less soil movement and is therefore more applicable to small farmers. These embankments change the inclination of the land and thus change the extent of slope gradient. In addition to slope gradient, the stone bunds change flow accumulation.

Immediately after construction, stone bunds reduce the slope length for surface runoff and provide retention space for runoff and sediments (Melaku et al., 2018). On medium-term and long-term bases, sediments accumulate and fill up the retention space. This leads to a reduction in slope steepness and subsequently the formation of bench terraces (Bosshart, 1997). Quantifying the effectiveness of this measure, various studies show different results for effects such as retention of soil and water or increase in crop yield. Nyssen et al. (2007), for example, found an average sediment accumulation rate of 58 t ha^{-1} yr^{-1}, an increase in mean crop yield of 0.58 to 0.65 t ha^{-1} yr^{-1} and enhanced moisture storage in deep soil horizons induced by stone bunds constructed in the Ethiopian Highlands.

The selection of an appropriate model structure depends on the function that the model desires to serve (Merritt et al., 2003). For this project, GeoWEPP was applied to selected target sites (Renschler, 2003). GeoWEPP uses the WEPP model (Laflen et al., 1991; Flanagan and Nearing, 1995), a continuous, process-based model that allows the simulation of small watersheds and hillslope profiles. The current version of GeoWEPP allows a user to process digital data such as Digital Elevation Model, soil surveys, land use maps, and precision farming data. Besides, required input data, including slope, land cover types, soil map, land use types, and climate, are integrated into spatial database of WEPP and necessary outputs are produced by using the geographic information system (GIS) functions of GeoWEPP.

Plot Study for Climate Change Scenarios

Ethiopia makes up the greater part of the East African Horn of Africa. At latitudes of 4°N to 15°N, Ethiopia's climate is typically tropical in the southeastern and northeastern lowland regions, but much cooler in the large central highland regions. Mean annual temperatures are around 15°C–20°C in these high-altitude regions, while they are 25°C–30°C in the lowlands. Seasonal rainfall in Ethiopia is driven mainly by the migration of the inter–tropical convergence zone (ITCZ). The exact position of ITCZ changes over the course of the year, oscillating across the equator from its northernmost position over northern Ethiopia in July and August to its southernmost position over southern Kenya in January and February. Most of Ethiopia experiences one main wet season (called *kiremt*) from mid–June to mid–September (up to 350 mm per month in the wettest regions), when ITCZ is at its northernmost position. Parts of northern and central Ethiopia also have a secondary wet season of sporadic, and considerably lesser, rainfall from February to May (called *belg*).

The southern regions of Ethiopia experience two distinct wet seasons which occur as ITCZ passes through this more southern position. The March–May *belg* season is the main rainfall season yielding 100 mm to 200 mm per month, followed by *bega* (around 100 mm per month) in October to December. The easternmost corner of Ethiopia receives very little rainfall at any time of year. The movements of ITCZ are sensitive to variations in Indian Ocean sea surface temperatures and vary from year to year. Hence, the onset and duration of the rainfall seasons vary considerably inter-annually, causing frequent droughts. The most well-documented cause of this variability is the El Niño Southern Oscillation.

Warm phases of El Niño have been associated with reduced rainfall in the main wet season in north and central Ethiopia causing severe drought and famine, but also with enhanced rainfalls in the earlier February to April rainfall season that mainly affect southern Ethiopia. Mean annual temperature increased by 1.3°C between 1960 and 2006, an average rate of 0.28°C per decade. The increase in temperature in Ethiopia has been most rapid in the main wet season at a rate of 0.32°C per decade. The strong inter–annual and inter–decadal variability in Ethiopia's rainfall makes it difficult to detect long–term trends. There was no statistically significant trend in observed mean rainfall in any season in Ethiopia between 1960 and 2006. Decreases in the main wet season rainfall observed in the 1980s showed recovery in the 1990s and 2000s.

The closest available long-term statistical climate data location with respect to the study site was available for Bahir Dar south of Lake Tana (Figure 2). The other short-term climate parameters (e.g. peak intensity precipitation, event duration, etc.) as well as daily values (e.g. maximum/minimum temperature, wind speed/direction, etc.) were derived by finding the most similar monthly statistics of a station in the US by comparing it to an international database with basic statistics climate data (USDA-ARS NSERL, 2006). The US climate data statistics were then adjusted to match the long-term monthly averages available and 100-year climate scenarios were derived and compared with long-term averages available for or near the study site.

Once the 100-year simulations of climate were comparable to long-term monthly average precipitation amounts as well as similar monthly average temperatures, these climate data sets were then used with WEPP to simulate plant growth, runoff, and sediment yields. These results were then compared to average annual crop yields (for correct plant growth; see Table 1), estimated runoff (water balance), and soil losses (sediment balance) (Table 2).

Climate change scenarios, provided by the United Nations Development Programme and the University of Oxford for Ethiopia, were then generated based on absolute and relative changes of precipitation and temperatures (McSweeney et al., 2010). The mean annual temperature is projected to increase by 1.1°C–3.1°C by the 2060s. Under a single emissions scenario, the projected changes from different models span a range of up to 2.1°C. Projections from different models in the ensemble are broadly consistent in indicating increases in annual rainfall in Ethiopia. These increases are largely a result of increasing rainfall in the 'short' rainfall season (OND) in southern Ethiopia. OND rainfall is projected to increase by 10%–70% over the whole area of Ethiopia. Proportional increases in OND rainfall in the driest, easternmost parts of Ethiopia are large. Projections of change in the rainy seasons AMJ and JAS which affect the larger portions of Ethiopia are more mixed but tend towards slight increases in the southwest and decreases in the northeast.

Plot Study Results for Climate Change Scenarios

Note that the following results are based on 100-year simulations with observed and predicted changes in rainfall and temperature characteristics. The representative agricultural field unit is a 25-m-long and 100-m-wide plot with a 10% slope on a clay loam soil with a 3-year Fabean-Barley-Wheat crop rotation. The anticipated changes in climate for 2030 and 2060 and their impact on average crop yields were compared to observed crop yields under current climate conditions (Table 1).

Table 1: Average Crop Yield, Precipitation, Runoff, and Soil Loss for a 100-year Climate Simulation (Crop Yield are Based on 33 Harvests of a 3-year Crop Rotation)

Crop Yields in t/ha	Observed (1970-1999)	Projected 2030	Projected 2060
Fabean	3.01	3.11	3.19
Barley	2.49	4.12	9.93
Wheat	2.53	1.70	0.92
Precipitation in mm/yr	1,268.86	1,264.00	1,268.59
Runoff in mm/yr	267.95	261.71	253.57
Soil Loss in t/ha/yr	56.87	64.13	65.59

mm = millimetre, ha = hectare, t = tonne, yr = year.

Source: Authors.

The design of the two climate change scenarios considered spatially distributed (regional grid pattern) and temporally distributed (quarterly, Jan/Feb/Mar, April/.., etc.) changing temperatures and precipitation patterns. The plant growth model in the process-based WEPP illustrates that fabean crop yields could slightly increase, while barley and wheat yields could drastically increase or decrease, respectively. Please note that the two climate scenarios did not include the change in the crop management calendar, and while increase in barley production would be certainly welcome, one might have to adjust the temporal scheduling for wheat production to adjust to expected changes in climate. With regard to the slight changes of average annual precipitation in the two climate scenarios (Table 2), the average annual runoff is expected to decrease by 2.3% and 5.4%, while the average sediment yield is expected to increase by 12.8% and 15.3% in 2030 and 2060, respectively. That means less water will be flowing downhill to other agricultural sites, but likely with more sediments. The analysis of the 100 years of predicted runoff and sediment yields illustrates that the total runoff of return periods for 50 years only slightly increases by 2.2% while those of sediment yield increases drastically by 39.5% in 2060.

Table 2: Return Periods for Daily Runoff and Sediment Yields

Runoff (mm)	Observed	Projected 2030	Projected 2060
2-year	39.6	39.4	38.7
5-year	52.2	52.5	52.7
10-year	70.8	66.6	70.0
25-year	86.1	85.1	85.5
50-year	95.2	94.2	97.1
Sediment Yield (t/ha)	**Observed**	**Projected 2030**	**Projected 2060**
2-year	20.6	23.8	25.7
5-year	34.1	38.0	44.3
10-year	41.7	49.8	60.7
25-year	69.5	86.7	107.1
50-year	79.5	101.9	110.9

ha = hectare, mm = millimetre, t = tonne.

Note: The rainfall intensities of a single precipitation event were not considered. The impacts are therefore solely on climate-driven changes to soils and plant parameters (e.g. soil moisture and infiltration capacity, leave area index, or plant residues depending on growth/harvesting).

Source: Authors.

Watershed Study Results for Stone Bunds Best Management Practice

GeoWEPP (WEPP v2012.8) was used to estimate the sediment yield and runoff in the Abakaloye (west watershed without BMP) and Ayaye sub-watersheds (east watershed with BMP stone bunds) of the Gumara-Maksegnit watershed in the Lake Tana basin. The initial sediment yield and runoff results from the GeoWEPP model were compared with the observed monthly data collected from the watershed to evaluate the performance of the model. The simulated paired Gumara-Maksegnit watersheds for 2012–2014 were able to assess the effectiveness of stone bunds BMPs on soil erosion, runoff, and sediment yields (Figure 4).

The preliminary simulation results show that the west watershed without stone bunds produced 184.2 mm of runoff and 126 t ha^{-1} y^{-1} sediment yield, while the east watershed with BMP stone bunds produced lower runoff of 151.62 mm and lower sediment yields of 86.2 t ha^{-1} y^{-1}. If the stone bunds had been removed from the eastern watershed, the runoff and sediment yields would have been 2,006.22 mm and 105.3 t ha^{-1} y^{-1} and therefore 36% and 22.2% higher, respectively. That means that an implementation of stone bunds in the western watershed could potentially reduce the runoff by about 26% or 53 mm and sediment yields by about 18% or 22 t ha^{-1} y^{-1}. The sediment yields of about 100 t ha^{-1} y^{-1} are still very high, but it is the first step in the right direction to reduce runoff and sediments.

Figure 4: Simulation Results for Watershed Outlets With and Without Stone Bunds BMP

71 storms produced 808.53 mm of rainfall for three year period (2011 to 2014)

West Watershed without Stonebunds	
45 events produced 184.20 mm of runoff	
Total contributing area to outlet	: 31.70 ha
Avg. Ann sediment discharge from outlet	**: 3,995.4 tonnes/yr**
Avg. Ann sediment delivery per unit area of watershed	**: 126.0 T/ha/yr**

East Watershed with Stonebunds	
41 events produced 151.62 mm of runoff	
Total contributing area to outlet	: 24.00 ha
Avg. Ann sediment discharge from outlet	**: 2,069.8 tonnes/yr**
Avg. Ann sediment delivery per unit area of watershed	**: 86.2 T/ha/yr**

East Watershed without Stonebunds	
41 events produced 206.22 mm of runoff	
Total contributing area to outlet	: 25.76 ha
Avg. Ann sediment discharge from outlet	**: 2,711.8 tonnes/yr**
Avg. Ann sediment delivery per unit area of watershed	**: 105.3 T/ha/yr**

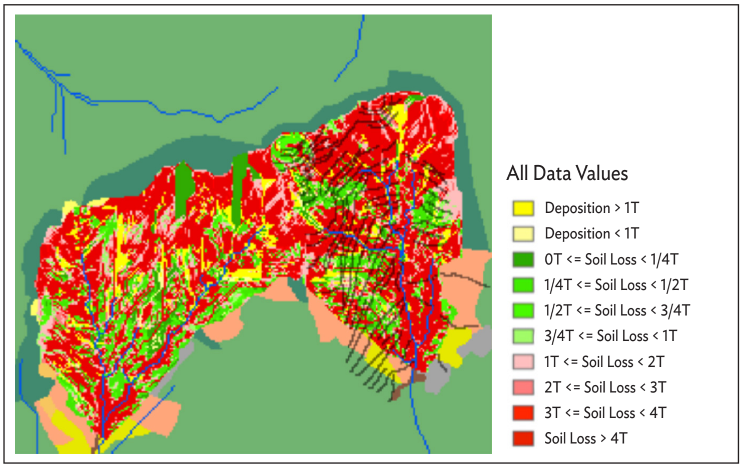
BMP = best management practice, ha = hectare, mm = millimetre, T = tonne, yr = year.

Note: The values above presented at the meeting in 2016 were preliminary results to illustrate the potential for the proposed assessment methodology. The final results documented in Melaku et al. (2018) were about half these amounts with 64.1 t $ha^{-1}y^{-1}$ for the untreated and 39.9 t $ha^{-1}y^{-1}$ for the treated sub-watershed.

Source: Authors.

Implementing BMP requires spatial and temporal scheduling of management activities in a watershed. GeoWEPP assists stakeholders in comparing spatial patterns of non-existing and existing stone bunds (see Figure 5) and enables designing and optimising the location of stone bunds to reduce runoff and sediment yields. This was not done in this study, but could be performed in collaboration with stakeholders in the study area.

Figure 5: Predicted Soil Redistribution Pattern Without (Western Sub-watershed) and with BMP Stone Bunds (Eastern Sub-watershed) (Target T = 10 t $ha^{-1}yr^{-1}$)



ha = hectare, t = tonne, yr = year.

Note: Soil loss above (red), soil loss below (green), and soil deposition (yellow).

Source: Authors.

Combined Natural Resources Management and Community Resilience

Since the impact analysis also considered plot-based, on-site economic productivity of crop yields (e.g. sorghum, wheat, teff, etc.), and watershed-based, off-site peak runoff, discharge, and sediment yields potentially damaging downstream fields and road infrastructure, one can now assess natural resources management and community resilience from a more holistic perspective. Utilising the PEOPLES Resilience Framework, one can answer different kinds of questions when assessing the impact of spatial and temporal BMP strategies from on-site and off-site decision-making and policymaking perspectives (Table 3).

For example, the planning of BMPs to promote water harvesting and ground water recharge can be quantified in its impact compared to the potential loss of land being taken out of crop production. In fact, in addition to the economic impact, one can assess impacts on the functionality of the other six dimensions of the PEOPLES Resilience Framework. Similarly, one could potentially assess other land use and/or land cover management strategies of creating wetlands or sediment control structures such as check dams. One could assess the impact not only on agriculture but also on other natural resources management businesses; infrastructure; and life lines such as roads, bridges, or electricity, etc.

Table 3: Potential Intended Goals Impacting Various PEOPLES Resilience Framework Dimensions

Natural Resources or Hazard Management Goals	P	E	O	P	L	E	S
Promote water harvesting/ground water recharge	–	X	X	X	x	X	–
Create wetland/nature reserve/impoundment	–	X	X	X	x	X	X
Sustain crop/timber/fishing harvest yields	x	X	–	x	–	X	X
Design resilient bridges/culverts against runoff/flood	X	x	x	x	–	X	X
Access shelter/food/hospital/emergency facility	X	x	X	X	x	X	x

Note: '–' has no impact, while 'x' and 'X' indicate potential minor and major impacts, respectively.
Source: Authors.

Conclusions

The stone bunds form a barrier that slows down water runoff, allowing rainwater to seep into the soil and spread more evenly over the land. This slowing down of water runoff helps in building up a layer of nutrient-rich fine soil and manure particles. The layers have impact on slope, flow direction, and flow accumulation changes. Based on the results of the two DEMs, the GeoWEPP model will be used to simulate the effects of stone bunds on runoff, sediment, and nutrient flow of the Abakaloye and Ayaye watersheds. The simulation results will be further compared with the observed values. Stone bunds on cultivated land reduce slope length and slope gradient but increase the number of boundaries of the cultivated plots, which aggravates tillage erosion.

Acknowledgement

This multidisciplinary project was partially funded through a scholarship of the OECD Co-operative Research Programme. Amongst the programme's main objectives are to strengthen scientific knowledge and support future policy decisions related to the sustainable use of natural resources in agriculture, forests, and land management. It specifically addresses the roles of natural resource stewardship and the challenges in managing environmental change by evaluating management changes based on a more holistic economic and societal evaluation of interdependent systems.

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CHAPTER 6

CHOICE OF POLICY INSTRUMENTS AND IMPACTS ON LAND USE AND THE FOOD INDUSTRY

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Introduction

The natural disasters we commonly think of include droughts, floodings, or large-scale pest attacks. A common feature of such natural disasters is sudden and unexpected crop losses. From an economics perspective, however, it could be more fruitful to frame yield losses in monetary terms. The primary reason for choosing this slightly different research angle is that bumper crops also constitute challenges for the food industry and farmers. Unexpected high yields tend to lower commodity prices, which in turn may adversely affect farm profitability and, hence, the long-term sustainability of primary production. For the food industry, things are more complicated: the local food industry benefits from low commodity prices for its own inputs, but faces severe challenges if processed foods from other regions are less costly.

With a focus on unexpected variability of crop revenues instead of crop losses, the emphasis becomes more on (economic) risk reduction. Skoufias (2003) lists similar perspectives in a survey paper. Still, some may argue that severe crop losses are more challenging than unexpected high yields as primary producers are left with nothing, while unexpected high yields only lead to lower farm incomes, but at least leave people with something to eat. This reasoning holds for subsistence-oriented farming systems, but for modern (market-based) farming, unexpected income variation and risk are important issues.

Local markets contribute in reducing farm level risks in the following way: high yields and the corresponding lower prices, or low yields and the corresponding high prices stabilise farm incomes. The same self-correction is necessarily not in place if local markets are integrated with larger markets as low local yields do not automatically lead to higher local prices for farmers. For consumers, however, the benefits of integrated markets are clear:

trade reduces prices and price variability, which in turn lowers consumer food expenditures and reduces uncertainty related to food expenses.

Designing policies to secure the welfare of consumers and to provide stable and low commodity prices for the food industry and high and stable prices for farmers is no straight-forward task. Add natural disasters to this picture and matters become even more complicated.

This paper looks at the following policy measures for reducing the negative effects of crop and income losses: crop and income insurance, futures market, acreage payment, and price support. The main method used is review of central literature on reducing crop and income losses.

Crop and income insurance are amongst the most interesting policy options for stabilising incomes and reducing risk exposure, for primary producers in particular. Land use may also particularly affect risk if existing policies lead to farmers taking too much risk. An example of this is from the flood-prone zones along the Mississippi River, where heavily government-subsidised crop insurance leads to more crop production (mainly cotton) in arable land that is sensitive to flooding than what would otherwise have been the case (Browne et al., 1992). In years with no flooding, yields are high, leading to cotton surpluses and deflated prices, and posing challenges for other cotton producers.

Other relevant policy instruments include acreage payment and price support. The latter is perceived as particularly problematic in terms of risk impacts if it leads to the same kind of farm level choices as in the aforementioned Mississippi River cotton case.

This paper is organised as follows: Section 2 deals with risk at the farm level, while Section 3 discusses risk for the food processing industry. Consumer risk issues, which basically entail low and stable food prices, are briefly dealt with in Section 4. Section 5 summarises.

Farm Level Risk

A well-known approach in dealing with risk in finance is diversification through portfolio management. Portfolios are commonly partitioned into risk classes, and most investors want some of their portfolios to be low risk even though this implies sacrificing some returns on investments. The possibilities for financial diversification are further accentuated as financial investments can take place at various geographical locations.

Primary production in agriculture is somewhat different as most farms are located within certain areas. Natural disasters that affect one field or installation are therefore likely to affect nearby fields or installations. For some productions, like animal husbandry, spreading production facilities is a well-known strategy to reduce the impacts of fires, isolate outbreaks of diseases, etc. In such cases, expected marginal gains are compared with expected marginal costs, i.e. well in line with standard microeconomic theory.

Applying the diversification principles from portfolio management by engaging in multiple productions is not without costs, as noted by Dercon (2002), and Abson, Fraser, and Benton (2013). There are several reasons for this. First, economies of scale tend to vanish. Second, it requires operators to be knowledgeable in multiple areas, which may entail substantial extra costs of acquiring the necessary knowledge. Still, we see many farmers diversifying, but frequently do this by coupling productions that either utilise production capital for longer periods of the year than the growing season of a single crop or engaging in productions that utilise positive externalities from one production to another, like the soybean–corn rotation. Some crop rotations also allow for more efficient utilisation of parts of the production equipment like tractors and storage facilities, or help to even out peak labour periods. While such micromanagement twists increase profitability and reduce price risk, they do little to reduce the risks associated with many natural disasters.

A risk-reducing feature that is often neglected is the self-correction of markets. When yields are low, prices tend to be high or vice versa. This works particularly well for local or regional markets but may not have the same impact with international trade: high yields somewhere else lead to lower farm gate prices.

While micro-level adjustments in farm operations may lower risks and increase profits, they do little to counter the effects of location-specific natural disasters, with the exception of productions that are time-wise separated. Moreover, local market self-correction may be of little value if most of the production volume is wiped out due to flooding, earthquake, or other natural disasters. We therefore need other mechanisms in place to maintain farm incomes and livelihood of farm households. In the following sub-sections, I address crop insurance, futures market, producer price support, and acreage payment.

Crop Insurance

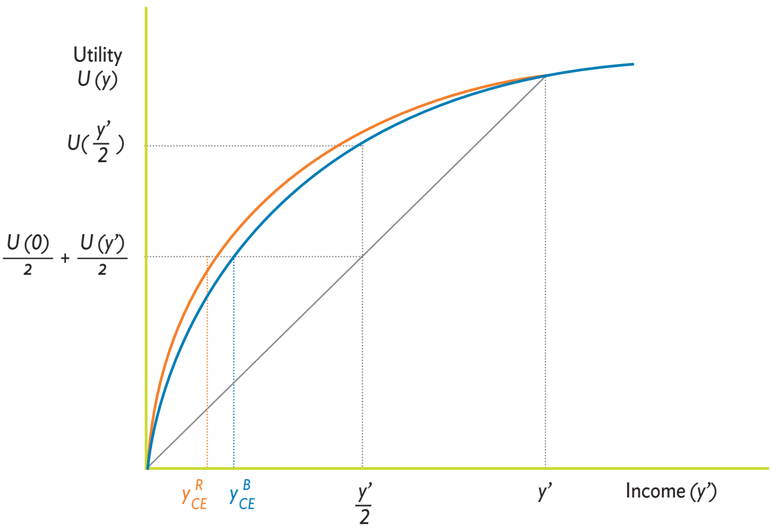
For insurance to work, the item to be insured needs to be insurable, i.e. the item is well defined, the cause of the damage is known, and the damage one insures against is known and finite (Varian, 1992). Crop insurance meets these criteria: the crop is known, the cause of the damage (hail, loss of rainfall, etc.) can be specified, and a clear baseline (normal yields or a percentage of normal yields) exists and is known.

I have already mentioned the market disruptions caused by subsidised insurance in the Mississippi flood area. That does not invalidate fair-priced insurance that farmers pay for an actuary-assessed insurance where insurance suppliers make normal profits from their investments. There are two driving forces behind insurance:

1 Economic agents are averse to risk, implying that they are willing to pay a premium to reduce the consequences of bad outcomes, like if your house burns.
2 Risk can be pooled, that is when one insured house burns, it is not devastation for the house owner, but it is highly unlikely that many houses insured in the same country will burn at the same time.

Figure 1 illustrates point (1). To make the sketch clearer, assume that an economic agent wants to insure against a situation where all his or her income in a period is lost, and that there is a 50% chance this bad event will happen.

Figure 1: A Risk-averse Economic Agent's Maximum Willingness to Pay for Insurance



Source: Pratt (1964).

Should the good event happen, the economic agent keeps all of his or her income. Being averse to risk, this agent has a concave von Neumann-Morgenstern expected utility function in income. The blue curved line denotes the expected utility function for a risk-averse agent. Let *y'* denote the income in the good state, i.e. the agent keeps all income, and 0 be the income under the bad state. With equal probability of the good state and the bad state taking place, the mean utility of the two states is given by 1/2U (0) +1/2 U (*y'*), while the utility of the mean income of the good state and the bad state equals $U(\frac{y'}{2})$. If this agent can insure against the bad state, the maximum willingness to pay for insurance – the risk premium – is

$$RP = \frac{y'}{2} - y^B_{CE}$$

where y^B_{CE} denotes the certainty equivalent given the initial (blue) curve. If this agent were more risk averse, the expected utility function would be more curved (for example, as depicted in the red curve), and the risk premium would increase to $\frac{y'}{2} - y^B_{CE}$. This basic example of insurance does not completely match the most common cases of crop insurance, but the basics are the same. A key issue in the insurance literature is that to reduce the risk for moral hazard, i.e. that agents do not take sufficient care to avoid the bad state, the insurance contract becomes more expensive, the higher share of the damages that are to be covered by the insurer in the event of the bad state. Most crop insurance schemes today therefore involve partial coverage (Vercammen, 2000). Still, one observes that the possibility of buying insurance also changes agents' actions. For example, Claassen et al. (2017) found that federal crop insurance in the US affected crop selection and crop rotation towards more risky cropping strategies.

Natural disasters pose some challenges for (2), pooling of risk, because flooding or an earthquake may affect all households in an area. This implies less scope for mutual insurance, i.e. members of a community insuring each other. That is also one of the reasons for the emergence of insurance companies as we know them today, covering several regions.

Moreover, that is seldom the case with multiple insurance companies with wide geographical coverage. In addition, insurance companies have other tools at their disposal to lower the risks associated with geographically correlated disasters. Here, reinsurance is the most common solution, i.e. an insurance company buys stakes in objects insured by other insurance companies. For example, the offshore oil and gas platforms in the North Sea are often reinsured as few single insurance companies would survive the financial burden of a sudden loss in the magnitude of €20+ billions.

Governments usually self-insure as they have so many insurable objects. The Norwegian government, for example, self-insures. But for large installations like its offshore oil installations, even Norway buys insurance at the international markets despite its €900 billion sovereign fund. Crop insurance is not of same magnitude as the above examples, but reinsurance is still important to deal with geographically concentrated or correlated damage.

Crop insurance comes in different versions: yield loss insurance and revenue loss insurance. Producers can insure against single or multiple causes for damages. Revenue loss insurance is, for example, particularly relevant for unexpected price declines caused by (global) high yields or dumping of products on the international markets. For such events, there also exist other instruments, most notably in futures markets, which I discuss in the next section. In the case of natural disasters, yield loss insurance is the most relevant. Here, the insurance is paid to the insured farmers based on the difference between actual and normal yields (the baseline yields), usually with some downward adjustment in the baseline as yields tend to fluctuate even in the absence of natural disasters.

Crop insurance is not a new construct. As early as 1938, the US introduced its first federal crop insurance programme. It has been revised several times, most recently in 2011, in the wake of increased knowledge about insurance and insurance markets, the existence of other risk-mitigating instruments like the futures markets, better understanding of disaster scenarios, and the emergence of private crop insurance schemes. Similar developments have taken place in other countries, most notably Canada which got its government crop insurance programme only one year after the US. Several countries, like India, currently require farmers who have state loans to take out crop insurance.

There is a growing literature on crop insurance. For our purposes, the strand of literature on integrated markets and risk (Miranda and Glauber, 1997; Miranda and Vedenov, 2001) is particularly relevant. Crop insurance markets are rapidly evolving (see, for example, Skees 2008a, 2008b) and becoming more present even in developing countries. For example, Skees et al. (2008) deal with crop insurance in Viet Nam. Weather-indexed crop insurance is gaining much attention due to possible climate changes. Crop insurance is probably even more applicable for smallholder farmers in developing countries given their less access to futures markets. Jensen and Barrett (2016) discuss how to overcome some of the difficulties of using index insurance in developing countries related to poor base data, coverage and quality of the insurance, and making insurance affordable for the rural poor. Their findings are quite optimistic, given the shortcomings, in particular, of other policies to reduce risk in agricultural production in developing countries. A recent CGIAR research programme for indexed weather insurance directed towards developing countries points to the same direction as Jensen and Barret's (2016).

This is an area where substantial growth is expected with several private initiatives on the risk and insurance consultancy side being launched in recent years. Global Ag Risk is one example of such an initiative. Such firms are now leading the development of new risk-mitigation strategies and insurance possibilities. These developments do not remove the demand for government initiatives, particularly in poorer developing countries where many smallholder farmers face difficulties getting credit (to buy insurance) and transaction costs are usually quite high.

Futures Markets

In futures markets, agents typically contract to buy or sell a certain amount of a commodity to an agreed price at a certain time into the future. This lowers risk to the agents as they secure the price for some of the quantities they plan to buy or sell at future time.

Options increase the flexibility of such forward contracts and come in two basic variants:
- A put option gives the owner the right, but not the obligation, to sell the underlying asset (a commodity or futures contract) at the contracted price on or before the expiration date of the option.
- A call option is the converse of a put option, as the owner of a call option has the right, but not the obligation, to buy the underlying asset at the contracted price on or before the expiration date of the option.

Agricultural commodities belong to a commodity group where futures markets and options have become an important way of reducing risk, particularly for food processing firms. For further details on futures markets and options, see, for example, Pindyck (2001) for a general overview on energy markets or Scnepf (2006) for an overview on agricultural commodities.

Price Support

Producer price support has also been heralded as a way to reduce risk. Such support distorts trade to quite a large extent, and most researchers view this as harmful to market development (see, for example, Xiao et al., 2001; Orden et al., 2011). The Global Trade Analysis Project's website is probably the place to go for further references on this.

The risk impacts from such support under natural disasters have not been much researched. However, it seems reasonable to conclude that as they inhibit market development, they also increase the risks associated with natural disasters. The rationale behind this reasoning is that well-functioning markets tend to reduce consequences of natural disasters as trade channels are well established, implying that it becomes easier to get food into crisis areas. The World Bank (2001) argues along the same lines, but is not so explicit on the damaging effects on natural disaster readiness from commodity price support. Sound macroeconomic policies and liberalised trade are, however, amongst the more general risk-mitigating strategies listed by the World Bank (2001). On the other hand, price support increases farm incomes which, in turn, reduces poverty, one of the key factors for preventive measures and coping strategies. Price support will influence land use in the sense that more land will come under cultivation (Romstad, 2008). The main driver behind this result is that price support makes agriculture more profitable.

Acreage Payment and Other Less Market-distortive Policies

Acreage payment does not affect food commodity markets to the same extent as price support. Possible beneficial impacts from such payment include increased farm income and hence, poverty reduction. However, acreage payment could also increase risks if it leads to farming on areas that otherwise may not be profitable to farm like steep hills or high-frequency flooded areas. Impacts from farm support policies vary and depend on many factors like possibilities for off-farm work, wages in other sectors of the economy, etc. Romstad (2004) provides an overview.

Farm-level Measures and their Impacts on the Food Industry

Crop insurance reduces financial risks to farmers, making it more profitable for them to invest in production, which means increase in yields. This may appear a bit counter-intuitive as insurance is usually thought off as lowering effort due to moral hazard. However, the moral hazard effects under natural disasters are minor, partly because agents cannot influence the occurrence of natural disasters, and partly because crop insurance, like other insurance, does not involve full compensation.

Price support leads to higher production volumes due to increased use of farm inputs like fertilisers, that increase yields, and due to increased acreage. Hence, commodity prices fall for the food processing industry.

The impacts of acreage support are more mixed. More acreage coming under cultivation increase agricultural production, but as these are marginal lands, the increase in production volumes is modest. For time-constrained farmers, the extra yields from the additional low-productive acreage may be offset by a decline in the yields on the acreage originally cultivated due to less time spent on it.

Risk for the Food Processing Industry

Stable and predictable supplies of inputs are key to any industry. For the food processing industry, stability entails both quantity and quality of farm deliveries and predictable input prices. Industries that are well integrated in larger markets and with sufficient infrastructure (roads, communications) are usually better equipped to deal with natural disasters.

On the market side, futures are found to lead to more stable commodity prices and hence reduce price risks. There have been questions raised on the price-stabilising properties of futures in the presence of index funds, particularly those related to the food price hikes in 2007–2008. Irwin and Sanders (2011) checked this issue and found that there were no statistically significant linkages between periodic high commodity prices and entrance of index funds in that period. They concluded that the price-stabilising properties of futures markets remain as other factors were more important such as major crop failures in several important food-producing regions coupled with increased demand for biofuels from biofuel requirements in the US and the EU, and an overall increase in food demand due to increased prosperity, particularly in China and Southeast Asia.

The food retail sector has changed considerably in the last few decades. Consumer demand has grown for fresh products and variation on packaging size depending on household size. Moreover, many stores have limited storage space due to higher property values and increased demand for fresh foods. These changes also influence the food processing industry, where production is done in smaller batches (freshness) and are increasingly made according to the specifications of the food retail chains (van Donk, 2001). ‘Just in time’ and ‘just right’ have come to the food sector. I have yet to find a paper that analyses the effects of these changes in logistics in the food industry on the vulnerability to natural disasters. There is, however, a substantial literature on supply chain management in general and in light of ‘just in time’.

Measures discussed in this general literature include interim storage, redundant suppliers, increased flexibility and responsiveness in the supply chain, and pool or aggregate demand (Chopra and Sodhi, 2004). Several of these measures are not well suited for the food sector. For example, interim storage is inconsistent with the increased demand for freshness. Still, this literature provides valuable insights that are also applicable for the food sector. Not all food items need to be fresh, and by separating perishable and easy-to-store products, parts of the risks can be mitigated. One reason for this is that transport volumes can be reduced in the event of a natural disaster as only perishable products are transported until the infrastructure is repaired or becomes usable again.

New firms have extra options available to them. A feature that seems to have been somewhat neglected in the past is location from a supply chain perspective, i.e. the availability of multiple transport routes to maintain the inflow of critical inputs for production to continue.

The main message from this session is that market integration, futures, and some supply chain management measures reduce risk in case of natural disasters, and that one needs to examine location issues to a larger degree than what has been done previously.

Consumer Risk

Poverty and poorly developed institutions remain the main determinants for the impacts the public at large get from natural disasters. A study of death tolls from natural disasters verifies this (Kahn, 2005). The main message is that economic growth and more equitable distribution of wealth are the key policy measures to reduce the impacts on society of natural disasters, coupled with mature markets with well-developed logistics. Markets and logistics are key factors to be able to supply food under natural disasters, particularly if the disaster is a complete food production failure in a region. Some disasters, like severe drought in a region, evolve slowly. This gives ample time to put the proper safety measures in place. Other disasters, like floodings and earth slides, occur with far less warning times and are hence also more difficult to safeguard against.

Even when the above-mentioned market and logistics conditions are satisfied, natural disasters may lead to severe disruptions like absence of electricity or limited communications, which may affect short-term food supplies. Households can reduce the immediate consequences of such events by following the old advice of having some non-perishable foods and reserve cooking facilities available until assistance arrives.

Consumer concerns related to the food sector include food security, i.e. there is enough food at affordable prices, and food safety, i.e. one does not get (acutely) sick from consuming the food. Depending upon the type of natural disaster, both issues can be important. Ample food supplies are, however, of limited value, without access to suitable drinking water.

Food security is strongly linked to the food sector's possibilities to meet consumer demand, which is greatly augmented through markets and sufficient logistics. Barrett

(2010) provides a recent and non-technical overview, and Falcon and Naylor (2005) provide some long-term perspectives. There is also a vast literature on emergency aid and its impacts that I will not address in this paper.

Antle (2001) provides a general economic overview of food safety. Food safety issues under natural disasters are more complicated as one often cannot see if the food is safe to eat or not. Breakdown of infrastructure, particularly electricity, may adversely affect food storage. For some types of food, this implies rapid loss of quality and, in some cases, that the food quickly becomes unsafe to eat. Smart labelling is one way of letting consumers know if perishable foods have passed their expiration date.

From a consumer perspective, however, the welfare losses of temporarily not being able to eat certain foods in case of a natural disaster are believed to be minor. The main issue is to supply consumers with sufficient food so they can survive until matters normalise.

Concluding Comments

Poverty and poorly developed political institutions tend to aggravate the negative impacts of natural disasters. Long-term policies to alleviate poverty are key to risk mitigation and minimising welfare losses from natural disasters.

Well-functioning and integrated food markets are the key measure in dealing with the most pressing food issue – supplying enough food – during a natural disaster. Natural disasters may be sudden (like an earthquake or a landslide) or evolve gradually (like severe drought). For gradually evolving crises, there is more time to prepare, and for many such crises, the necessary infrastructure for markets to work is in place. Sudden natural disasters are more demanding. Again, the main focus must be on providing consumers with sufficient food supplies until the crisis situation normalises.

Regarding impacts of natural disasters on farmers and the food processing industry, suitable measures to reduce the negative economic impacts of natural disasters exist provided that well-functioning markets and proper logistics are in place: crop insurance for farmers, and futures markets for food processing firms.

Crop insurance reduces the economic risks associated with agriculture, and will therefore make it more profitable to invest in agriculture. This will cause production volumes to increase.

Risk mitigation and risk sharing are essential in modern economics (Schlee, 2001), and crop insurance and futures markets are two instruments that spread risk under natural disasters while allowing markets to work.

Other instruments like producer price support or acreage payment increase farm incomes, but may adversely affect resource allocation. Producer price support is also likely to distort commodity markets, and hence be counterproductive. The effect of acreage support on production volumes is likely to be minor and could, in some cases, even be negative if the yield gains from new marginal land under cultivation is less than the yield losses from less attention put on the original acreage under cultivation.

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PART 3
KEY MESSAGES: LESSONS TO BE LEARNED FOR AGRICULTURAL PRODUCTION NETWORKS AND FOOD VALUE CHAINS

Hiroyuki Nakata concentrates on the effects of natural disasters on company behaviour in an oligopolistic market by closely observing the changes in price and quantity. He transfers his experience from the hard disk drive industry and flood events to agricultural production networks. Contrary to the more common view that firms directly affected by natural disasters are victims, he presents cases showing that companies can profit from disasters by acting collusively. He generates the hypothesis that certain actors in the value chain can take advantage of natural disasters while others, namely the producers, carry the burden.

Willem Thorbecke speaks about trading networks in the manufacturing sector in East Asia. These are associated with technology transfer, mushrooming productivity growth, and tumbling prices for final goods. Similar value chains have yet to emerge in Asia in the agricultural sector. To promote agriculture, Asian countries should harmonise bio-security standards; rethink agricultural self-sufficiency; eschew protectionism; focus on comparative advantages; and foster cooperation between research agencies, the government, and commercial enterprises.

Venkatachalam Anbumozhi discusses the effects of natural disasters on water management and regional food value chains. For Asia, biophysical crop model results show yield reductions under climate-changed scenarios compared to those with no climate change. By 2050, the expected reduction is in the range of 14%–20% for irrigated paddies; irrigated wheat, 32%–44%; irrigated corn, 2%–5%; and irrigated soybean, 9–18%. Disaster damage comes on top of this. ASEAN countries experienced nearly 40% of the global total of natural disasters in 1990–2011. The optimisation of regional food value chains is critical for the regional food supply.

Kim Yeon Tae and Malinee Phonsuwan argue that the agricultural sector continually adapts to climate change through changes in crop rotation, planting times, genetic selection, fertiliser management, pest management, water management, and shifts in areas of crop production. The agriculture sector – in particular, industrial agriculture – is dependent on effective information for warning and preventing losses in the food supply chain. In Korea, industrial agriculture uses advanced methods of information and communications technologies to match cropping practices to climatic trends, use inputs sustainably, and cope with productivity threats

CHAPTER 7

THE DIFFERENT VULNERABILITIES OF INDUSTRIAL AND AGRICULTURAL PRODUCTS AGAINST RARE DISASTERS: LESSONS TO BE LEARNED FROM THE HARD DISK DRIVE INDUSTRY

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Introduction

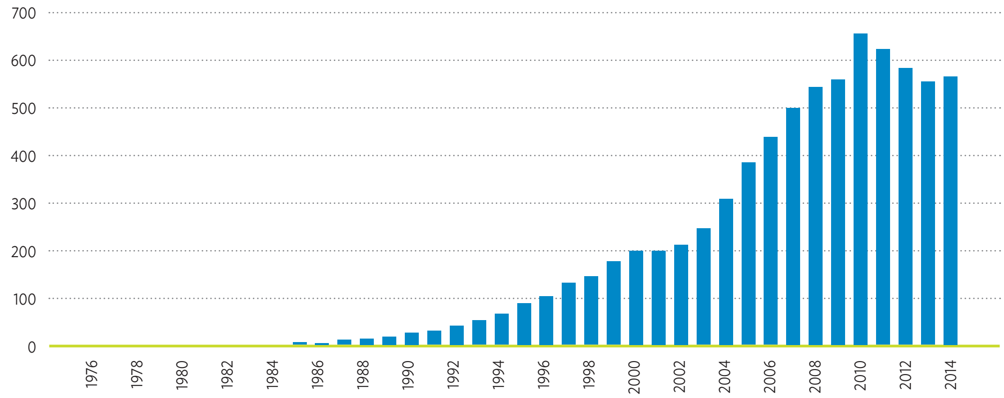
Our paper first reviews the hard disk drive (HDD) industry and the 2011 floods in Thailand. It then introduces a static Cournot oligopoly model and extends it to a dynamic one by following Radner (1980). Other works on cartels include Green and Porter (1984) and, more recently, a review of literature by Levenstein and Suslow (2001). The key question is the condition with which a cartel may be sustained, and the key prediction of Radner (1980) is that the difficulty or ease of sustaining a cartel depends on the number of players when the industry-level demand is a function of the number of players but is independent of the number of firms when the industry-level demand is also independent of the number of firms. The observations about the price and quantity in the HDD industry before and after the 2011 Thailand floods are consistent with the case in which a cartel was formed after the floods. On the other hand, a shift in demand alone cannot explain the behaviour of price and quantity in the industry, although a shift in demand may have happened simultaneously with the formation of a cartel.

Although this paper does not study directly if there was indeed a formation of a cartel in the HDD industry or a shift in demand, it discusses how the issues should be investigated empirically. Based on the analysis on the HDD industry, we discuss the implications for agriculture. One key observation is that the corporate sector, especially the vertically integrated multinational agriculture business, may resemble the HDD manufacturers. Also, the asymmetry between small producers and large corporate middlemen may well cause distortions in the allocation of the costs of risk prevention and/or losses or damage from natural disasters. Based on such observations, we provide some policy recommendations. The rest of the paper proceeds as follows. Section 2 describes the HDD industry and the 2011 Thailand floods, followed by Section 3, which analyses the behaviour of the HDD manufacturers based on the theoretical predictions of Radner (1980). Section 4 discusses the implications of the analysis on the HDD industry, mainly focusing on the incentives to invest in risk prevention, and the implications for agriculture. Section 5 concludes.

The HDD Industry and the 2011 Thailand Floods

This section reports some basic facts about the HDD industry. Figure 1 illustrates annual global shipments of HDDs from 1976 to 2014. With the exception of the dip around 2001 – happening at the time of the collapse of the information technology bubble – HDD shipments kept increasing exponentially until 2010 before the recent decline. Figure 2, on the other hand, reports quarterly global shipments of HDDs from the fourth quarter of 2010 until the fourth quarter of 2014, where we can see a sharp drop in the fourth quarter of 2011, reflecting the disruption of production in Thailand due to the floods. Western Digital's production facility was greatly affected by the floods, halting production. See, for instance, Fuller (2011). Also, for more general discussion about the impacts of the 2011 Thailand floods, see Ministry of Economy, Trade and Industry (2012) and the World Bank (2012).

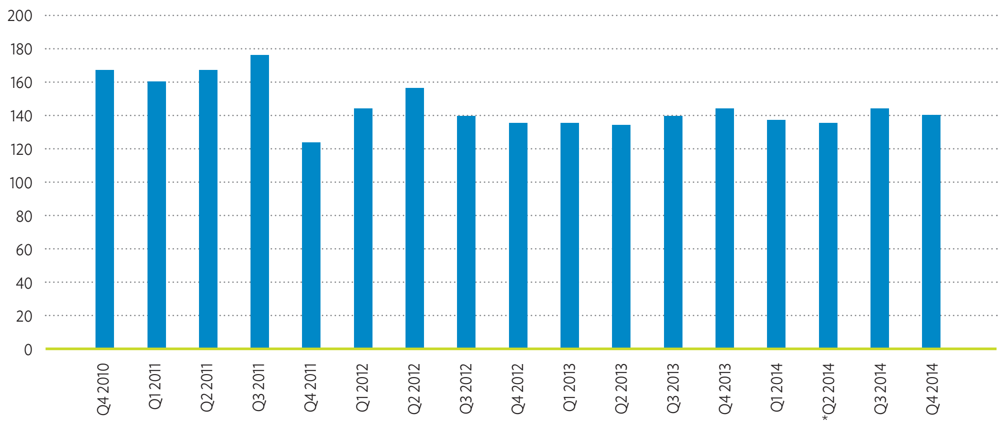
Figure 1: Annual Global Shipments of Hard Disk Drives, in million pieces



Source: TrendFocus, 2015.

The shipments, however, recovered quickly and the level has been stable since then, albeit at a lower level than before the 2011 floods.

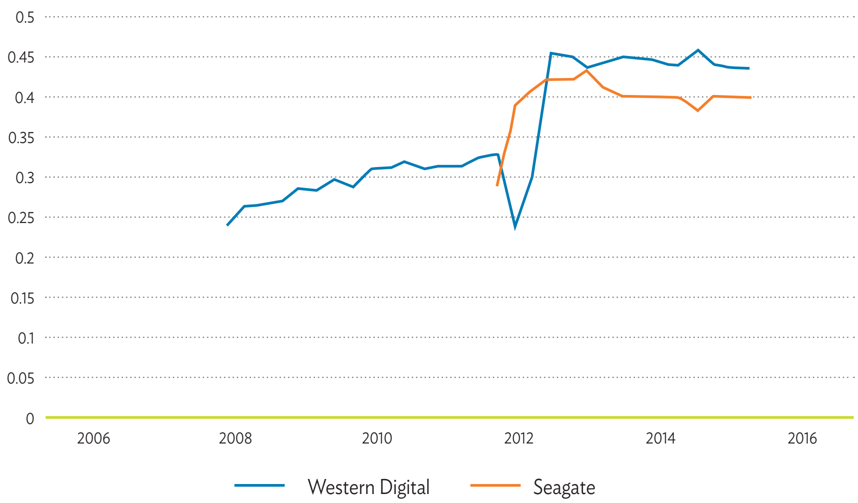
Figure 2: **Quarterly Global Shipments of Hard Disk Drives, in millions**



Source: TrendFocus, 2015.

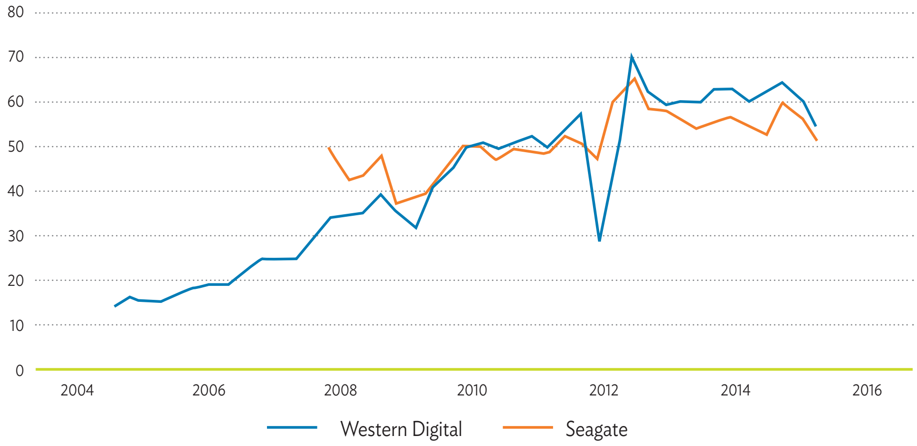
The HDD industry has been through a continuous consolidation process in the past 25 years. Currently, only three players remain in the industry: Western Digital, Seagate, and Toshiba, although the former two are dominant (Figure 3). Seagate purchased Maxtor in May 2006, Toshiba bought Fujitsu's HDD business in October 2009, Seagate acquired Samsung's HDD business in December 2011, and Western Digital obtained Hitachi's HDD business in March 2012, decreasing the number of players from seven to three in 10 years.

Figure 3: **Market Shares of Hard Disk Drives**



Sources: Financial statements of Seagate and Western Digital, 2016.

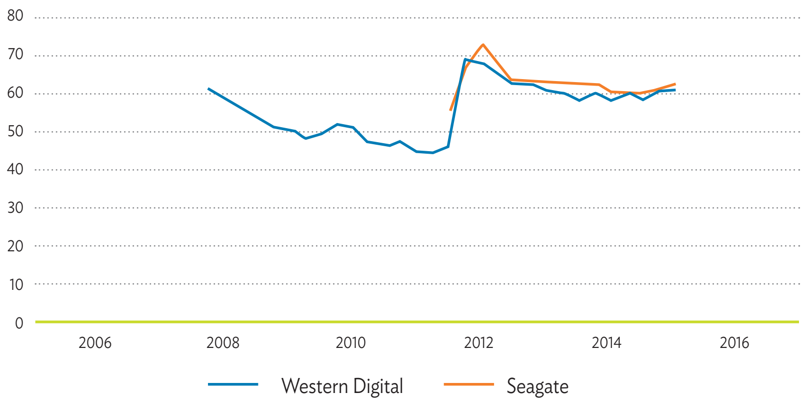
Figure 4: Shipments of Hard Disk Drives, in millions



Sources: Financial statements of Seagate and Western Digital, 2016.

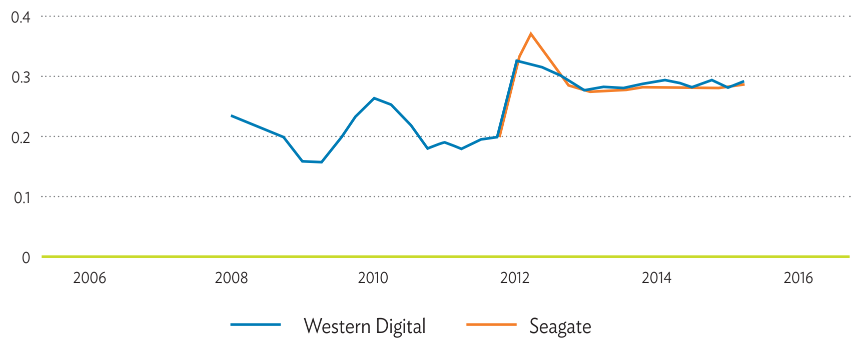
By comparing Figure 3 and Figure 4, we can see that the market shares of Western Digital and Seagate both rose after their acquisitions of the HDD business of Hitachi (Western Digital) and that of Samsung (Seagate) more than the general increase in their shipments. Figure 5 exhibits the average HDD selling price of Western Digital and Seagate. Before the 2011 Thailand floods (fourth quarter of 2011), the average HDD selling price had been in steady decline, at least for Western Digital, but shot up at around the time of the floods, both for Western Digital and Seagate. What is striking is that the average selling price was staying at a higher level than the pre-flood level and was fairly stable. A similar pattern emerged for their gross margins (Figure 6).

Figure 5: Average Selling Prices of Hard Disk Drives (US$)



Sources: Financial statements of Seagate and Western Digital, 2016.

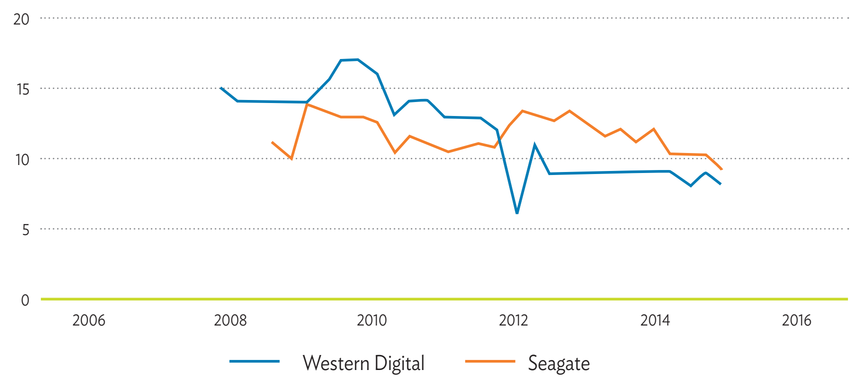
Figure 6: **Gross Margins**



Sources: Financial statements of Seagate and Western Digital, 2016.

To summarise, the HDD shipments fell slightly and the price (and the gross margins) went up substantially after the 2011 Thailand floods. Figure 7 illustrates the inventory turns of the two major players. Western Digital's inventory turns dropped sharply in the first quarter of 2012, probably reflecting the temporary closure of its production facilities in Thailand, although it had been gradually declining before the 2011 floods, and has been at a low level since the third quarter of 2012.

Figure 7: **Inventory Turns of Hard Disk Drives, by Manufacturer**



Sources: Financial statements of Seagate and Western Digital, 2016.

In contrast, Seagate's inventory turns increased substantially in the first quarter of 2012, but has been slowly declining since then and is converging to the inventory turns of Western Digital.

Analysis

In what follows, we first present a standard Cournot oligopoly model, and then extend it to a dynamic one with a finite horizon by following Radner (1980). Then we use the theoretical framework to analyse the case of the HDD industry to evaluate the effects of the 2011 Thailand floods.

Static Model

Consider an industry in which there are n firms (or players) indexed by $i = 1, 2, \dots, n$ and there is little or no product differentiation. Each firm i can choose its production level Q^i directly but not the price of its product, i.e. the industry is in a Cournot oligopoly, and the firms are facing an inverse demand function

$$P = \alpha - \beta Q,$$

where P denotes the price and is Q the aggregate quantity of the product produced, i.e. $Q = \sum_{i=1}^{n} Q^i$. By letting $Q^{-i} := \sum_{j \neq i} Q^j$, we can express $Q = Q^i + Q^{-i}$, i.e. the aggregate production is decomposed into firm i's production and that of all other firms. The cost function of the firms is assumed to be identical and that of constant returns to scale, $(Q^i) = cQ^i$, where the parameter c is both the marginal and average cost. We assume $\alpha > c$.

Each firm solves the following optimisation problem:

$$\max_{Q^i} P\left(Q^i + Q^{-i}\right) \cdot Q^i - cQ^i \text{ subject to } Q^{-i} \text{given.}$$

It is straightforward to show that the solution to this problem $Q^i\left(Q^{-i}\right)$ is

$$Q^i\left(Q^{-i}\right) = \frac{\alpha - c}{2\beta} - \frac{Q^{-i}}{2} \text{ if this is non-negative and zero otherwise.}$$

Thus, in the symmetric Cournot-Nash equilibrium, $Q_c^{-i} = (n-1)Q_c^i$ holds, where subscript c indicates that the quantity is in a Cournot-Nash equilibrium. It follows that each firm's equilibrium quantity is $Q_c^* = \frac{\alpha - c}{(n+1)\beta}$, and the equilibrium price is $P_c = \frac{\alpha + nc}{n+1}$. Thus, the equilibrium aggregate quantity is $Q_c = \frac{n}{n+1} \cdot \frac{\alpha - c}{\beta}$, which converges to $\frac{\alpha - c}{\beta}$ as the number of firms goes to infinity, i.e. the equilibrium quantity in a competitive equilibrium, in which the price equals the marginal cost.

Now, consider the case in which all firms in the industry form a cartel so that they behave as though they are in a monopoly. This case can be described above by setting $n = 1$ for the aggregate quantity and for the price, i.e. $Q_m = \frac{\alpha - c}{2\beta}$ for the aggregate quantity and $P_m = \frac{\alpha + c}{2}$, where m indicates monopoly. Thus, the aggregate quantity Q_m is smaller than Q_c, i.e. $Q_m < Q_c$ in the symmetric Cournot-Nash equilibrium and the equilibrium price P_m is higher than P_c, i.e. $P_m > P_c$ when $n \geq 2$. Each firm will produce $Q_m^* = \frac{\alpha - c}{2n\beta}$, which is smaller than Q_c^*, i.e. $Q_m^* < Q_c^*$ for all i when $n \geq 2$.

Finite-Horizon Dynamic Case

We now consider a dynamic case with a finite horizon by following Radner (1980). Let T denote the number of periods, and we assume that the firm's payoff is the average of the T one-period profits. Each firm plays a sequential T-period game in which the one-period game is repeated T times.

As noted by Radner (1980), in every perfect Cournot-Nash equilibrium of the T-period game, each firm produces Q_c^* in each period. Radner (1980) then considers the following strategy: firm i produces Q_m^* $(< Q_c^*)$ in each period as long as all other firms have been doing the same; thereafter firm i produces Q_c^* in each period. This strategy is denoted by C_T, which is defined formally below. First define D_i as follows:

$$D^i = \begin{cases} \infty & \text{if } Q_t^j \text{ for all } t \text{ and all } j \neq \text{i}, \\ \min\{t: Q_t^j = Q_m^* \text{ for some } j \neq i\}, & \text{otherwise.} \end{cases}$$

The strategy C_T is defined by

$$Q_t^i = \begin{cases} Q_m^* \text{ if } t \leq D^i, \\ Q_c^* \text{ if } t > D^i. \end{cases}$$

More generically, for any integer k between 0 and T, define the strategy C_k as follows:

$$Q_t^i = \begin{cases} Q_m^* \text{ if } t \leq \min(D^i, k), \\ Q_c^* \text{ if } t > min(D^i, k). \end{cases}$$

Radner (1980) further considers a more general class of strategies below, which he called trigger strategies of order k. Let Q^D some (defection) production level. If $D^i \geq k$, then

$$Q_t^i = \begin{cases} Q_m^* \text{ if } t \leq k, \\ Q^D \text{ if } t = k + 1, \\ Q_c^* \text{ if } t \geq k + 2. \end{cases}$$

If $D^i \leq k$, then

$$Q_t^i = \begin{cases} Q_m^* \text{ if } t \leq D^i, \\ Q_c^* \text{ if } t > D^i. \end{cases}$$

With these trigger strategies, Radner (1980) shows the following:

Proposition 1 (Radner, 1980): Suppose all firms other than firm i use the same trigger strategy of order $k > 0$ with some defection production level $Q^D > Q_m^*$. Then, firm i's best response is a trigger strategy of order $(k-1)$, with defection production level equal to

$$\widetilde{Q} := \frac{(\alpha - c)(n+1)}{4n\beta}.$$

An important implication of this result is that the advantage to any one firm of defecting from the cartel one period before the end of the game approaches zero as the number of periods $T \longrightarrow \infty$ provided that all other firms use trigger strategy of order T. The result can be verified by comparing the average profit per firm when using a trigger strategy of order $(T-1)$ and the cartel profit per firm.

Radner (1980) then introduces an equilibrium concept that is looser than the standard Nash equilibrium: epsilon-equilibrium, which is defined as follows:

Definition (Epsilon-equilibrium; Radner, 1980): For any positive number ε, an ε-equilibrium is an n-tuple of strategies, one for each firm, such that each firm's average profit is within ε of the maximum average profit it could obtain against the other firms' strategies.

Radner (1980) applies this definition to the dynamic case by extending the concept of perfect Cournot-Nash equilibrium, which is called a perfect ε-equilibrium. One central ε-equilibrium of interest is the one in which each firm produces its cartel output level for exactly k periods, i.e. combination (C_k) of trigger strategies. Furthermore, two cases are considered: (a) the fixed-demand case, and (b) the replication case. In the former case, the aggregate demand is independent of the number of firms, while it is a function of the number of firms in the latter case – more specifically, $Q = \left(\frac{\alpha - P}{\beta_1}\right) \cdot n$. The following two results are shown by Radner (1980). First, for the fixed-demand case:

Proposition 2 (Radner, 1980; Fixed-demand case): Consider the fixed-demand case. For every $\varepsilon > 0$ and $T \geq 1$ there is a number $B(\varepsilon, T)$ such that for every $n > 1$ and every ε-equilibrium, the following are all bounded by $B(\varepsilon, T)$:

$$\left|Q_t^i - Q_c^*\right|,$$

$$\left|\sum_{i=1}^{n} Q_t^i - nQ_c^*\right|,$$

$$\left|\left(\alpha - c - \beta Q_t^{-i}\right) \cdot Q_t^i - \beta \cdot \left(Q_t^i\right)^2 - \frac{1}{\beta} \cdot \left(\frac{\alpha - c}{n+1}\right)^2\right|,$$

for $i = 1, 2, \ldots, n,\ t = 1, 2, \ldots, T$. In addition, for every T,

$$\lim_{\varepsilon \to 0} B(\varepsilon, T) = 0.$$

The first line states that the deviation of firm-level production from the Cournot-Nash equilibrium firm production level is bounded by $B(\varepsilon, T)$. Similarly, the second line is regarding the industry-wide production level and the third line is on the firm's profit. Next, for the replication case:

Proposition 3 (Radner, 1980; Replication case): Consider the replication case. For every $\varepsilon > 0$, $T \geq 1$ and $n > 2$, there is a number $B(\varepsilon, T, n)$ such that for every $n > 1$ and every ε-equilibrium, the following are all bounded by $B(\varepsilon, T, n)$:

$$\left|Q_t^i - Q_c^*\right|,$$

$$\left|\sum_{i=1}^{n} Q_t^i - nQ_c^*\right|,$$

for $i = 1, 2, \ldots, n,\ t = 1, 2, \ldots, T$; the bounds $B(\varepsilon, T, n)$ may be chosen so that for every $\varepsilon > 0$, $T \geq 1$,

$$\frac{B(\varepsilon, T, n)}{n^{0.5}} \text{ is uniformly bounded in } n,$$

and for every $T \geq 1$ and $n > 2$,

$$\lim_{\varepsilon \to 0} B(\varepsilon, T, n) = 0.$$

The main difference between the two cases is that the bound in the fixed-demand case is not a function of the number of firms n, while it is the case in the replication case. However, in both cases, when the deviation ε is sufficiently small, the cartel collapses and the ε- equilibrium will be the same as the static Cournot-Nash equilibrium effectively. Also, Radner (1980) shows that for any fixed ε and number of periods T, the cartel cannot survive at all if the number of firms n is sufficiently large in the replication case, while it is irrelevant for the survival of the cartel in the fixed-demand case.

Hypotheses

Casual observations above have provided us with the general direction that the price became higher and the quantity decreased slightly after the 2011 Thailand floods. Thus, we propose the following hypotheses that could explain the mechanism that brought the higher price and slightly lower quantity.

Hypothesis I: The 2011 Thailand floods caused a shift in the (inverse) demand function, in particular, α went up.

Hypothesis II: The 2011 Thailand floods triggered the formation of a de facto cartel between Western Digital and Seagate (and possibly with Toshiba, too).

We claim that these two hypotheses hold simultaneously for the current HDD industry. Hypothesis I is simple. Since the Cournot-Nash equilibrium price is $P\hat{}\_c=(\alpha + nc)/(n + 1)$ and the Cournot-Nash equilibrium firm production level is $Q\hat{}\_c= n/(n + 1)\cdot(\alpha - c)/\beta$, an increase in α will bring both the price and the production level higher. This means that Hypothesis I alone is unable to offer a consistent prediction with the actual observations, i.e. a higher price level and a lower production level.

As for Hypothesis II, there are two separate cases possible: the fixed-demand case and the replication case (or a more generic case in which the industry-level demand is a function of the number of firms). In the fixed-demand case, the difficulty of forming a cartel is independent of the number of firms. Thus, that the market consolidation happened almost simultaneously at the time of the Thailand floods through Seagate's acquisition of Samsung's HDD business and Western Digital's purchase of Hitachi's HDD business should be irrelevant to the formation of cartel, and the shock due to the Thailand floods is the only trigger for the formation. In contrast, in the replication case (or a more generic case), the market consolidation would have made the formation of the cartel easier.

In the fixed-demand case, the cartel price will be higher than the Cournot-Nash equilibrium price, and each firm's production will be fewer than the Cournot-Nash equilibrium production level. In the replication case, the decrease in production will be even greater since a smaller number of firms in the industry directly decreases the industry-level demand for and production of the product, while the prediction about the price is essentially the same as in the fixed-demand case. Thus, the observed facts, i.e. the higher price level and lower production level sustained after the 2011 floods may be explained by Hypothesis II in both fixed-demand and replication cases, i.e. whether or not the aggregate demand is a function of the number of firms does not matter with this regard.

Discussion

We saw above that a shift in demand alone would not be able to explain the observed behaviour of price and quantity after the 2011 Thailand floods, but a formation of a de facto cartel would be needed to explain the behaviour. Also, unless the industry-wide demand is independent of the number of firms within the industry, Radner (1980) showed that it is easier to sustain a cartel when there are fewer firms. Thus, it may well be that the ongoing consolidation of the HDD industry before the floods paved the way for a formation of a cartel with the floods acting as a trigger for it.

The fact that the average price and the gross margins of both Western Digital and Seagate rose substantially after the floods suggests that industries with fewer players may act collusively to exploit the temporary supply shortage caused by a natural disaster. Thus, natural disasters may induce a welfare loss due to collusive behaviours of firms, causing further losses in addition to the direct losses.

However, to show that HDD firms indeed formed a cartel in the aftermath of the floods require a more detailed empirical analysis based on micro data. In so doing, we need to evaluate the scale of the price pass-through to the clients, which corresponds to an increase in α in our model. Also, we need to measure the possible increase in the market power of the firms after the floods. These two effects need to be isolated so as to claim that a de facto cartel was indeed formed. To this end, the industrial organisation literature on the measurement of market power and cartel should be followed closely, for instance, Stigler (1964), Salant (1976), Bresnahan and Reiss (1991), Nevo (2001), and a survey by Andrade et al. (2001).

Implications

Risk Prevention Incentives and Moral Hazard

We have seen above that natural disasters may not cause losses to directly affected firms but may even benefit some firms. If a price rise follows a disaster as a result of a shift in the demand function or by a formation of a cartel, the costs of natural disasters would not be borne by the directly affected firms. Instead, their clients, consumers, and taxpayers pay the costs. Also, if a natural disaster triggers a shock to the industry so that a cartel is formed, there will be efficiency/welfare loss to the economy as a whole, which provides rent to the directly affected industry and welfare losses to other parties. Although it is not obvious if firms believe ex ante that they might benefit from natural disasters, this is still potentially a reason for such firms to spare investment in risk prevention. Also, firms would pay no particular attention to potential natural disasters in determining locations of factories if they believe no large losses would be incurred from natural disasters, but would instead benefit from them. Thus, a perverse incentive may have been given to firms; thus, serious moral hazard issues may arise. Our analysis therefore calls for two significant questions:

(a) Who incurs losses or damage from natural disasters?
(b) How and who should bear the costs of risk prevention against natural disasters?

In the case of the HDD industry, the answer to the first question appears to be the clients of the HDD industry, possibly including the end users, although this requires a further investigation into the structure of the chains involving the HDD industry, both upwards and downwards. The first best solution to the second question would be to design an incentive mechanism so that the HDD industry would be given incentives to invest in risk prevention, i.e. internalise the costs to the HDD industry. However, this is not straightforward because of the global nature of the industry. Direct interventions by the government such as Thailand's that force the HDD industry to invest in risk-prevention measures may well lead to relocation of the industry to other countries. Thus, it is unlikely that such legislation could be brought forward. Thus, to improve resilience against natural disasters: (1) a public policy that directly prepares for natural disasters should be implemented, e.g. conduct detailed geographical surveys to develop extensive hazard maps; implement better land use planning; improve infrastructure such as drainage system, dikes, and power grids with back-ups; and (2) incentives should be provided to firms to invest in risk prevention. To this end, one possible policy is to grant tax breaks or advantages if the firms make such investment. Such a preferential set-up is a common practice to invite foreign firms to invest in factories, but a similar arrangement should be put in place to incentivise investment in risk prevention.

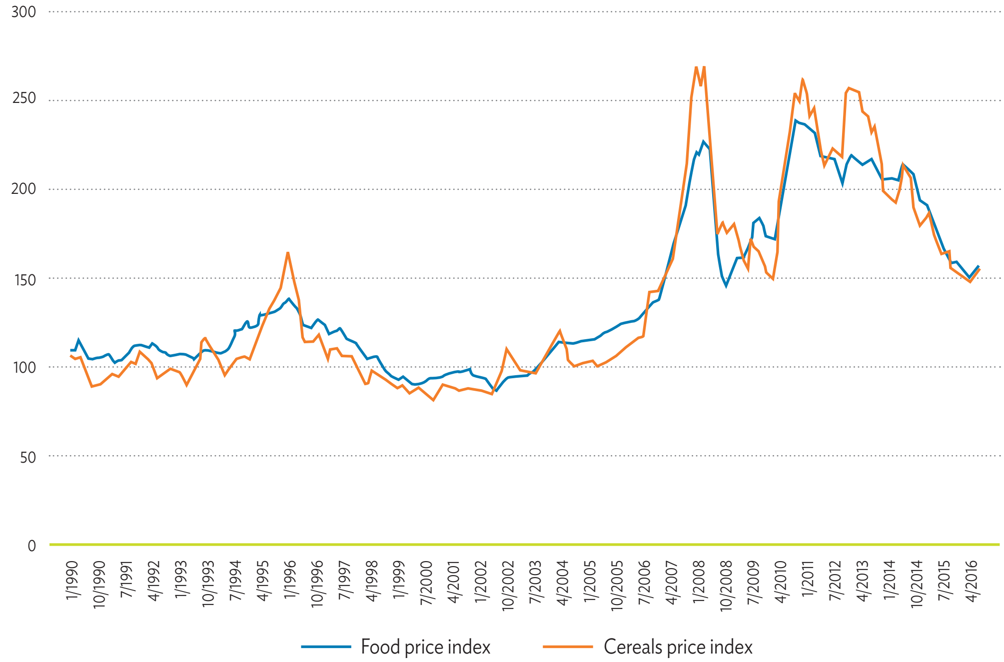
Implications for Agriculture

Agricultural production involves a variety of price and yield risks which appear to be prevalent, especially amongst small-scale, poor farmers in the semi-arid tropical areas in developing countries. Stakeholders in the agricultural sector adopt risk management strategies to smooth the income stream before risks or uncertainties unfold, which can be defined as activities for risk mitigation for and reduction in income instability. Farmers have traditionally managed agricultural production risks by crop diversification, inter-cropping, flexible production investments, the use of low-risk technologies, and special contracts such as sharecropping. Also, interlinked contracts amongst workers, producers, traders, and businesses have been widely observed in agriculture. However, it is often difficult by nature to adopt proper risk management strategies against natural disasters because they are typically rare events or, even worse, they are sometimes unforeseen. Accordingly, even if people adopted a variety of risk management strategies, a disaster can happen unexpectedly, causing serious damage to the welfare of those involved in the agricultural sector. For example, crops, livestock, farmland, and facilities may be destroyed or damaged by a natural disaster at an unprecedentedly large scale. Against such unexpected natural disasters, ex post risk-coping will be necessary so as to reduce profit fluctuations involving a variety of transactions in goods, labour, and credit markets. Moreover, formal insurance policies including index insurance contracts have been attracting wide attention as an effective financial instrument against covariate shocks arising from natural disasters. Index insurance contracts are written on specific events such as drought or flooding with specific attributes such as location, severity, etc. As such, index insurance involves a number of positive aspects: they can insure against aggregate events (i.e. events involving macro risks); affordable and accessible even to the poor; easy to implement and can be privately managed; and much less affected by moral hazard, adverse selection, and high transaction costs that have plagued conventional agricultural insurance policies such as crop insurance schemes. The World Bank and other institutions have been piloting weather-based index insurance contracts in Morocco, Mongolia, Peru, Viet Nam, Ethiopia, Guatemala, India, Mexico, Nicaragua, Romania, and Tunisia. Since natural disasters are typically an aggregate event, index insurance is thought to be an appropriate instrument to combat them. Nevertheless, natural disasters frequently involve highly covariate risks, which cannot be diversified within a country. Accordingly, the insurers may well need to rely on the international reinsurance market, although the capacity of the reinsurance market is limited. Also, recent studies show that the extent of international risk-sharing remains surprisingly small when the overall effectiveness of mutual insurance across national borders is measured.

Vertically Integrated Agricultural Businesses

Year 2008 is recorded as the year of a global food crisis: wheat and corn prices tripled and the price of rice increased fivefold between 2005 and 2008 (National Geographic, 2009). The global food prices spiked again in 2011 for the second time in 3 years (World Bank, 2016) as we can see from Figure 8 of the Food Price Index and Cereal Price Index compiled by the Food and Agriculture Organization (2016). The Food Price Index is composed of the average of five commodity group price indices: meat, dairy, cereals, oil, and sugar price indices. The Cereals Price Index consists of different grain indices such as 10 different wheat price quotations, one maize export quotation, and 16 rice price quotations, where rice quotations are combined into three groups of Indica, Japonica, and Aromatic rice varieties. Large spikes in global food prices led to reduction in real income and consumption levels of households, resulting in poverty. According to the World Bank (2012), an estimated 105 million people were pushed into poverty in low-income countries in 2007 and 2008, necessitating emergency supports for farming inputs, feeding programmes, and other safety net programmes. It should be noted that these price hikes stimulated political movements in a number of countries.

Figure 8: Global Food Price (Monthly real price, 2002-2004=100)



Source: Food and Agriculture Organization, 2016.

While price hike is a signal of excess food demand, market mechanisms behind the global food crisis have been under-investigated. To bridge this gap in the literature, we discuss the implications for agriculture of our analysis on the case of the HDD industry. To this end, we compare the players that are involved in the two sectors. The HDD industry itself is an oligopoly and their (upwards) suppliers are parts and component suppliers, i.e. firms, while there are four market segments amongst their clients (see, for instance, Western Digital, 2014): personal computers, enterprises, consumer electronics (mainly digital video recorders, game consoles and video recording systems), and branded products (external drives for home and small offices). Thus, the clients include both consumers and firms. In contrast, the majority of producers in agriculture are small farms although there are vertically integrated agriculture businesses too. Thus, the small producers would not have the market power unlike the HDD manufacturers, while the vertically integrated agricultural businesses may be similar to the HDD manufacturers. The middle of the stream before reaching consumers, the end users, is essentially corporate, however.

Thus, for the vertically integrated agriculture business, similar incentives may well hold as the HDD industry. Also, the corporate sector in the middle of the stream may exert market power or form a cartel. To be more specific, they may buy produce from the small suppliers at lower prices than ones that may reflect the costs of risk prevention or the potential costs of risk or uncertainty of natural disasters, and they may also sell produce to consumers at higher prices than the prices that would be observed in perfect competition, either due to oligopoly or by forming a cartel. Thus, the true costs of natural disasters or risk prevention may not be reflected in the prices for the transactions between producers and the corporate middlemen, while the corporate middlemen may enjoy higher profits from the occurrence of natural disasters against the consumers just as the HDD industry did.

The possible distortions due to the larger market power held by the corporate sector in agriculture may well be aggravating because of the furthering of globalisation of the sector: the total value of the global agricultural products exports grew from US$550.8 billion in 2000 to US$1,765.4 billion in 2014 (World Trade Organization, 2015). This makes the issue more difficult to be resolved because investment in risk prevention funded by the taxpayers may not bring sufficiently large benefits to the country due to the fact that the corporate sector can easily change the sources of supply across countries. In other words, the corporate sector can free ride the benefits of risk preventions and may also benefit from natural disasters when the agricultural production is hit by natural disasters as we saw above for the HDD industry.

Thus, to enhance risk prevention in disaster-prone areas, we need to consider the incentives of the corporate sector that may exert market power as in the case of the HDD industry. To this end, the policy recommendations for the HDD industry essentially hold the same for agriculture: (1) implement a public policy that directly prepares for natural disasters, e.g. conduct detailed geographical surveys to develop extensive hazard maps; implement better land use planning; improve infrastructure such as drainage system, dikes, and power grids with back-ups; and (2) provide the corporate sector with incentives to invest in risk prevention. The second point requires more detailed and careful considerations to design and implement incentive mechanisms as the structure of the agricultural sector is more complicated than the HDD industry.

Conclusion

This paper examined the possible effects of the 2011 Thailand floods on the HDD industry. Contrary to the common idea that the firms hit directly by floods are victims, the major HDD firms benefited instead from the floods by maintaining a higher price or gross margins than before the floods. This implies that firms expecting to benefit from natural disasters may have perverse incentives regarding investment in risk prevention. We also found that the industry-wide shipment has become consistently lower than what it was before the floods, which cannot be explained by the shift in demand. The combination of higher price and lower quantity suggests that the floods may trigger a formation of a cartel, i.e. the firms act collusively, according to the predictions of our theoretical framework based on Radner (1980). Cartel formation may well be easier when the industry is more consolidated. Thus, the degree of market concentration may be an important factor that drives incentives to invest in risk-prevention measures.

Based on the analysis of the HDD industry, we discussed the implications for the agricultural sector. The basic recommendations are essentially the same as those for the HDD industry, i.e. (1) implement a public policy that directly prepares for natural disasters, and (2) provide the corporate sector with incentives to invest in risk prevention. The key issue is the market power held by the corporate sector since it may well cause distortions in the risk-prevention efforts and the allocation of its burdens.

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CHAPTER 8

EAST ASIAN PRODUCTION NETWORKS AND LESSONS FOR AGRICULTURE

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Introduction

Intricate trading networks have emerged in East Asia, developed by Japanese multinational corporations (MNCs) seeking to maintain price competitiveness as the yen appreciated by 60% in the 1980s. Japanese corporations tried to lower production costs by relocating factories to lower-cost locations. These foreign direct investment (FDI) flows not only reduced costs but also transferred technological and managerial know-how, increased local procurement, multiplied trade in intermediate goods, and strengthened distribution networks (Gaulier et al., 2005). These value chains have multiplied efficiency gains and caused prices of consumption goods to drop.

The slicing up of the value chain in East Asia is particularly sophisticated and well-developed. It involves complicated combinations of intra-firm trade, arms-length transactions, and outsourcing (Kimura and Ando, 2005). Borrus et al. (2000: 2) have provided a definition of these value chains:

> By a lead firm's "cross-border production network" (CPN) we mean the inter- and intra-firm relationships through which the firm organizes the entire range of its business activities: from research and development, product definition and design, to supply of inputs, manufacturing (or production of a service), distribution, and support services. We thus include the entire network of cross-border relationships between a lead firm and its own affiliates and subsidiaries, but also its subcontractors, suppliers, service providers, or other firms participating in cooperative relationships, such as standard setting or R&D [research and development] analysis.

Production activities within these networks can be fragmented into individual modules, and the modules can be allocated to different locations based on differences in comparative advantage. For instance, research and development and technology-intensive activities can be performed in advanced countries and labour-intensive assembly can be performed in lower-wage countries. This type of trade is vertical intra-industry trade. It differs from the trade in final goods emphasised by Ricardian and Heckscher-Ohlin models of international trade. Kimura and Ando (2005) have developed a theoretical model to explain how these trade–FDI–technology linkages can be promoted. In their framework, firms fragment production when the cost saving arising from fragmenting production exceeds the costs of linking geographically separated production blocks. This latter cost is called the service link cost, which can be lowered by, inter alia, improving infrastructure, educating workers, strengthening the rule of law and the enforcement of contracts, protecting intellectual property, and ameliorating information asymmetry problems. Within the manufacturing sector, value chains in Asia have exploded, promoting technology transfer and development in emerging Asia and causing prices of final goods to tumble. However, within the agricultural sector, similar value chains have yet to emerge.

This paper first recounts the emergence and evolution of production networks in manufacturing and then seeks to draw suggestions for agriculture. The next section examines the emergence of production networks in Asia. Section 3 considers China, which has become more and more central in global value chains. Section 4 discusses the agricultural sector in Asia. Section 5 concludes.

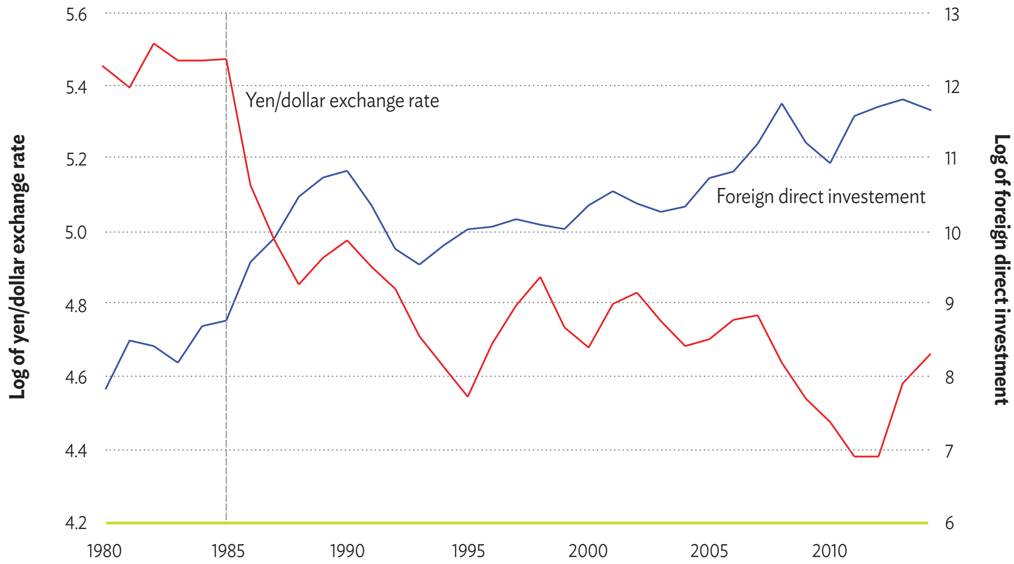
The Emergence of Production Networks in East Asia

On 22 September 1985, France, Germany, Japan, the United Kingdom (UK), and the United States (US) agreed to push down the value of the dollar in an attempt to reduce large US trade deficits with Germany, Japan, and other countries.

The Japanese yen subsequently appreciated by more than 50% and Japanese exporters lost their price competitiveness. To reduce costs, Japanese firms transferred labour-intensive operations to lower-wage countries. They continued to produce technology-intensive parts and components domestically and shipped these abroad for assembly and re-export (Figure 1).

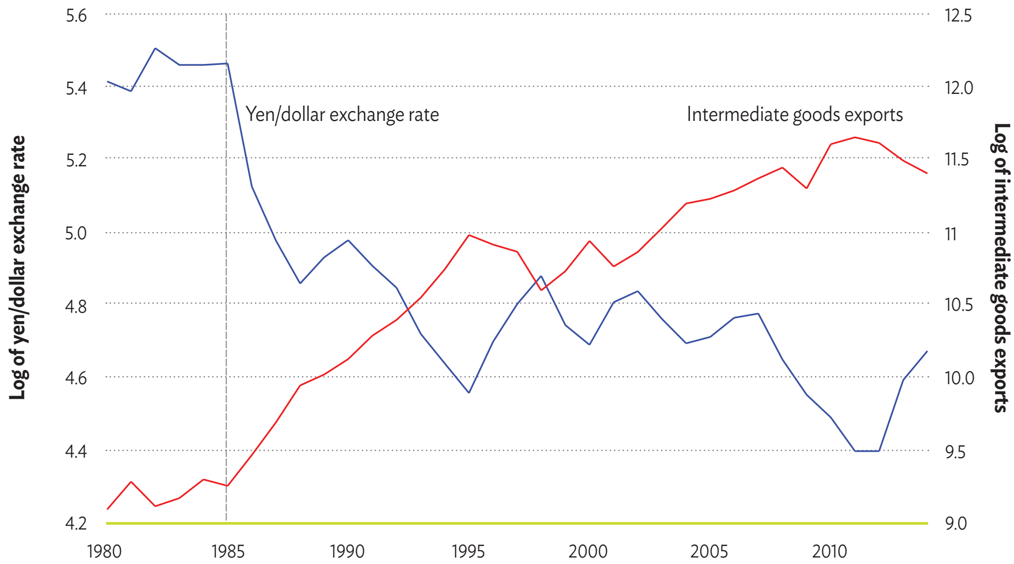
Figure 1 shows that as the yen began appreciating, Japanese FDI increased logarithmically by 50% as Japanese MNCs began transferring factories abroad. Figure 2 shows that as the yen appreciated, exports of parts and components – all intermediate goods – to East Asian neighbors soared. Where did these goods go?

Figure 1: Yen-Dollar Exchange Rate and Japanese Outward Foreign Direct Investment



Source: CEPII-CHELEM database, 2015.

Figure 2: Yen–Dollar Exchange Rate and Japanese Intermediate Goods Exports to East Asia



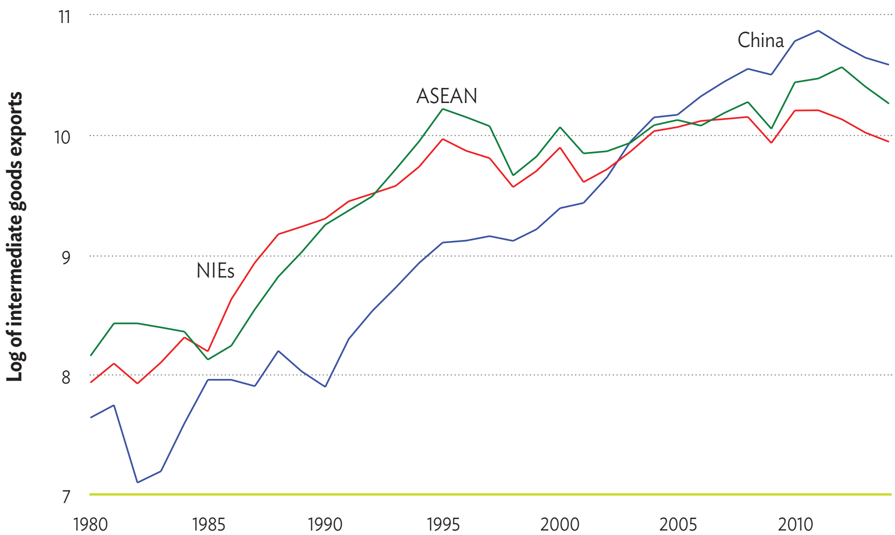
Note: East Asia includes China, Malaysia, Indonesia, the Philippines, Singapore, Republic of Korea, Taiwan, and Thailand.

Source: CEPII-CHELEM database, 2015.

Figure 3 and Figure 4 show that initially, intermediate goods and FDI went largely to the newly industrialised economies (NIEs) of the Republic of Korea and Taiwan. The infrastructure was good in these countries, the work force disciplined and educated, and the governments stable. However, between the Plaza Accord in September 1985 and the middle of 1989, the Korean won appreciated by 30% and the New Taiwan dollar by 45%. In addition, wages skyrocketed in these two economies at the end of the 1980s as the flow of labour from farms to factories dried up (see Yoshitomi, 2003). Performing labour-intensive operations in NIEs became costly for Japanese MNCs. As Figure 3 and Figure 4 indicate, they shifted production to the Association of Southeast Asian Nations (ASEAN) countries.

Within the important electronics value chain, FDI and intermediate goods went to Malaysia, the Philippines, and Thailand, but not to Indonesia. One problem with the latter is the low quality of its roads, ports, and other infrastructure.

Figure 3: Japanese Intermediate Goods Exports to Parts of East Asia



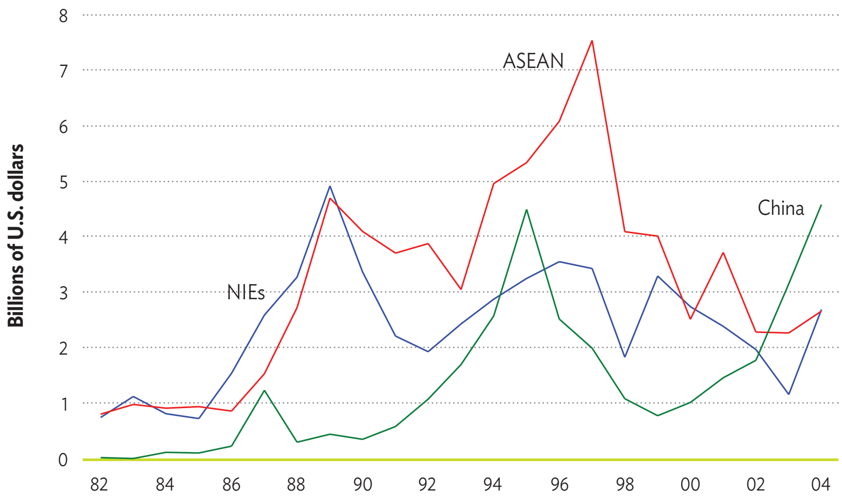
Note: NIEs refers to Republic of Korea and Taiwan. ASEAN refers to Malaysia, Indonesia, the Philippines, Singapore, and Thailand.

Source: CEPII-CHELEM database, 2015.

ASEAN experienced a major crisis in 1997–98. The banking sectors collapsed and there were riots and other problems. The crisis dampened the appetite of Japanese firms to invest in ASEAN. Figure 3 and Figure 4 show the decline of FDI and intermediate goods flowing from Japan to ASEAN after the crisis. While Japanese companies left their factories in ASEAN, they began looking for other locations for new production. Figure 3 and Figure 4 show that China emerged in the 2000s as a leading destination for Japan's overseas production. China joined the World Trade Organization in 2001, and this gave

MNCs confidence to invest in this country because they believed that it would follow the rule of law more closely. In addition, foreign investors were attracted by the high-quality roads, ports, airports, and other infrastructure in the Pearl River Delta and the Yangtze River Delta.

Figure 4: Japanese Outward FDI to Parts of East Asia

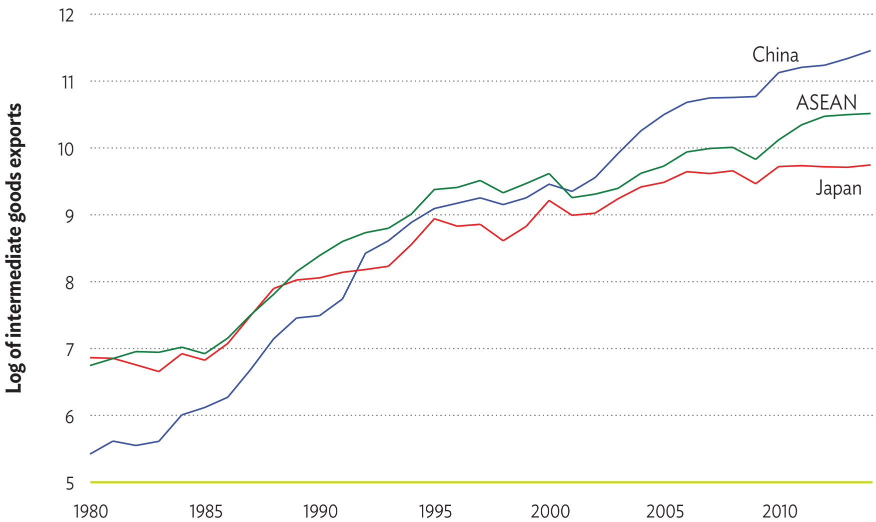


ASEAN = Association of Southeast Asian Nations, FDI = foreign direct investment, NIEs = newly industrialised economies.

Note: NIEs refers to Republic of Korea and Taiwan. ASEAN refers to Malaysia, Indonesia, the Philippines, Singapore, and Thailand.

Source: Japanese Ministry of Finance, 2005.

Figure 5: Intermediate Goods Exports of NIEs to Parts of East Asia



ASEAN = Association of Southeast Asian Nations, NIEs = newly industrialised economies.

Note: NIEs refers to Republic of Korea and Taiwan. ASEAN refers to Malaysia, Indonesia, the Philippines, Singapore, and Thailand.

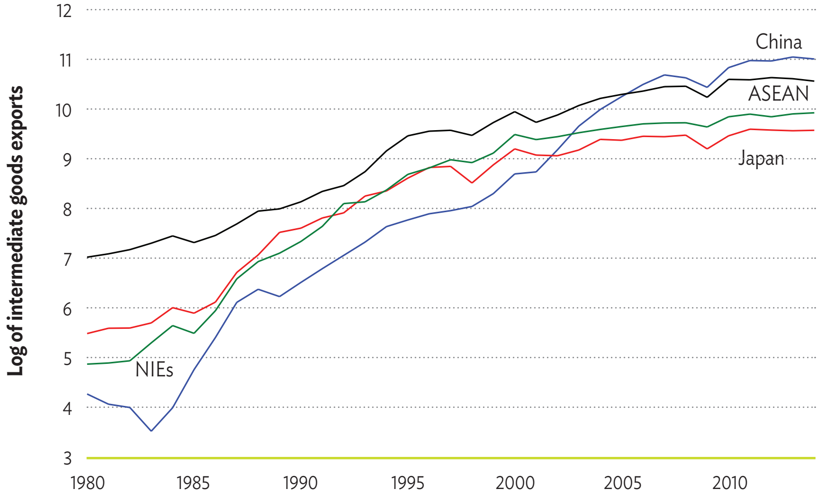
Source: CEPII-CHELEM database, 2015.

As the Republic of Korea (henceforth, Korea) and Taiwan were climbing the technology ladder and as wages in their economies increased, they also began moving factories to lower-wage regions of Asia. Figure 5 shows that before China's accession to WTO, ASEAN was an important location, but more and more productions were relocated to China after 2000. However, as wages have increased in China, MNCs in NIEs have relocated production to Viet Nam. Korea's intermediate goods exports to Viet Nam increased almost four times after 2008 to reach US$8 billion.

ASEAN countries have also been increasingly active in sending parts and components and other intermediate goods to their Asian neighbours. Figure 6 shows that the leading recipient of these goods is China, but many of these flow to other ASEAN countries as well. An example will help clarify how production links in ASEAN work. Hiratsuka (2011) discussed in detail the operations of Hitachi Global Storage Technologies (HGST), a leading producer of hard disk drives (HDD) in Thailand. He documented how HGST procured most parts and components from Indonesia, Malaysia, the Philippines, and Singapore. The close locations meant that supplier firms could send parts and components by overnight express and could also send engineers to improve communication with HGST engineers. These engineers could also come quickly should there be problems with parts. HGST procured media from Malaysia and Singapore; printed circuit boards from Indonesia, the Philippines, and Thailand; pivots from Malaysia, Singapore, and Thailand; voice coils from Indonesia, Malaysia, and Thailand; and bases from Malaysia and Thailand. These parts and components were also procured from countries other than those mentioned. Hiratsuka (2011) noted that employing multiple suppliers increased competition between suppliers and reduced the risk of parts and components being unavailable due to natural disasters, political problems, and other factors. While the parts and components listed above were obtained through arms-length transactions, core components such as heads and suspension were procured through intra-firm trade with HGST's head office in the US and its affiliate in Mexico.

Figure 7 shows total intermediate goods exports from all of East Asia to the individual parts. It makes clear that Japan has been the most upstream location since the 1980s. ASEAN was the most downstream until 2003. Since then, China has more and more become the final link in regional value chains.

Figure 6: ASEAN's Intermediate Goods Exports to Parts of East Asia

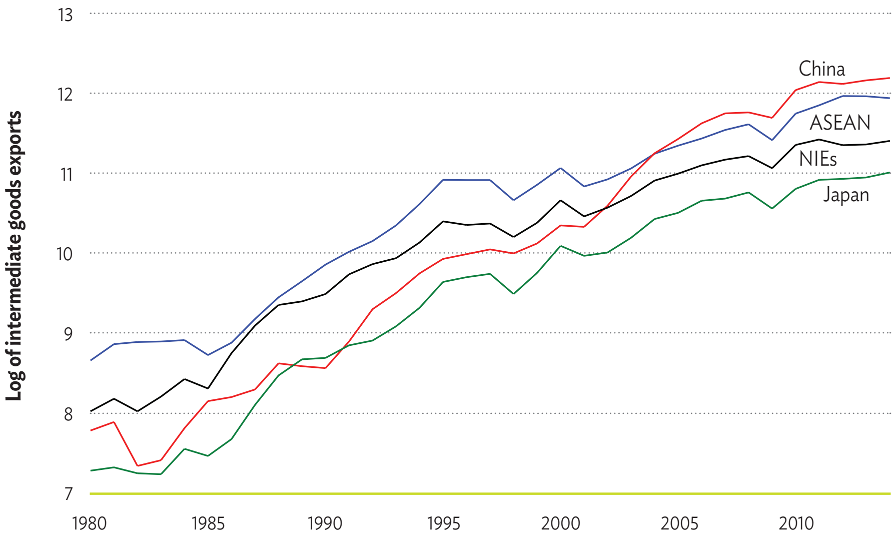


ASEAN = Association of Southeast Asian Nations, NIEs = newly industrialised economies.

Note: NIEs refers to Republic of Korea and Taiwan. ASEAN refers to Malaysia, Indonesia, the Philippines, Singapore, and Thailand.

Source: CEPII-CHELEM database, 2015.

Figure 7: East Asia's Intermediate Goods Exports to Parts of East Asia

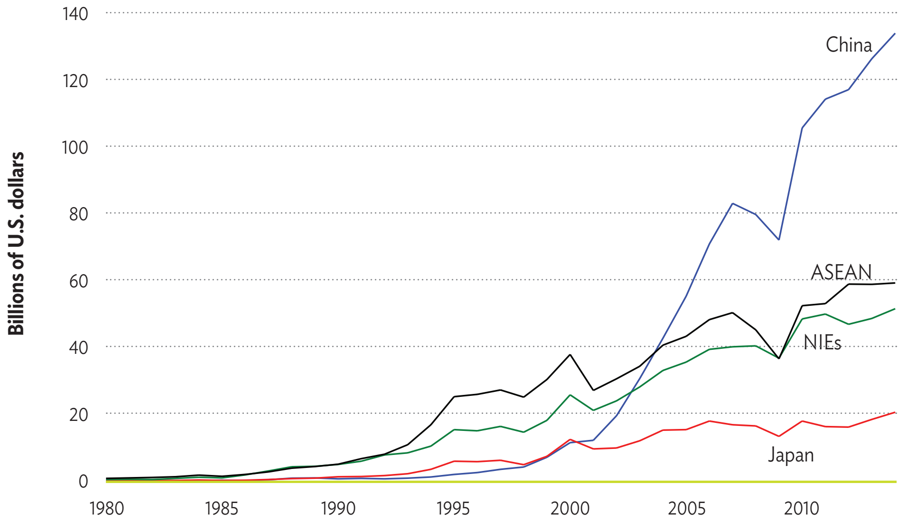


ASEAN = Association of Southeast Asian Nations, NIEs = newly industrialised economies.

Note: NIEs refers to Republic of Korea and Taiwan. ASEAN refers to Malaysia, Indonesia, the Philippines, Singapore, and Thailand. East Asia includes NIEs, ASEAN, Japan, and China.

Source: CEPII-CHELEM database, 2015.

Figure 8: East Asia's Exports of Electronic Parts and Components to Locations in East Asia



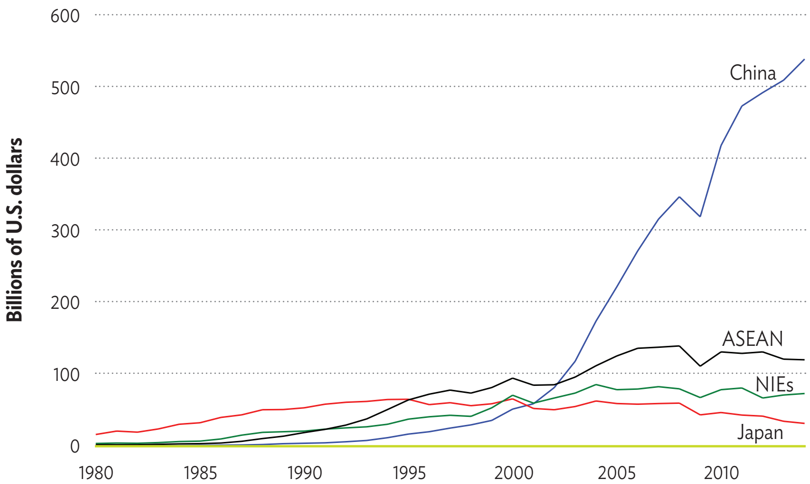
ASEAN = Association of Southeast Asian Nations, NIEs = newly industrialised economies.

Note: NIEs refers to Republic of Korea and Taiwan. ASEAN refers to Malaysia, Indonesia, the Philippines, Singapore, and Thailand. East Asia includes NIEs, ASEAN, Japan, and China. Electronic components come from the HS classification numbers 8540, 8541, and 8542.

Source: CEPII-CHELEM database, 2015.

Far and away, the most important industry within East Asian value chains is the electronics industry. This sector has done well partly because of very low tariffs.

Figure 9: East Asia's Exports of Final Electronic Goods to the World



ASEAN = Association of Southeast Asian Nations, NIEs = newly industrialised economies.

Note: NIEs refers to Republic of Korea and Taiwan. ASEAN refers to Malaysia, Indonesia, the Philippines, Singapore, and Thailand. East Asia includes NIEs, ASEAN, Japan, and China. Final electronic goods include computers, telephones, and consumer electronic goods and correspond to HS classification numbers 8469-73, 8517-22, 8525-39, 8543-48.

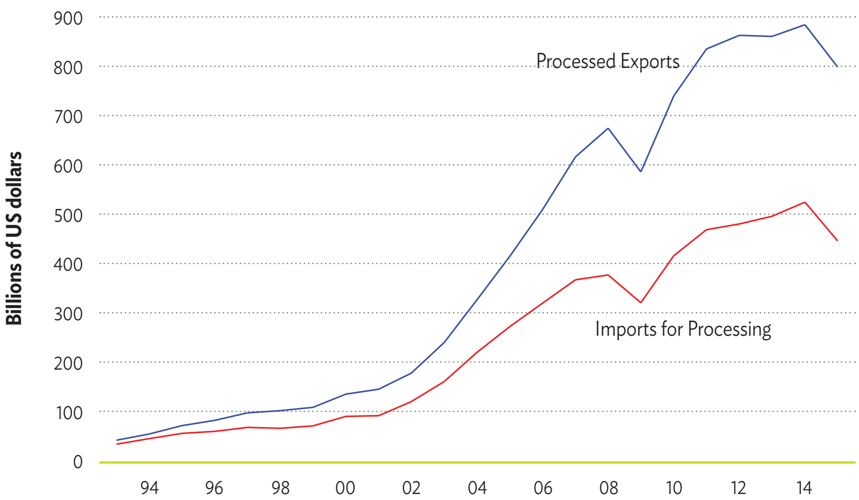
Source: CEPII-CHELEM database, 2015.

To shed further light on the evolution of value chains in the region, Figure 8 shows the flow of electronic parts and components within the region, and Figure 9 shows the exports to the world of the final electronics goods produced using electronic parts and components. These final goods include computers, telephones, and consumer electronics goods. Figure 8 shows that more and more electronic parts and components go to China, and more and more final electronics goods are exported from China. Thus, China is not only the final link but has also become the central country within regional value chains.

China's Ordinary and Processing Trade

To shed light on China's role in global value chains, it is helpful to consider China's two primary trading regimes: processing trade and ordinary trade. Processed exports are produced using parts and components that are imported duty free. Processed exports can only be used to produce goods for re-exports and are not allowed to enter the domestic economy. Ordinary exports are produced using local inputs and using imported inputs that are not imported duty free. Figure 10 plots China's processing imports and exports.

Figure 10: China's Processing Trade, 1993-2015



US = United States

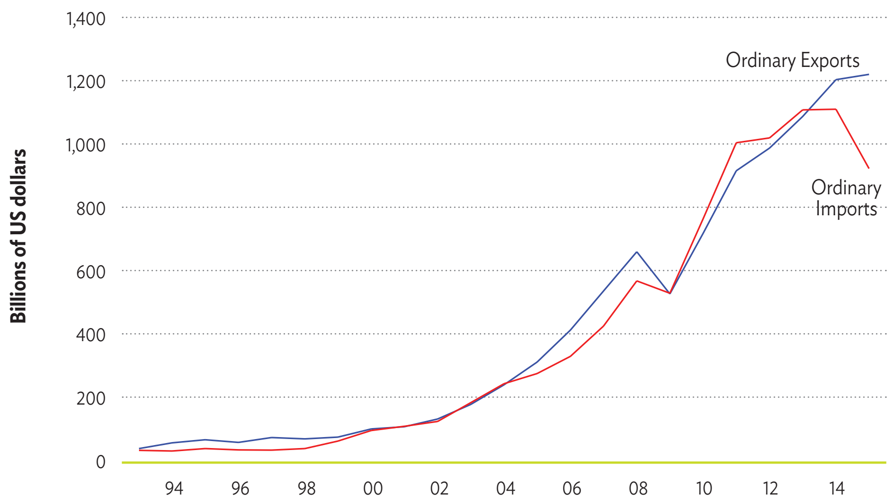
Source: China Customs statistics, 2016.

As the figure shows, the surplus in processing trade keeps increasing. This indicates that more of the value added of sophisticated processed exports come from China. The surplus is wider than the figure indicates, since each year more than US$70 billion of imports for processing are actually produced in China and then shipped out and back in to obtain favourable tax benefits (Xing, 2012).

The increase in China's value added in processed goods reflects the fact that the Chinese government has steered Chinese firms towards higher value-added activities (Republic of China, 2012). In addition, China's capital deepening has permitted more parts and components to be produced domestically (Knight and Wang, 2011). China's industrial clusters and processing supply chains have also become deeper (Kuijs, 2011). Finally, investments in education in China have facilitated technology assimilation from FDI firms and progress towards higher value added activities (see Kiyota, Matsuura, Urata, and Wei, 2006; Yusuf et al., 2003).

Figure 11 plots China's ordinary imports and exports. The figure shows that ordinary exports had grown rapidly, and that the growth rate only started to slow down in 2015. Figure 11 also shows that ordinary imports fell in 2015. This fall was due to the drop in the prices of primary products such as crude oil and iron ore, and to a decrease in import demand because of China's slowdown and because of President Xi Jinping's crackdown on government officials receiving luxury imported goods (Qian and Wen, 2015).

Figure 11: China's Ordinary Trade, 1993-2015

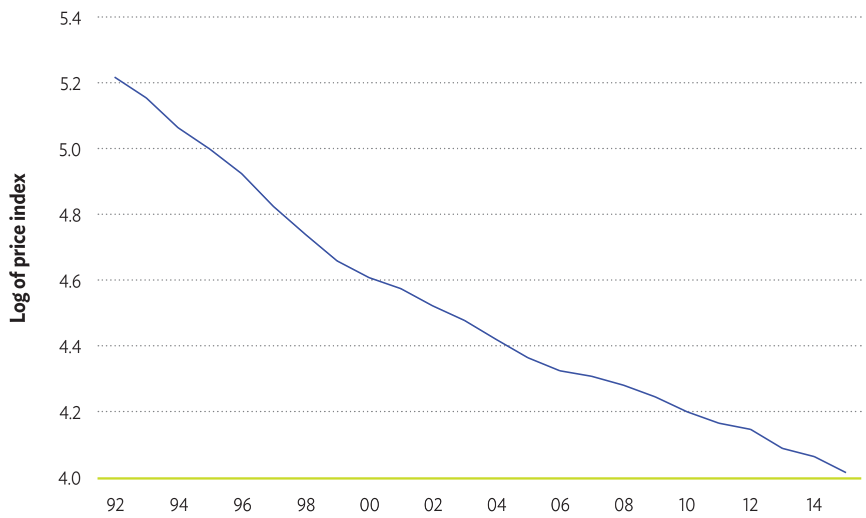


US = United States

Source: China Customs statistics, 2016.

Correcting both processing and ordinary trade for goods produced in China and then round-tripped for tax reasons, China ran a surplus in 2015 of US$422 billion in processing trade and US$330 billion in ordinary trade. China's combined surplus in processing and ordinary trade thus equaled US$752 billion. Thus, China ran a huge surplus in the primarily manufactured goods that are part of processing and ordinary trade. The huge surplus indicates that China's value added in manufacturing has risen. China's rising value added in processing trade implies that more of the technology-intensive parts and components are now produced in China. There is now fierce competition between China and the newly industrialised economies of Korea and Taiwan in producing microchips and other sophisticated inputs. Korea and Taiwan still have a technological advantage, but China is closing the gap quickly.

Figure 12: Price Index for East Asia's Exports of Final Electronic Goods



Note: Final electronics goods include computers, telephone equipment, and consumer electronics goods.

Sources: CEPII-CHELEM database, Bureau of Labor Statistics, and author's calculations, 2016.

This competition and mushrooming productivity growth have reduced prices for consumers. Figure 12 shows that the prices of computers, cellphones, and other final electronics products have dropped.

Lessons for Agriculture

Agricultural supply chains have not developed in the same way as manufacturing supply chains have and there are several reasons for this. Asian governments have long viewed agriculture as less of a priority than manufacturing, and have sought to promote manufacturing development at the expense of agricultural development. Many countries such as Indonesia have pursued self-sufficiency in agriculture. Thus, rather than focusing on their comparative advantage, these countries try to produce all crops and impose tariffs on imported crops (Murdoch Commission, 2015). In contrast, regional value chains in manufacturing have reaped large efficiency gains by allocating production to each region based on comparative advantage and by liberalising trade. Asia also has a preponderance of small farms. In China, for instance, 95% of farms are less than 2 ha. Small farm size hinders mechanisation and productivity growth.

So, how can Asia promote productivity growth and expansion of regional value chains? One key step would be to harmonise food quality and safety standards. This would allow freer trade in agricultural goods in Asia. In this case, individual regions could specialise in producing crops that follow their comparative advantage, secure in the knowledge that other countries would trust their products and that they could also safely purchase other crops from abroad. Finding a means to harmonise standards is trickier. Australia and New Zealand have integrated these tasks in the One Biosecurity initiative, but it is hard to see this working more broadly for Asia. Perhaps a regional organisation could oversee harmonisation.

Research and development at universities could be combined with commercial activities and government assistance (Ministry of Economic Affairs, 2012). In Taiwan, when bicycle manufacturers faced intense competition from Chinese exporters, research and development centres, universities, and the government worked together with businesses. The Cycling and Health Tech Industry R&D Center and the National Cheng Kang University worked with the industry to develop environmentally responsible manufacturing techniques. The Metal Institute R&D Center developed lightweight, high-quality metals to use in bicycle manufacturing. Government agencies and corporations helped bicycle manufacturers reduce their inventory levels and implement efficient management systems. The Taiwanese bicycle industry then developed innovative, high value added bicycles that competed with Chinese products on quality rather than on price. Asian countries should reflect long and hard about the proper roles for research institutes, the government, and the commercial sector in promoting agricultural production.

They should also carefully think through the concept of self-sufficiency in agriculture. The combination of focusing on all crops and protecting imports leads to stagnation. Government should find ways to balance legitimate needs for self-sufficiency with approaches that increase agricultural productivity. To increase productivity, more focused policies should be chosen, where possible, over protectionism. For instance, Huang, Wang, and Rozelle (2013) documented how the Chinese government, rather than using protectionism to raise farmers' incomes, put money in each of their bank accounts before planting seasons (Murdoch Commission, 2015). Where appropriate, Asian countries should also promote the movement away from smallholder farms so that farmers can take advantage of economies of scale. Politicians in the past have sometimes sought to exert control over farmers by, for example, rigidly allocating fertilisers and farm machines. In the future, government should encourage off-farm activities for low-productivity small farmers and seek larger farm sizes that could benefit from economies of scale. Stronger property rights for land and for key inputs such as water would also be helpful. This would remove uncertainty and increase farmers' ability to obtain loans.

Finally, well thought out initiatives can help to redirect farmers into more remunerative activities. For instance, in the 1960s, Japan's Oita Prefecture launched the One Village, One Product movement where each village specialised in one productive crop such as shitake mushrooms or *kabosu* (a lime-like fruit). The government provided extension services, capacity building, and technical assistance. Some villages also tried to produce higher value added products from the original good (e.g. wine from plums). Similarly, on the Japanese island of Shikoku, residents have tried to maximise the value they obtain from *sudachi* and *yuzu*, two locally grown citrus fruits. Not only do they obtain high prices domestically and abroad for these fruits, but they use them to make cider, sherbet, *gokkun* (a local drink), and to flavour a variety of foods. They also have a design institute on the island to promote *zudachi* and *yuzu* to international audiences and a research institute to investigate and make known the health benefits of these fruits (see Thorbecke, 2016).

Conclusion

Production networks in the manufacturing sector have emerged and now crisscross East Asia. China is becoming more central within these networks. The networks have multiplied efficiency gains, led technology transfer to developing and emerging countries and caused prices of final goods to plummet. This paper has traced the evolution of these networks over time. Several factors contributed to lowering the cost of linking geographically separated production blocks and the slicing up of the value chain in Asia. China's accession to the World Trade Organization gave investors confidence that China would follow the rule of law. In addition, China's superb infrastructure in the Pearl and Yangtze River Deltas made producing there attractive. The growing human capital in urban China has also led to technology transfer and more of higher value added activities being relocated in China. Low tariffs in the electronics sector have also facilitated the flow of electronic parts and components throughout the region. The paper also discusses other factors that have contributed to fragmenting production in the region.

In contrast to the manufacturing sector, value chains in the agricultural sector are less developed. There are many reasons for this. Asian governments have long viewed agriculture as less of a priority than manufacturing. Countries have also eschewed comparative advantage and used protectionism to pursue self-sufficiency in agriculture. The preponderance of small farms has hindered mechanisation, economies of scale, and productivity growth. While productivity has exploded within Asian value chains in the manufacturing sector and caused prices to tumble, productivity in the agricultural sector has languished. By harmonising biosecurity standards, eschewing protectionism, rethinking agricultural self-sufficiency, focusing on comparative advantage, and fostering cooperation between research agencies, the government and commercial enterprises could promote value chains and increase agricultural productivity in the region.

Acknowledgements: This paper was written for the OECD International Conference on Vulnerability of Agricultural Production Networks and Global Food Value Chains due to Natural Disasters held in Vienna, Austria on 21–24 June 2016. I thank the organisers for inviting me to the conference. I also thank the participants and especially Michael C. Huang for helpful comments. Any errors are my responsibility.

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CHAPTER 9

IMPROVING THE RESILIENCE OF REGIONAL FOOD VALUE CHAINS TO CLIMATE CHANGE AND NATURAL DISASTERS

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Introduction

The general consensus amongst those in the research community is that agriculture is highly vulnerable to increased frequency, severity, and unpredictability of extreme weather-related events caused by climate change. On a global scale, various models predict the impact of climate change on different time scales. Although positive opportunities may arise for increased production in temperate countries due to carbon fertilisation effects, past and current research indicate that in the tropical Association of Southeast Asia Nations (ASEAN) countries, the net effect will be negative (ADB, 2009a; FAO, 2002; IPCC, 2007; USDA, 2012; Parry et al., 2004). For Asia, biophysical crop model results show yield reductions under climate change scenario compared to no climate change scenario. By 2050, the expected reduction of irrigated paddies is in the range of 14%–20%; irrigated wheat, 32%–44%; irrigated corn, 2%–5%; and irrigated soybean, 9%–18% (ADB, 2010). Within ASEAN, the differences may occur locally. It is very difficult to make exact predictions as available data at sub-national level and on other food and cash crops are scarce.

On the other hand, ASEAN is a highly disaster-prone region that experiences frequent climate-induced disasters such as floodings, typhoons, earthquakes, and tsunamis. In 1990–2011, the region experienced nearly 40% of the total of world natural disasters. In the same period, Asia's share of the total death toll from these climate-induced disasters was nearly 80%. Also, nearly 58% of natural disasters in Asia occur in the East Asia region. In particular, the Asian countries prone to natural disasters are Bangladesh (312 disasters), China (681), Hong Kong (103), India (604), Indonesia (412), Iran (193), Japan (291), Pakistan (166), the Philippines (529), Sri Lanka (81), Thailand (119), and Viet Nam (177). The average number of people exposed to yearly flooding more than doubled in

1970–2010, from 30 million to 64 million (Anbumozhi et al., 2011). Half a billion people live in rural areas. When disaster strikes, the impacts on them is devastating, affecting food production systems and value chains.

Vulnerabilities to climate change and other natural disasters constitute a set of interactions between society and food value chains. Research on vulnerability to disasters and adaptations to climate change is a major component of assessments conducted by Intergovernmental Panel on Climate Change, United Nations Framework Convention on Climate Change, United Nations Environment Program, International Geosphere-Biosphere Program, and many national and regional disaster risk reduction programmes. Southeast Asian economies are particularly vulnerable to current disasters and future climate change projections due to their physical geography and manifold economic and institutional challenges (Anbumozhi, 2015).

This paper is focused on the disaster risks and vulnerability in ASEAN. The next section of the paper provides ample evidence on vulnerability and assessment based on disaster and climate change scenarios. Section 3 provides analysis of climate change, disasters, and food value chain linkages, and discuss key uncertainties. Section 4 examines food security challenges in ASEAN and proposes a set of policy measures that can bring long-term stability to resilience to food value chain. Particular attention is given to the interplay between the technical and institutional changes needed. Section 5 examines how multi-dimensional integrated strategies can help reduce the vulnerability of food production network in a long-term sustainable way. The concluding section discusses some challenges and limitations in the proposed assessment frameworks.

Effects of Climate Change and Disasters to Fisheries and Aquaculture Production System

Many inland fisheries in ASEAN will be threatened by alterations to water regimes, reduced precipitation and greater evaporation, and indirect effects when more water is used for irrigation to offset reduced precipitation. Threats to aquaculture arise from increase in temperature, pH values, biochemical oxygen demand, increased frequency of diseases, sea level rise and salt water intrusions, and uncertain future supply of fishmeal and oils from capture fisheries (FAO, 2007). Table 1 projects changes in agriculture and decline in aquaculture production. However, Indonesia (11.1%), the Philippines (13.4%), Thailand (9.0%), and Viet Nam (10.0%) have projections for growth in aquaculture, which will be influenced by climate change. For these countries, in recent years, net export of fish generated more foreign exchange earnings than other agricultural products such as rice, coffee, and sugar. At the policy level, there is a need for increased cooperation and flexibility in fishing agreements to cope with declining fishing stocks, as well as integration of fisheries into other national policies on climate change, food security, and trade.

This regional assessment of vulnerability of agricultural production to climate-induced disasters such as drought or flooding relies primarily on the global scenarios. It focuses on the physical aspects of risk such as land degradation and changes in productivity, and on impacts of availability of water resources to meet future needs. On the other hand, a considerable amount of economic research on global and regional environmental change suggests that the institutional aspects of vulnerability to hazards along the value chain represent another critical dimension of understanding vulnerability of food production and distribution system, and that this perspective shifts the focus proximate cause to reducing the causes of vulnerability. Such factors as economic choices, institutional capacity, and trade on agricultural commodities can be equally important as bio-physical impacts in identifying and defining the effects of disasters and the differentiated abilities of farmers and other population groups to adapt to changes. This emphasis on socio-economic dimensions of vulnerability along the value chain is particularly prominent in large-scale land use change assessments that define a vulnerability framework as a combination of exposure, sensitivity, and resilience components of physical-economical-human system.

Table 1: Effects of Climate Change on Agricultural Production in ASEAN

Mean Global Temperature Increase (°C)	Agriculture Production	Number
1.0	0.82	-0.12
1.3	0.0	-0.28
1.8	-0.82	-1.39
2.8	-1.58	-1.17
4.0	-2.62	-1.83
4.2	-2.78	-2.04
5.2	-4.78	-3.15

ASEAN = Association of Southeast Asian Nations

Source: Darwin, 2001.

Despite some methodological divergence between different approaches, the assessment of vulnerability along the value chain requires blending of top-down analysis motivated by climate change scenarios with location-specific risk analysis of vulnerabilities and options for resilience, in which both physical and socio-economic factors contribute to the spectrums of possible resilience choices. Monitoring changes in the physical environment is a necessary pre-condition for an assessment of effects of natural disasters, stressors, vulnerabilities, and adaptive capacities at most geographic scales. It is not sufficient, however, as sensitivity to stressor and the adaptation spectrum is strongly modulated by economic and social factors. The case of regional food value chain is one example of this complex dynamic interactivity between bio-physical, economic, and social systems.

Climate Change, Disasters, and Regional Food Value Chains

Climate change and disasters have direct impact on intra-regional trade and food value chain. The total food supply of any country depends on production capacity, imports, and exports that generate income and foreign exchange to buy food. In this context, changes in food availability (due to climate change and other factors) in China and India (with markets of 2.8 billion people) will affect world prices, generating more or less capacity for any ASEAN country to obtain food on the global markets. When bio-physical impacts of climate change discussed in section 1 are integrated into the International Model for Policy Analysis on Agricultural commodities and Trade model, food prices increase sharply for key crops. Rice prices are projected to be 29%–37% higher in 2050 compared to a no-climate change; wheat prices, 81%–102%; corn 58%–97%; and soybean, 14%–49% (ADB, 2009b).

Table 2: ASEAN Rice Balance Sheet in 2015 (tonnes)

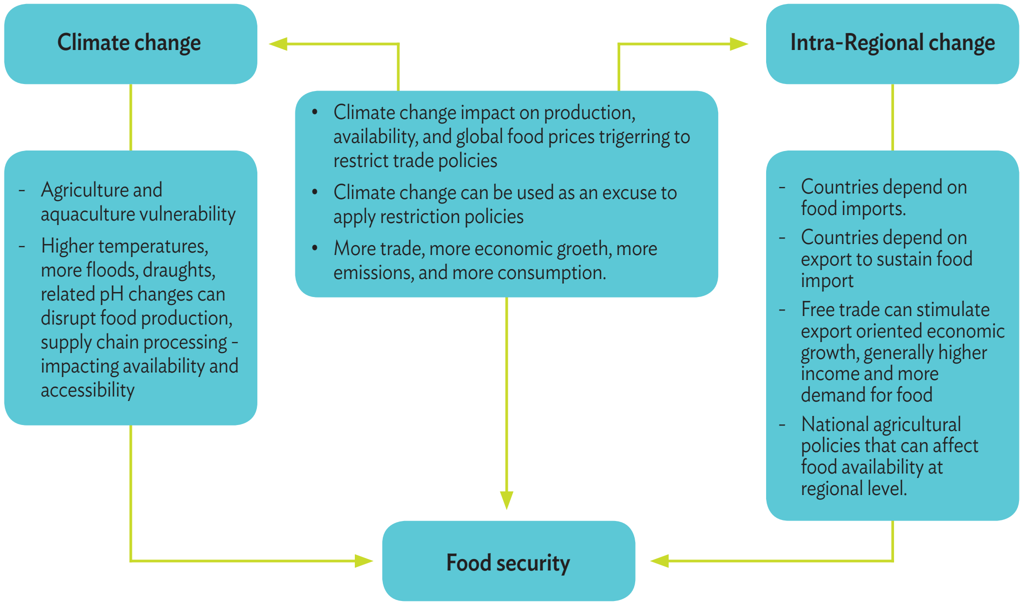
Country	Initial Stocks	Production	Domestic Utilisation	Imports	Exports
Brunei Darussalam	15,505	869	33,797	32,294	0
Cambodia	128,000	4,590,000	2,927,000	0	1,471,000
Indonesia	1,172,435	40,346,922	38,433,251	186,438	2,897
Lao PDR	30,169	1,820,750	1,764,642	n.a.	n.a.
Malaysia	275,899	1,585,708	2,531,159	1,094,419	n.a.
Myanmar	4,345,208	20,196,456	19,157,000	0	667,000
Philippines	2,638,287	10,737,201	13,163,706	1,638,314	159
Singapore	55,000	n.a.	262,000	280,000	33,000
Thailand	6,251,800	20,899,417	11,267,000	0	8,500,000
Viet Nam	5,680,101	25,282,075	18,327,996	0	5,950,000
ASEAN	20,592,404	125,449,397	107,867,551	3,231,465	16,624,056

ASEAN = Association of Southeast Asian Nations, Lao PDR = Lao People's Democratic Republic.

Source: ASEAN Food Security Information System, 2016

Table 2 shows the rice balance sheet of ASEAN. The regional group houses the world's major rice-exporting countries (Thailand and Viet Nam), the major rice importers (Singapore, Indonesia, the Philippines), and the still agrarian countries (Lao PDR, Myanmar, and Cambodia). In the event of sharp increase in world prices, large exporting countries like Thailand and Viet Nam can impose export ban to bring stability and security to the domestic market. Indeed, they invoked the agreement on agriculture within the World Trade Organization framework when the food crisis erupted in 2008. Nevertheless, it remains unclear how free trade restrictive measures can be reasonably implemented if the needs of neighbouring ASEAN countries that rely heavily on trade to ensure food stability under varying climate conditions are taken into consideration. These linkages are illustrated in Figure 1.

Figure 1: Climate Change, Trade, and Food Security Linkages



Source: Author.

In analysing the vulnerability of the regional food value chain, the identification of main areas of vulnerability and the most important transmission mechanisms need to be considered. In particular, three main macro areas of influence can be identified.

The first, impact to farmers, includes the economic costs and benefits and disruptions generated to the agricultural production system that produces the basic and intermediate food products. The second, impact to infrastructure, includes all the disruptions affecting the traders and infrastructure used for transport. The third, impact to consumers, includes all the direct and indirect costs and benefits generated on final consumers. Disaster and climate change events affecting one or more entities along the supply chain could generate impacts on other parts of the agricultural production network. For this reason, the main vulnerabilities of each of the components need to be analysed. However, since a multitude of different supply chain systems exist, the magnitude of damage and transmission mechanisms can be different based on value chain characteristics. In particular, some of the most important factors determining disaster and climate change vulnerability of ASEAN food value chain can be identified as (i) complexity and dimension of stages and networks: when the food value chain is constituted by a large number of suppliers, the possibility of suffering negative impacts generated by disruptions is larger than in the case of small and local supply production system; (ii) concentration of supplier: the possibility of having different suppliers of the same commodity, e.g. rice, is an important element to increase the flexibility of the supply chain and to reduce the costs and the time of recovery after a disaster; and (iii) the magnitude of the impact, which is dependent on how and how much the agricultural commodity is susceptible to the effects of disasters and climate change. Resilience and adaptability or substitution between resources are important elements to determine the magnitude of impacts. Further, how resilient the supplying area is in coping with unexpected disaster events is also important. This is based on elements such as recovery, risk management, and governance.

Table 3 illustrates the policy response of ASEAN countries during the 2008 financial crisis. The cascading effects of domestic policy interventions affected the market conditions and changed the food value chain structure.

Food availability and access are mainly influenced not only by productivity variation but price changes as well. When combined with external shocks, climate change-induced disasters affect food manufacturing and trade. A limited number of analyses have specifically quantified the economic impacts related to food affordability, purchasing power, or prices during the disasters.

Table 3: Policy Responses of Selected ASEAN Countries to the 2008 Global Food Crisis

Policy Response	Cambodia	Indonesia	Malaysia	Myanmar	Philippines	Singapore	Thailand	Viet Nam
Reduce import duties		X						
Increase supplies using reserves	X	X					X	
Build up reserves/ stockpiles	X		X		X	X	X	X
Increase imports/relax restrictions		X			X		X	X
Increase export duties								
Impose export restrictions	X							X
Price control/consumer subsidies	X	X	X		X		X	
Minimum support prices					X			X
Minimum export prices								
Subsidies to farmers					X			

Policy Response	Camb odia	Indo nesia	Malaysia	Myan mar	Philipp ines	Singa pore	Thai land	Viet Nam
Promote self-sufficiency			X	X	X			
Cash transfers						X		
Food rationing		X			X			

ASEAN = Association of Southeast Asian Nations

Note: Cambodia, Thailand, and Viet Nam are considered to be net exporting countries, whereas Indonesia, Malaysia, Myanmar, the Philippines, and Singapore are net importing countries.

Source: Author.

Implications of ASEAN Food Value Chains Under Climate Change and Disaster Conditions

Climate change is already affecting food production and livelihoods of vulnerable, small-scale producers in ASEAN, and providing indication of challenges that lie ahead (ADB, 2009b). Although the relationship between trade along the value chain and food security is complex to understand, the available adaptation options (Table 3) are easy to grasp.

Table 4: Examples of Climate Change Adaptation Measures and Policy Options

Adaptation Measure	Policy Option
Near-term Actions (5-10 years)	
Crop insurance for risk coverage	Improved access to information, risk management, revised pricing incentives
Crop/livestock diversification to increase productivity and protect against diseases	Availability of extension services, financial support, etc.
Time adjustment of farm operations to reduce risks of crop damage	Extension services, pricing policies, etc.
Changes in cropping pattern, tillage practices	Extension services to support activities, policy adjustments
Modernisation of irrigation structures	Promotion of water saving technologies
Efficient water use	Water pricing reforms, clearly defined property rights
Risk diversification to withstand climate shocks	Employment opportunities in non-farm sectors
Food buffers for temporary relief	Food policy reforms
Redefining land use and tenure rights for investments	Legal reforms and enforcements
Medium-term Targets (2030)	
Development of crop and livestock technology adapted to climate stress: drought and heat tolerance, etc.	Agriculture research (cultivar, fish, and live stock trait development
Development of market efficiency	Investment in rural infrastructure, removal of market barriers, property rights, etc.
Irrigation and water resources consolidation	Investment by public and private sector
Promoting regional trade in stable commodities	Pricing and exchange rate policies
Improving early warning/forecasting mechanisms	Information and policy coordination across the sectors
Capacity building and institutional strengthening	Targeted reforms on existing institutions on agriculture and skills development

Source: Adopted from ADBI, 2012.

However, the above policy options should be seen from the fact that trade and climate change factors will continue to have implications for food security at the national and regional levels for ASEAN countries. Thus, policymakers need to increase their awareness of these issues (UNCTAD, 2011). Specific policy recommendations for ASEAN should include:

- A more precise assessment of local food production vulnerabilities to climate change is made for major agricultural trading crops and inland fish species. ASEAN economic integration or free trade efforts should be enhanced with the recognition that food security and climate change are interlinked cross-cutting issues. Buyers in importing countries should build longer-term and more stable relationships with suppliers in food-exporting countries to create the means to mitigate production volatility.
- National planning efforts should incorporate food security early warning systems, taking into consideration factors such as weather-related events at ASEAN level and potential external shocks coming from their major trading partners (ASEAN+5 countries).
- Long-term innovative financing plans should be developed to support adaptation actions at national level.

Developing 'no regret' adaptation measures and 'win-win' strategies in ASEAN requires careful balancing of long-term and short-term, proactive and reactive, planned and spontaneous adaptation options. In the context of the fragile agricultural eco-systems of Southeast Asia, already affected by human-induced land and water degradation, any short-term, unplanned, and reactive adaptation may provide an immediate solution for a limited group of population at risk but are likely to exacerbate the problem over longer term. Unfortunately, the history of natural resource management in ASEAN is replete with examples of short-term adaptation to disaster and climate vulnerability. For example, a study conducted in Indonesia showed that 49% of the respondents indicated that they wanted to leave their farmland because of severe drought in 2010 (ADBI, 2015). It is estimated that the number of displaced people due to flooding was more than 100,000 in Thailand in 2013 (Anbumozhi, 2015). The recent drought in Viet Nam that started in 2007 doubled the net emigration from over 3,000 to over 6,000 persons. The prospect for the long-term resolution of drought-related disasters remain doubtful in ASEAN as precipitation levels vary widely and trans-boundary water disputes preclude the upstream release of more water for downstream uses. Temporary labour migration from countries like Cambodia, Lao PDR, and Myanmar to Thailand is also very common, with about 10% of working-age agricultural population leaving home for industrial work every year (ILO, 2016). These migrants are usually individuals with skills, opportunity, and psychological aptitude in managing climate and disaster risks. The concern arises that the population left behind might have lower capacity, skills, and potential to respond effectively to disasters. To cope with multiple stresses in the context of increasing risks caused by disasters, climate change, land use, and socio-economic changes of the past decades, ASEAN needs to develop and implement sustainable adaptive strategies.

Table 5: **Triple Bottom Line Considerations for Assessing Adaptation for Building Resilient Food Supply Chains**

Vulnerability Area	Agriculture and Food Security	Water Resources	Human Health
Adaptation sector			
Risks	Yield reduction due to drought	Higher evaporation; higher water consumption	Higher risk of malaria in irrigated areas caused by the longer transmission season
Adaptation measure	Changing the planting dates, and cultivar and irrigation method	Rehabilitation of existing irrigation systems	Use of pesticides
Triple Bottom Line criteria			
Environmental appropriateness	Minor or no environmental impact	Reduction of water loss; water pollution by pesticides	Negative impact on watershed ecosystems and health
Economic cost effectiveness	Cost effective, does not require additional investments	Increased water efficiency; significant investments are required	Relatively cost-effective; additional investments are required
Social acceptability	Acceptable	Reduction of water-related conflicts	May have adverse impact on health

Source: Author.

Successful adaptation to climate change, and disaster risk reduction in the context of continuous economic integration would require consideration of many environmental, economic, and social criteria. To be plausible, the resilience strategies along the value chain should be appropriate from a climate change perspective, cost-effective from economic perspective, and acceptable from socio-cultural perspective. In other words, adaptive strategies need to meet the triple bottom line criteria that place equal importance on environmental, social and, economic considerations. Table 4 illustrates how these criteria can help assist the assessment of potential adaptations. In this example, three sector-specific adaptation measures provide examples of how the triple bottom line criteria can be used to assess the suitability of each adaptive strategy.

It is obvious that development of almost any adaptation strategy along the value chain involves inevitable trade-offs. In fact, the potential trade-offs between the TBL criteria represent an objective limitation of sustainability of any adaptation option. As several impact assessment studies suggest, the risk of win–lose scenario caused by trade-offs can be reduced by incorporating minimum acceptability thresholds for each criterion into the TBL model and requiring that any adaptation initiative at least meets its minimum threshholds. At the regional scale, multi-objective multi-criteria evaluation algorithms based on geographic information system, such as ordered weighted averaging and weighted linear combination, can be particularly useful for assessing potential risks and trade-offs involved in the TBL assessment of adaptation strategies and policy choices.

Supply Chain Logistics and Associated Disaster Risk Management Strategies

Adaptation at the farm level is necessary but not sufficient to tackle the wide array of problems that arise along the (global) food supply chains. Technical expertise, market power, and actionable knowledge of downstream actors such as processors, wholesalers, and retailers will play seminal role in facilitating the long-term co-investment needed to thwart climate change impacts on food security. It may be feasible to scale up local level adaptation to global supply chain assuming that other chains actors bring their capacities to the adaptation process. But this will require structural changes, in which adaptive measures are applied at critical spots of food value chains. Bringing about such changes requires a collective approach to assessing climate change impacts and adaptation options.

Because ASEAN food supply chains are complex and often informal, it is difficult for decision makers and it discourages them from taking part in collective targeted interventions (Anbumozhi et al., 2011). This also underlines the importance of more case study research analyses on specific food chains (rice, corn, shrimp, etc) to provide actionable recommendations for collective adaptation. The key factors for any food supply chains in ASEAN countries include crop impacts, the vulnerability of small producers (income, housing, road, education), supply chain characteristics (logistics–technology and finance), and behaviours along with institutions (economic operators).

To help farmers/producers build their adaptive capacity and deliver more resilient supply chains, the private sector should:

- Raise awareness and understanding of adaptation among suppliers/producers/retailers, drawing upon their market knowledge and technical capacity;
- Continuously ask producers/suppliers about current climate trends and impacts; and
- Work through existing institutions, including governments, to spread the risks to more sites by diversifying procurement.

Governments should:

- Provide a research support platform to share knowledge about crop and site-specific impacts and adaptation strategies;
- Improve physical infrastructure for irrigation, transportation, and marketing; and

- Offer business operators and farmers easier and more equitable access to financial instruments such as start-up investments and micro-financing to implement collective adaptation measures.

Adaptation measures and resilience strategies that are likely to be successful should target multiple aspects vulnerability and remain useful regardless of existing uncertainties about climate change projects and occurrence of high-impact low-frequency disasters. For example, diversifying agriculture and growing drought-tolerant legume crops and climate-resilient fruits and vegetables along with applying conservation tillage practices could increase food security while improving soiling through nitrogen fixation, decreasing water use, and reducing net carbon flux to the atmosphere. Replacing the existing network of open irrigation canals by more efficient irrigation system could significantly reduce evaporative loss while simultaneously improving crop productivity, reducing soil salinisation, and decreasing the risk of water contamination and transmission of vector-borne and water-borne diseases. However, such extensive rehabilitation of rural infrastructure would be expensive and would necessitate the large-scale introduction at farm level of technologically advanced management techniques. To be truly integrated, the interactions amongst the three bottom lines of impact assessment must be considered, since both positive and negative synergies may occur.

Developing early warning systems such as forecasts on droughts, floodings, pests, and diseases, and water quality monitoring systems should also be considered as an important strategy for improving resilience along the value chain. Such early warning systems should integrate surveillance systems and provide forecasts at sub-national scale to capture heterogeneity of risks and climate hazards across ASEAN.

Economic and social equity have been an enduring challenge along the food value chain in many parts of ASEAN. Economic inequalities amongst the regions and individual groups of farmers increase immediately after disasters. After disasters, several urban centres have shown positive increase in the quality of life, whereas in rural areas, the quality of life and food security and the level of health are profoundly poor and continue to deteriorate. Reduction of socio-economic vulnerability to disasters and climate change along the value chain can be only achieved through income distribution, effective business continuity plans formulation, and building resilient infrastructure.

Public education and communication of disaster risks to all groups of stakeholders, farmers, middlemen, business intermediaries, traders, and consumers are important components of long-term adaptive strategies. Education and public awareness, supplier technical assistance programmes, and climate advocacy can play an important role in the recognition of existing links amongst economic and social components of vulnerability and the need for such integrated approach at ASEAN or national policies.

Enhancing Local-level Climate Change Adaptation and Disaster Resilience in ASEAN

A broad range of national needs and priorities exist across ASEAN member states. Generally, climate change and disaster risk are mainstreamed at the national level but the trickle down to the local level is very limited. Stakeholder consultations in many countries have highlighted the need for area-based pilots focusing on selected priorities. Amongst the aspects highlighted include the following:

- Not only agricultural and aquaculture but forest value chains in ASEAN are expected to be impacted by climate change and disasters, such as landslides. Hence, the aspect of carbon stock is of importance as carbon sinks. Disaster-coping strategies and adaptation practices for addressing climate change impacts on forests should be investigated by drawing on TBL method or modelling studies.
- There is much discussion on the issue of carbon credit mechanisms amongst some Southeast Asian countries. It has been identified as priority area for supply chain resilience, but local experts are limited. Building capacity in this area is needed, particularly on the aspects of securing income or incentives out of carbon credits that shall be used for building resilience along the value chain.
- Health is identified as a priority issue, particularly health problems in the aftermath of extreme events such as floods and droughts. For example, water-borne diseases, dengue fever, and malaria are common and have been projected to become worse according to the National Adaptation Program of Action. The capacity to model health impacts need to be enhanced in ASEAN.
- There was emphasis on the need to differentiate vulnerability to current climate and disaster risks and vulnerability to long-term climate risks, where both approaches are equally important. Methods are available for both approaches. Inherent vulnerability index may be suitable for short-term adaptation of agricultural development projects to current climate, i.e. water resource development, ecosystem-based adaptation approaches, etc. However, for long-term resilience, the use of vulnerability-index-based climate change scenario is more relevant.
- To effectively tackle the impact of disasters and climate change, the participation of local governments in supply chain resilience and climate change adaptation is important and necessary as they are the ultimate implementers. However, coordination at the national level is critical to make this happen. There are many changes in local

development planning, including mainstreaming of adaptation, allocation of resources, provision of local mandate, etc.

Variations in local conditions exist within a national boundary and this is where the problems need to tackled. In this regard, the need should be to select a specific area of high priority, e.g. a landscape or an ecosystem with a cluster of villages or a sub-basin within a watershed that may have a small landscape with communities, aquaculture farms, crops lands, plantations, water resources, etc. Within this specific area, both aspects of adaptation and mitigation of risks can be considered. Short-term risks can be handled via immediate adaptation programmes and policies that could integrate disaster risk reduction, where climate modelling outputs are optional. There is a need to identify climate extremes and hotspots that constitute pockets of highly vulnerable communities in various landscapes such as coastal areas, forests, watersheds, etc., so that adequate adaptation measures can be given priority. Long-term planning and long-term resilience programmes will require modelling. This can be handled using the same context- and area-specific approach. The benefits of the projects in facilitating learning and capacity building need to be emphasised in local communities. Establishing platform comprising academia and researchers to exchange information on good international practices and communicating with local leaders on continuous basis will be helpful. This could serve as the starting point for mobilising expertise from within ASEAN on a consortium basis to address regional needs and priories. This network, when linked with Asian Europe Network on Climate Science and Technology, will facilitate exchange of information amongst universities and other affiliated organisations in the region.

Conclusion

This paper has attempted to provide insights into how climate change is affecting agricultural production networks and value chain in ASEAN. Governments and the private sector can strengthen the adaptive capacity of producers and in doing so make their food value chain resilient. ASEAN is projected to become more vulnerable in the coming decades due to climate-induced disasters and integrated economic activities. These events are one of the most important elements influencing the efficiency of the present value chain and production networks. The increasing rate of unexpected and extensive disasters taking place along the food value chain make climate change a serious factor of concern in terms of food security, economic stability, and social welfare.

During the last decades, an increasing number of studies have investigated the main elements of disaster risks and vulnerability in the ASEAN region. The largest part of the studies focused on the main direct impacts generated in a specific sector or in a specific geographical area. This paper analysed the overall vulnerability of the supply chain and its impact on socio-economic systems. A good understanding of the most vulnerable entities is in fact a fundamental step to avoid, reduce, and mitigate the potential costs of disasters. A combination of climate modelling, date, and intra-regional and intra-sectoral analysis are the fundamental elements needed for the assessment of risks. However, lack of database on adaptation options and assessment of trade-offs make it difficult to determine cascading effects resulting from the disruption of regional food value chain. In general terms, a wide data gap exists in ASEAN countries where climate change and disaster-related events are expected to generate the biggest catastrophic impacts. In addition, the lack of updated and detailed information covering the trade links between economic sectors and geographical areas is one of main limits for the quantification of benefits of recommended adaptation measures along the value chain. Much more research is needed on how countries and companies can best invest in building adaptive capacity along the entire value chain of food-importing countries of ASEAN. They are often one step removed from primary production and thus from focus of policy research. Furthermore, many small-scale producers do not form part of global supply chain. Subsistence farmers have small surpluses to sell in the local markets. It is thus the primary role of individual governments to bring them at the core of addressing climate change and food security issue, while ASEAN as a community must ensure that they have appropriate knowledge, technology, and financial resources to increase their productivity, and stay connected to global markets. Governments and the private sector should take key steps to support them in their value chain rather than leaving them bear disproportionately the cost of climate change.

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CHAPTER 10

BIO-INDUSTRIAL AGRICULTURAL PRODUCTION NETWORKS AND ROBUSTNESS AGAINST DISASTERS: THE ROLES OF INFORMATION AND COMMUNICATIONS TECHNOLOGY IN INDUSTRIAL AGRICULTURAL PRODUCTION IN THE REPUBLIC OF KOREA

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Introduction

Over the past 150 years, the global average surface temperature has increased by 0.76°C (IPCC, 2007) and has caused greater climatic volatility such as changed precipitation patterns or increased frequency and intensity of extreme weather events including typhoons, heavy rainfalls, floodings, and droughts. Although the agricultural sector continually adapts to climate change through changes in crop rotations, planting times, genetic selection, fertiliser management, pest management, water management, and shifts in areas of crop production, it needs effective information on important environment factors that can be used for warning and preventing adverse impacts of climate change. In particular, industrial agricultural production requires monitoring for a secure production and control of food safety standards.

In 2015, there were 1,237,000 farm, forest, and fishery households in the Republic of Korea with 2,924,000 dependent persons (Statistics Korea, 2016). Compared to the previous agricultural census in 2010, this was a reduction of 7.6% in the number of households and a 16.4% reduction in the number of the primary sector population. Out of 10,027 ha of total land area, 1,711 ha are used for cultivation and food production (KREI, 2015). The average Korean farm size is 1.4 ha, very small compared to those of other highly industrialised countries. The income of the agricultural population is less than 80% of the national average. The farming population is ageing, with 37.8% over 65 years old in 2015.

Information and communications technology (ICT) has played a role in supply chain management but is increasingly being included in farm management. Farmers can use ICTs to match cropping practices with climatic trends, use inputs and resourses environmentally and sustainably, and cope with threats to productivity. Indeed, ICT is gaining momentum as part of sustainable development, and environmental and climate change strategies. To achieve sustainable agricultural production, it can be used as a method in increasing crop yields, reducing water consumption, and increasing profits. ICT has been implemented in several risk areas in developing and developed countries although it has limited accessibility to poor farmers because of cost (WB, 2011). Many countries have strategies and targets to improve, develop, and optimise the use of this technology by reducing its accessibility limitations.

In this article, we deal with scenarios of climate change and significant impacts of natural disasters on Korea's agricultural production by focusing on the implementation of ICT.

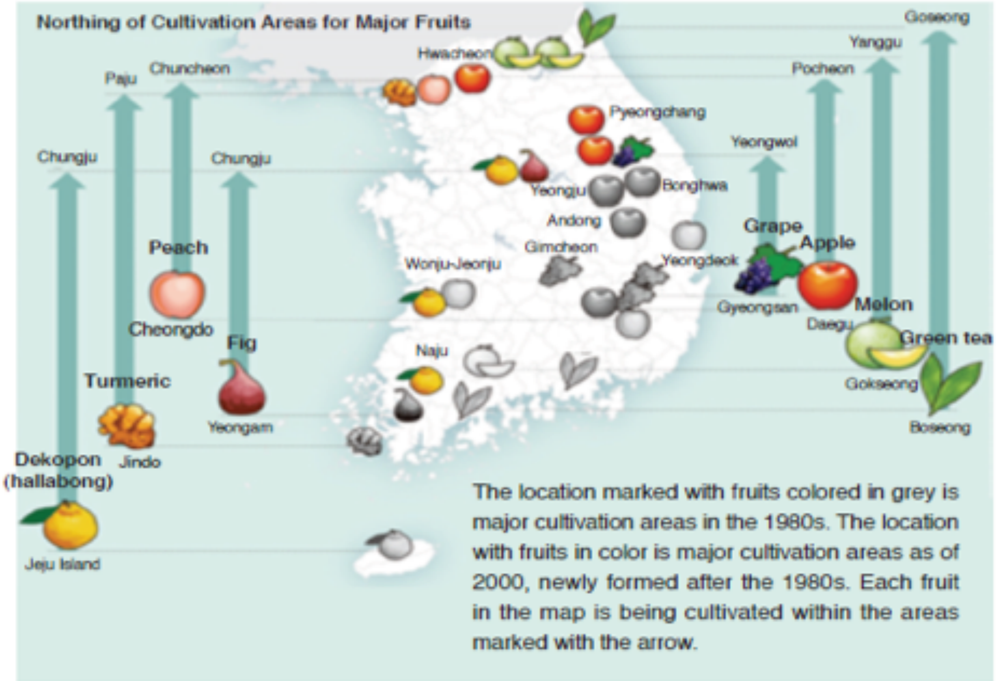
Scenarios on Climate Change and Occurrence of Disasters

According to the projections of Korea Meteorological Administration based on observation data accumulated over 30 years, the temperature in Korea will continuously increase until 2100. For instance, the current annual average temperature of the southern part of Jeju Island, located in the subtropical climate zone, is 16.7°C.

Climate change will affect major production areas. In 2013, the Future Digital Climate Map for Agriculture Use forecast changes in Korea's cultivation areas (Figure 1). Rice production, for instance, will fall to around 18.3% in 2050 due to increasing high temperature (KREI, 2015).

The total areas for apple cultivation will continuously decrease, while those for pear, peach, and grape will remain until the mid-21st century before they start to decrease. Conversely, cultivation-capable areas for sweet persimmon, tangerine, and subtropical crops will increase.

Figure 1: Changes in Suitable Cultivation Areas for Major Crops as Induced by Climate Change

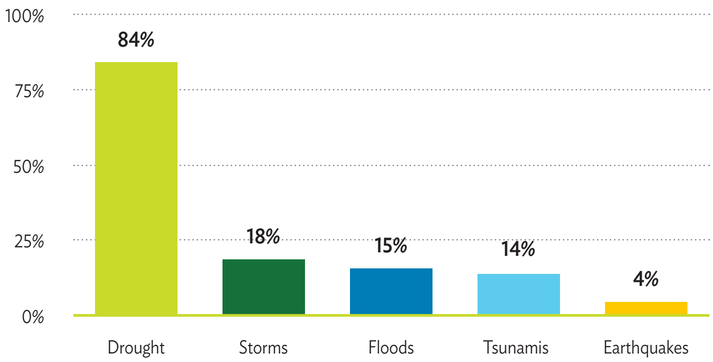


Source: Rural Development Administration, 2015.

Loss and Damage to Agricultural Production

Over the last three decades, there has been a rising trend in the occurrence of natural disasters worldwide, particularly climatological events such as droughts, hydrological events like floods, and meteorological events such as storms. The increase in weather-related events is of significant concern to the agriculture sector given its dependence on climate (FAO, 2015b).

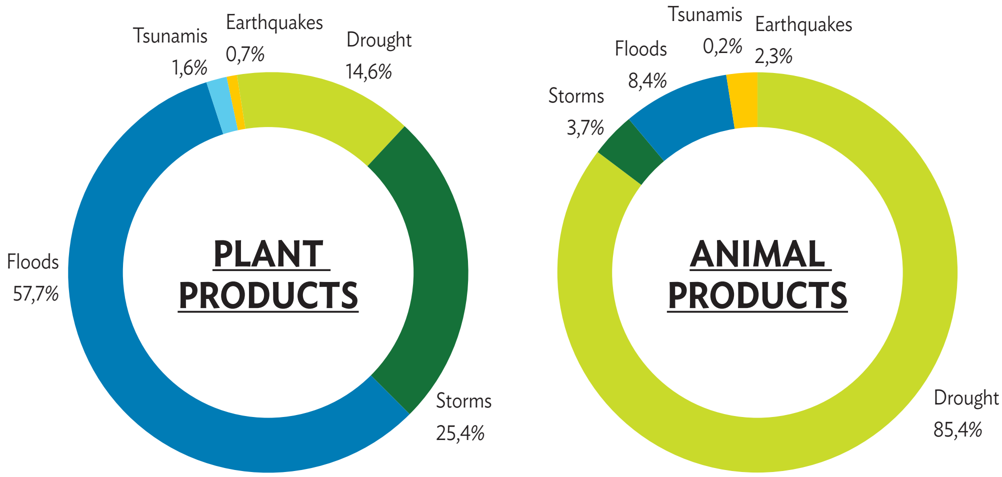
Figure 2: Kinds of Natural Disasters



Source: FAO, 2015b

The Food and Agriculture Organization (FAO) (2015a) found that from 2003 to 2013, natural hazards and disasters in developing countries affected more than 1.9 billion people and caused over US$494 billion in estimated damage. Moreover, FAO's findings show that the 78 disasters caused a total of US$30 billion in loss and damage to the agriculture sector. As illustrated in Figure 3, the relationship between drought and agriculture is particularly important as 84% of the loss and damage caused by droughts is to agriculture (FAO, 2015b). Moreover, total loss and damage to the crop sub-sector amounted to about US$13 billion, almost 60% of which were caused by floods, followed by storms with 25%. Livestock is the second most affected sub-sector, accounting for US$11 billion or 36%. A total of 67 developing countries were affected by at least one medium to large natural disaster between 2003 and 2013, causing crop and livestock production losses amounting to US$70 billion. Damage and loss to crop and livestock production caused by droughts and floods amounted to 44% and 39%, respectively (FAO, 2015a).

Figure 3: Loss and Damage to Agriculture Subsectors by Type of Hazard



Source: FAO, 2015b

Different types of disasters have different impacts on each subsector, as illustrated in Figure 4. Crops tend to be most affected by floods and storms, accounting for an estimated 83% of economic impact on the sub-sector. Livestock is overwhelmingly affected by droughts, causing nearly 86% of all loss and damage to the sub-sector (FAO, 2015b).

Understanding these differences is critical in the formulation of policies and practices at national, sub-national, and community levels. Disaggregated sub-sectoral data on disaster impact are needed to support the implementation of innovative risk management tools, such as weather risk insurance schemes for agriculture and rural livelihoods. Systematic and coherent data availability will facilitate the design of insurance schemes, which would help further diversify risk-mitigation strategies.

The Republic of Korea is seriously affected by climate change such as changes in temperature, rainfall patterns, increase in extreme weather events including floods and droughts, and occurence of easily spreading diseases which affect agricultural production and people's livelihoods. Natural disasters have significantly contributed to unstable domestic agricultural production and food supply in the country. Natural disasters in Korea increased from 48 cases in 1910 to 190 cases in 1990.

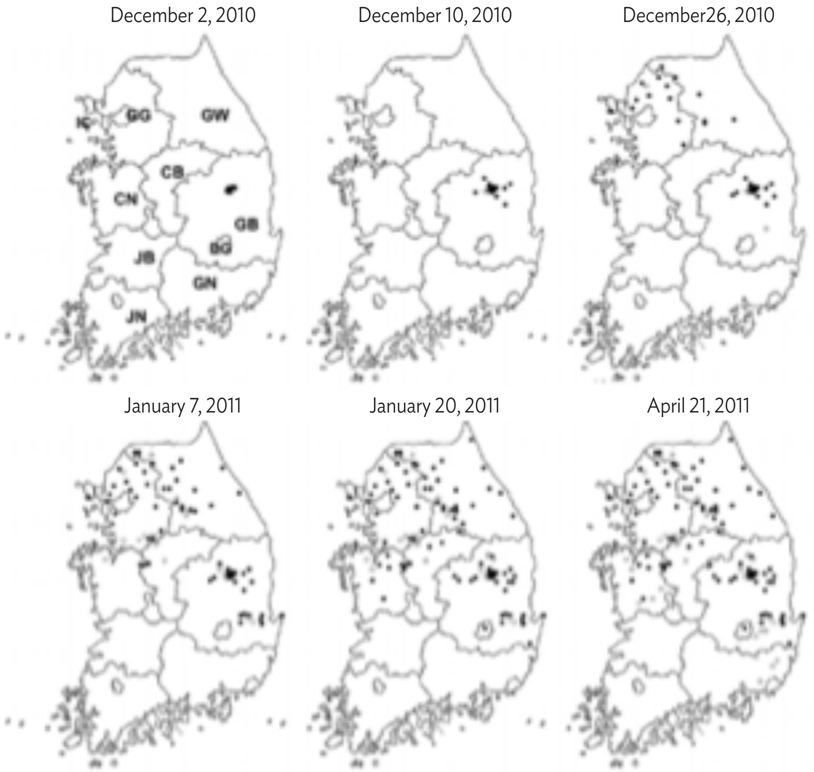
Table 1: Natural Disasters in Korea (1981–2016)

Natural Disasters	Range of Years	Impacts
East Asia cold wave	January 2016	Temperatures in Seoul fell to -18°C (0°F), the lowest in 15 years.
Drought in Korea	June 2015	Soyang Lake completely evaporated
Typhoon Chan-hom	2015	Rainfall and wind
Korea floods	July 2011, August 2014	Heavy rainfall, flash floods, and landslides
Typhoons	1981–2012	Rainfall and wind
Foot-and-mouth disease	November 2010–April 2011	Effect on livestock
Winter storms in East Asia	May 2009–February 2010	Blizzard and heavy snow

Source: Wikipedia, 2016.

An outbreak of foot-and-mouth disease (FMD) in Korea in November 2010–April 2011 seriously affected the country's food supply chain which could not respond to domestic consumption demand. The economic losses amounted to approximately US$1.7 billion. Consequently, market prices of meat were increased to control and manage the situation while at the same time introducing the use of technologies, improved breeds, and more intensive production systems, and consequently taking market opportunities at local, national, and international levels. The government imposed quarantines and initiated a vaccination campaign that targeted nine million swines and three million heads of cattle while culling 2.2 million livestock. The overall cost of this effort was estimated at US$1.6 billion. After vaccination and culling were implemented, the number of daily FMD cases decreased gradually. Amongst cattle, the number of FMD cases began to decrease 40 days after the initial outbreak (12 days after the first cattle vaccinations). In swines, the number decreased 60 days after (18 days after the first swine vaccinations) (Park et al., 2013) (online Technical Appendix Figure 5).

Figure 5: **Progress of Foot-and-mouth Disease Transmission Throughout Korea During 2010–2011 Outbreak**



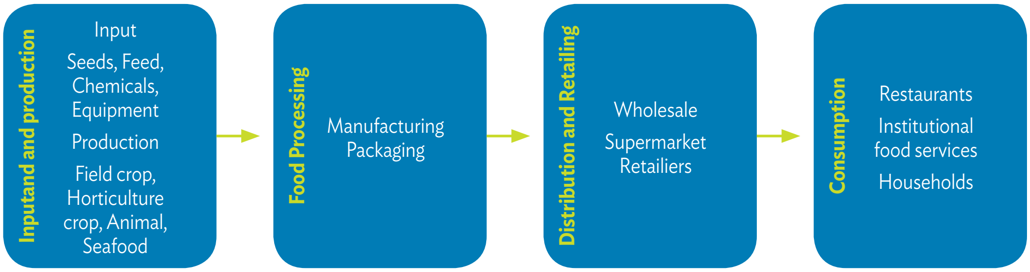
Note: Circles indicate swine cases in index farms; black dots, cases in cattle. A timeline of case detection is provided in online Technical Appendix.
Source: wwwnc.cdc.gov/EID/article/19/4/1- 1320-Techapp1.pdf .

Impacts to Food Supply Chain of Loss of Agricultural Production

The industrial system for agricultural production network is created to provide sustainable food security and to ensure a healthy life for present and future generations. However, recent climate change situations have created various impacts on agricultural production networks especially on initial farm-level production networks. More than 80% of loss and damage was caused by droughts and floods (FAO, 2015b), mainly involving reduction and loss of crops and livestock. For food supply chain (Figure 6), insufficient raw materials and price variables affect industrial agricultural production, which needs increased investment to be able to provide raw materials into food supply chain to be transformed as agriculture products in food processing for delivery to retailers or supermarkets. At the same time, a producer in food processing must realize return profit to his investment by determining proper prices for the consumer. For instance, cereal prices in Southeast Asia are likely to rise up to 30% if mean temperatures change in the range of 5.5oC (Easterling, 2007) which will lead to a decline in crop yields. This issue can be a reason to import

(Ministry of Agriculture, Food and Rural Affairs 2015). The rice farms are of small scales at 1.19 ha in average. Therefore, its food self-sufficiency rate is very low. (KREI, 2015).

Figure 6: **Food Supply Chain – Linear Model**

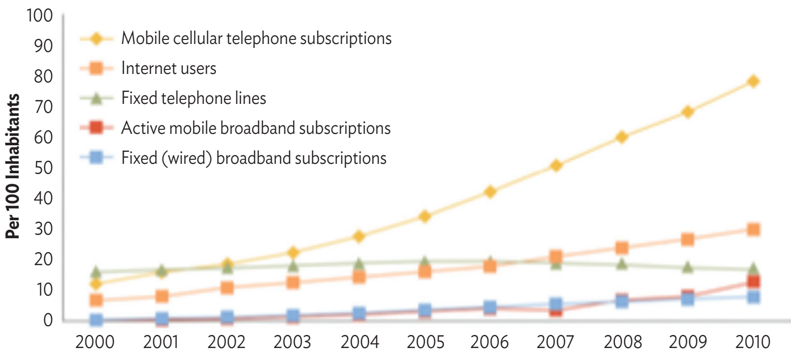


Source: Berti and Mulligan, 2015.

Implications of Using ICT in Agriculture Sector

ICT intervention for the agricultural value chain is on pricing service where commodity price information is provided to customers on a regular basis. Such service offers advantages such as price transparency and improved negotiating leverage for the often disempowered seller (farmer). Furthermore, crisis management helps prevent crop losses and raise productivity. Alert systems enable farmers to react quickly before disasters occur, including weather conditions and diseases. For long-term productivity and risk management information services, ICT does not replace work of agents but it can help add an extension to agents for better services. For example, extension agents may be very knowledgeable in their field, but may be receiving training on the latest techniques only once a year. ICT can provide extension agents access to virtual libraries and the internet to research new ideas and techniques. ICT can also help extension agents be more productive by enabling them to serve more beneficiary farmers at once. This can be done with fewer visits to the field and more interaction with beneficiaries through the ICT platform, such as via distance learning or day-to-day monitoring and advice using personal mobile phones.

Figure 7: **Global Development, 2000–2010**



Source: International Telecommunications Union's world Telecommunication/ICT indicators base 2016.

An ICT is any device, tool, or application that permits the exchange or collection of data through interaction or transmission. Development of this technology, especially mobile network, is continually increased to make useful information more widely available (Figure 7).

Roles of ICT Network in Agricultural Production

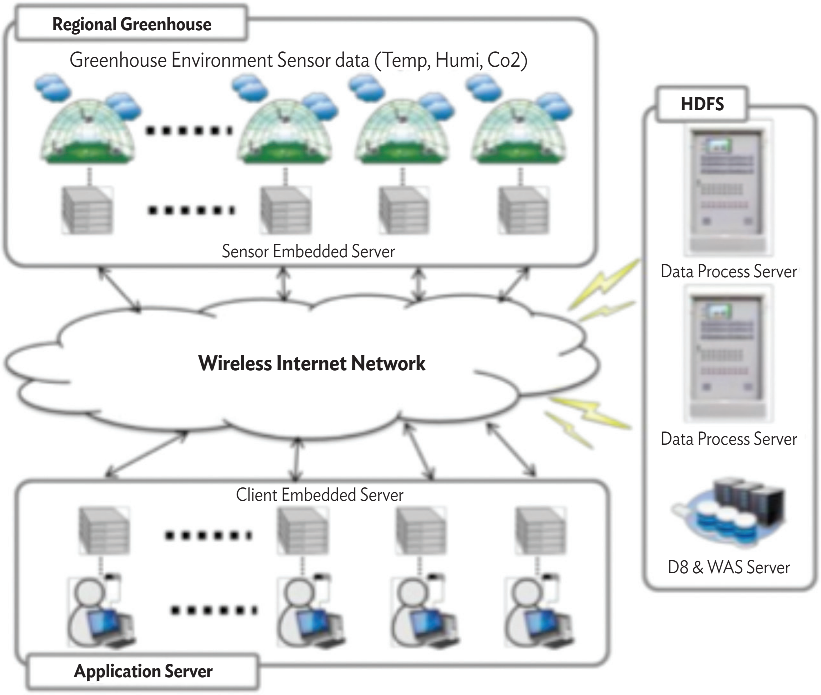
As ICT plays very important role in increasing agricultural production, priority should be given to this technology. ICT, combined with agriculture, has a big impact on productivity and can help countries against vulnerability to natural disasters, help farmers improve their productivity, and minimise risk.

Data-based Collecting System

The green environmental data consulting system to improve crop quality is presented in Figure 8. As described by Kim and Yoe (2015), the system is categorised into areas of data collecting, data saving and processing, and data analysis including visualisation.

In the data collecting area, environmental sensors gather greenhouse environmental information data that affect growth and development of greenhouse crops in each region such as temperature, humidity, illumination, carbon dioxide, etc. Collected data are managed by the embedded server and transmitted to greenhouses in each of the regions. The data saving and processing area consist of servers installed in each greenhouse, and in Hadoop Distributed File System, which stores and handles big data collected from the greenhouses in each of the regions. The data analysis and visualisation area works with a Web application that monitors a greenhouse environment in each of the regions while checking crop quality at the same time. The servers in greenhouses receive and process environment data in real time, and maximise storage and processing functions of HDFS. Environmental data from HDFS undergo separate storage and processing work. Through the Web application programme, a user is given regional environmental data information to enable him to, for example, understand proper temperatures for his crops.

Figure 8: Data Collection System



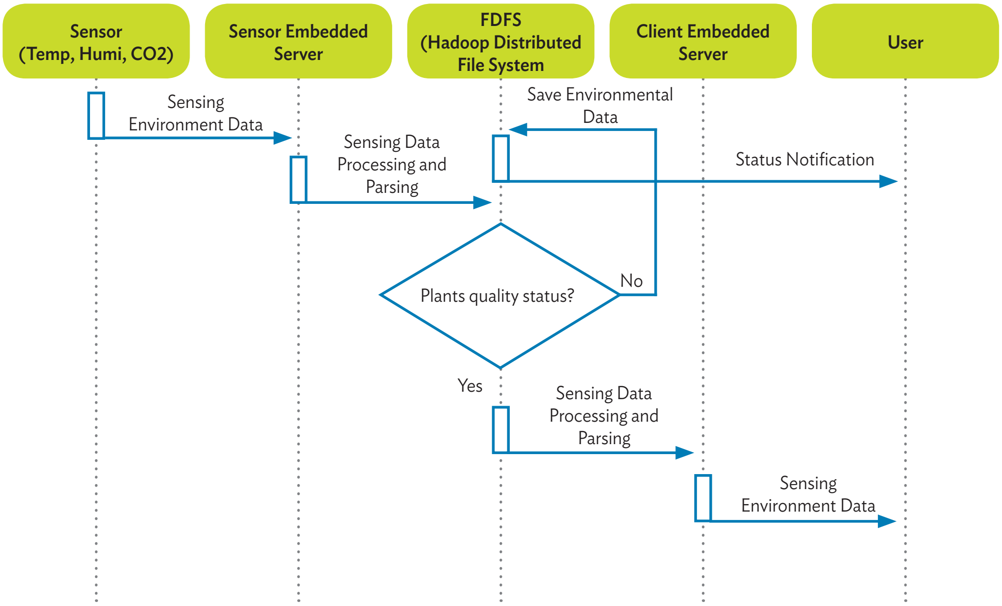
Source: Kim and Yoe, 2015.

Achieving Farming Practices

Plant factories and greenhouses are increasing in Korea due to climate changes such as unexpected heavy snow, heavy rains, and typhoons. Abnormally high and low temperatures and droughts often happen, causing shortage of food and rise in its prices. By providing suitable environmental condition, growth management can be performed using robot ICT. A plant factory using robotics produces crops of high added value in a planned way.

A flow chart of the proposed system is presented in Figure 9. Data collected by greenhouse environmental sensors are transmitted to servers in greenhouses, where they are processed before sending to HDFS. HDFS checks and analyses environmental information and conditions of crops and sends out results. When crops are in good condition as analysed, data are saved in the system. When crops look most satisfactory, the data are transmitted to a client server. The server delivers environmental data information to a user after properly processing the information to the latter's interface. The user takes care of one's greenhouse based on the transmitted data and again saves new data gathered in the greenhouse in HDFS (Kim and Yoe, 2015).

Figure 9: Flow Chart of the System Process



Source: Kim and Yoe, 2015.

Applied ICT and Smart Farm Development in Korea

The Korean smart farm project being promoted by Rural Development Administration aims to achieve optimum growth environment in horticulture and livestock production. The smart farm is an automatically controlled environment of greenhouses and animal houses using a combination of technology and information communication for agricultural management through remote control. Also, depending on the project, DEMETER would be used as climate model ensemble and to forecast seasonal climates. According to a study by the Ministry of Agriculture, Food and Rural Affairs, average production rose by 25% while production cost decreased by 27.2% after the introduction of smart farming. The ministry has vowed to invest W107.5 billion in research and development related to smart farming until 2021.

Korea aims to pursue the following technologies to reduce the vulnerability of agriculture: robot-based technology for agricultural and livestock production, state-of-the-art intelligent precision technology, eco-friendly smart plant factory technology, and integrated intelligent control system for agricultural irrigation.

Still, more innovations in technology for agriculture are urgently needed. The integration of agriculture technology is also likely to address the challenges of ageing farmers and attracting youth into the industry.

Summary

Climate change poses extreme risk to the potential of agricultural areas especially in tropical and subtropical regions. Although warming is projected to affect more areas of high latitudes than those of low latitudes, small increases of temperature in low-latitude areas may have a greater impact possibly because agriculture in these regions is already marginal. The increasing frequency of disaster events signifies climate change. In the last couple of decades, 78 natural disasters cost the agriculture sector of developing countries US$30 billion, with droughts causing the most loss and damage. Loss and damage to the food supply by disasters affect food supply chains that transform agriculture products into processed food for delivery to retailers or supermarkets.

Industrial agriculture relates to the development of technological innovations to increase productivity. Because it is seriously affected by climate change, it must seek several technologies to add efficiency such as the ICT system which plays role in overcoming losses by providing relevant and timely information and agricultural services, mapping agro-biodiversity in multiple cropping systems, forecasting disasters, and predicting yields. Yet, even if ICT plays a significant role in agricultural value chains, it has its limitations because of the high investments needed for it and the lack of experience of smallholder farms.

Discussion for Future Works

Protection from natural disaster events must consist of early warning systems through mobile devices and the Internet. It should provide detailed weather forecast for household and industrial farms. It should improve global and regional databases and information systems based on national data. The methodology for assessing impacts of natural disasters should be improved to better capture their full extent in agriculture and its subsectors, food value chains, food security, the environment, natural resources associated with the sector, and national economies. Precision is critical in formulating well-tailored policies and investments in the sector. Moreover, the agricultural disaster insurance, which functions as a risk-management tool in creating favourable farm conditions and achieving economic stability of household farms affected by natural disasters, should be revised for smart farms to reduce the high investment required.

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PART 4
KEY MESSAGES: DECREASING VULNERABILITY TO NATURAL DISASTERS OF AGRICULTURAL PRODUCTION NETWORKS AND FOOD VALUE CHAINS

László Miklós uses a landscape-based approach to improve natural resource management. Landscape includes geological substratum, soils, georelief, land cover, and man-made objects that function as water vessels similar to watershed for surface water and aquifer for underground water. Disasters affect not only single resource sectors but the whole landscape system. A territorial approach is needed to secure agricultural production as a basis of all food supply chains.

Theresia Oedl-Wieser highlights the particular role of women in agricultural production networks in the mountains. While the global average of food-insecure people in developing countries is one in eight, almost half of those living in rural mountain regions are vulnerable to hunger and face poverty and malnutrition. Mountain regions are a gendered space, which means that the living conditions, resources, power relations, and perspectives for a good livelihood are unequally distributed between men and women. Women have roles as plant gatherers, home gardeners, herbalists, informal plant breeders, and seed custodians, and help to maintain the productive value of mountain environments.

Pia Kieninger and her colleagues target improving the environmental quality and combating ecological risks in Austrian landscapes. She reports on research on the way Austrian vintners evaluate national agro-environmental programmes, underlining how such programmes are needed to alter the resilience to natural disasters by stimulating a better resource management and amending the agricultural value chain. Without such programmes, positive environmental effects would not prevail.

Meinhard Breiling investigates effects of upscaling in food supply chains and changed vulnerabilities to disasters and food security. The small-scaled, remote production units are particularly vulnerable as they often live through subsistence agriculture and are usually not or not sufficiently integrated in large agricultural production networks and food markets. The better the integration into regional or global food chains is, the higher food security and disaster resilience will be at the expense of resource consumption/depletion and enhanced climate change. Climate change and increase in resource prices in turn hit smaller food producers and local food chains more than regional and global food chains.

CHAPTER 11

INTEGRATED LANDSCAPE MANAGEMENT IN SLOVAKIA

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Introduction

Slovakia produces less than 1% of total greenhouse gas (GHG) emissions out of the total European Union (EU) amount, but the impact of climatic change affects Slovakia to the same extent as the territories of the big emitters. It is obvious then that mitigation and adaptation policies to the expected climatic changes should be more emphasised than the struggle against emissions. The base problem in relation to climate change in Slovakia's climatic belt is generally the changed unbalanced water regime, the most visible expression of which are the more often occurring sudden intensive rains and local storms. These are the procuring cause of quick surface run-offs, which cause soil erosion, silting of channels and reservoirs, flash floods on small rivers and creeks, and disturbance of the stability of slopes, which cause landslides. Beside these are other unfavourable changes in ecosystems such as overwhelming waterlogging or its opposite, draught.

Another decisive cause of these phenomena is human activity, particularly the present land cover created by land use. Since runoff takes its course through forest, agricultural, rural, and urban lands, which are under the management of different sectors, it should be axiomatic that the mitigation of consequences needs harmonisation and coordination of policies in the forestry, agriculture, water management, nature conservation, landscape protection, urbanisation, and other sectors.

However, sectoral approaches to the management of landscape and its resources strongly prevail, separately managing approaches for each component such as soil protection, water management, mineral resources utilisation, waste management, building codes, nature conservation, etc. (Breuste et al., 2009; Belaňová et al., 2014).

Theoretical-methodical background

The theoretical-methodical base for integrated approach to landscape management already exists as well as the legally supported institutional tools.

As far as management is concerned, those tools serve not only to mitigate climate change but to solve problems depending on optimal organisation and utilisation of landscape.

A crucial precondition in the implementation of the integrative approach to landscape management is the complex analysis and mutual comparison of the scientifically defined requirements of what landscape ecological/physical/biological regulative are essential to be implemented to the management tools on one side, with the legal surroundings, preconditions and provisions formulated in existing, legally supported management tools on other side.

The next sections introduce the principles of harmonisation of the landscape ecological scientific base with the legal surroundings of territory management. Since these bipartite preconditions are borne in different milieus of fully different scientific branches with different aims, methods, and practices, their harmonisation is highly difficult, long-term, and a demanding process requiring an indispensably harmonised teamwork of different specialists. The specialists working on the implementation of integrated landscape management in Slovakia (and in the former Czechoslovakia) have worked on this harmonisation since the 1970s. Accordingly, these scientific works were focused on both sides of this bipartite process as the development of a methodics appropriate for implementation of landscape ecological principles and data to the physical planning. This work issued basically the methodics of the landscape ecological planning LANDEP (in Slovak: *krajinno-ekologické plánovanie*, Ružička Miklós, 1982, 1990), which has been recommended also in Agenda 21, Chapter 10, and to the specific methodics for projecting ecological networks called territorial system of ecological stability ÚSES (in Slovak: *územný systém ekologickej stability*, Buček et al., l986; Miklós, 1996). The appropriate content of the Act on physical planning (called *územné plánovanie* or territorial planning), which issued to the creation the Act No.50/1976 Zb. on Territorial Planning and Building Order, which later allowed to implement elements of both of the above mentioned landscape-ecological methodics, in particular to the amendment numerate as Act No. 262/1992 Z.z., than to the Act No 237/2000 Z.z.

With certain amendments, these Acts remain valid. Moreover, the projection of ÚSES became part of several other Acts. Also, the basic principles of the LANDEP and ÚSES methods are still valid as they continually develop applying current knowledge and new technics such as geographical information systems, remote sensing, etc. (Kozová et al., 2007; Miklós et al., 2011; Miklós and Špinerová, 2011; and Izakovičová and Moyzeová, 2011).

The Methodical Principles

The Material Basis of Landscape Management

The material basis of integrated landscape management with the concept of landscape as a geosystem is respected in Slovakia. This concept is defined on the basis of the general system theory (Bertalanffy, 1968) as the set of components of the geosphere and their mutual relationship (e.g. Krcho, 1968; Neef et al., 1973; Demek, 1974; Preobrazhensky, 1983). This basic theory has also been elaborated for its application to the LANDEP and ÚŚES methods (Miklós and Izakovičova, 1997; Diviaková, 2010; Miklós and Špinerová, 2011; Miklós et al., 2015; Špinerová, 2010, 2015). This theory, as well as our consequently applied methods, emphasises that the basic geosystem elements the geological substratum, the soils, the georelief, the land cover, the man-made objects – are never isolated but exist in integrated form. The water regime is considered the vessel for water, i.e. the watershed for surface water and the aquifer for underground water, and is never isolated from the atmosphere and its climatic performances. As elements of geosystem acting according to natural patterns, all these are interrelated, irrespective of which sector manages them. Even if parts of the same material object are subjects to particular sectoral managements, their integrated character should be considered in all management tools (Agenda 21, 1992). All sectoral policies should therefore respect the natural patterns and the geosystem as a whole should be encompassed in the integrated management, planning, assessment, and updated concept of the evaluating ecosystem services (Nassauer, 2012; Grunnewald and Bastian (eds.), 2015). These principles have been fundamental in the development of the LANDEP and ÚSES methods.

Integrated Approach in the Management of Land Resources

Beside its practical importance, the integrated approach is a mainstream, trendy term in science as well as a favourite theme for politicians (Breuste et al. (eds.), 2009; Mizgajski and Markuszewska, (eds), 2010; Hynek, 2010; Belaňová et al., 2014). The approach is actually not new. Chapter 10 of the Agenda 21 from Rio Summit 1992 mentions only one space, one landscape that must be accepted by each sector and that all activities may find their own area in the same landscape. These activities can conflict with each other, and, therefore, an integrated approach is needed in practice. The fundamental tool of such management strategies is physical planning, which must act as a frame and basis for the plan of each sector. The integrated plan should function as a base frame outlining the optimal organisation and utilisation of a territory for all sectors (Agenda 21, 1992).

In accordance with these theses, we accept:

a) management as a ruling device, comprising the chain of activities as planning, organising, controlling;
b) integrated management is a ruling device for harmonisation of the demands of different sectors with respect to sustainable development, i.e. we do not consider as management some concrete physical actions executed, for example, in forestry, in agriculture, etc. Although they can finally lead to desired effects, they are, nevertheless, still physical sectoral actions, not management. Management is the ruling policy requiring the subjects to provide such actions (Izakovičová et al., 2007; Belaňová et al., 2014).
c) These provisions of Agenda 21 have been generally accepted and many times applied in both science and practice (Barsch et al, 1993; Langevelde, 1994; Oťaheľ, 1994; Nassauer, 2012). On other side is to state that these provisions are not fully exhausted! However, in Slovakia, these provisions have just served as the canon for the implementation of landscape-ecological principles and methods of LANDEP and ÚSES to the management tools (Ružička Miklós, 1982, Izakovičová et al., 2000).

Legal Basis of Sectoral and Integrated Planning

Different sectoral planning tools are used to manage agricultural land, forests, waters, urbanised landscape, nature conservation in standard and more or less separate ways. It can hardly be presumed that integrated management will ever become a single over-sectoral tool in real situation. It should rather be a rational process of coordinating chosen spatial planning procedures, where the final goal is the harmonisation and satisfaction of the demands of different – if possible, all – sectors towards the land resources, with respect to sustainable development. This principle was also accepted in the case of Slovakia.

This approach is not new and many good practices can be found in developed countries (e.g. Fabos, 1979; Ružička and Miklós, 1982; Haber, 1990; Barsch et al., 1993, Jongman, 1995; Breuste et al., 2009; Kolejka et al., 2011). The spatial planning tools which might be subject for integration are physical (territorial, spatial) planning, regional planning, watershed planning and management, flood management, agricultural land arrangement (land consolidation) planning, land-use planning, forestry planning, and ecological network planning. Nevertheless, their unified, harmonised spatial projection and integration remain a not fully solved problem.

One basic precondition of the desired harmonisation is the definition of integration by law. A clause from Act No. 7/2010 Z.Z. on Flood Prevention in Slovak Republic might serve as an example. Paragraph 9 (on coordination of management plans) reads as follows: '.. plan of the flood risk management and the watershed management plan shall be coordinated with the land arrangement projects, the territorial plans, the forest management plans. They altogether will constitute the tool of integrated landscape management on the whole territory of the watershed'.

The practice, however, is still not satisfactory. The results of effort towards integrated management, particularly those focused on the implementation of landscape ecological principles as provided by the legal system in Slovak Republic, are described in the next chapter.

Institutional Tools for Landscape Management and their Integration in Slovakia

During the last 30 years, Slovakia's landscape-ecological principles and methods have been implemented step by step per the existing, amended, and newly created legal tools that are appropriate for integration in landscape management. This process has been quite difficult.

The precondition for the integration of different tools to an integrated system is the elaboration and implementation of legal clauses to respective Acts, which ensure that their key provisions will be mutually recognised for synergistic cooperation. Another precondition is their correct factual-time arrangement based on their character and successive role in the integrative process. Accordingly, we rank and characterise the current landscape management tools in Slovakia as follows:

1. **The integrated spatial informational base (obviously GIS based)**
   As these tools serve as the unified information base for all kind of activities in the landscape, we consider them as the information base for integrated management of landscape. The legal basis of these tools are:
   - Act No. 3/2010 on the national infrastructure for spatial information, an adoption of Directive 2007/2/EC/EP (INSPIRE) by the Slovak legal system; and,

- The landscape-ecological base for integrated management as defined in Act No. 7/2010 on flood prevention. In this Act, the basic data on geosystem necessary for integrated landscape management are itemised.

2. **The tools as the physical base and spatial frame for all other sectoral plans**
   The very base tool for the whole integration process is territorial planning (physical planning). In fact, it plays the role of 'frame and base for all other sectoral plans' as defined in Agenda 21. This is also the tool for the transformation and transfer of the landscape-ecological data to the real executive planning tools, i.e. transporting the results produced by LANDEP and ÚSES, which are obligatory parts of the territorial planning, to other spatial planning tools. The legal basis of these tools is Act No. 50/1976 Zb. on territorial planning and building order, particularly its amended Act No. 237/2000 Z.z

   The most important provisions for integration of landscape-ecological principles to theplanning defined in the amended Act No. 237/2000 Z.z. are as follows:
   - The definition of landscape as geosystem fully in accordance with scientific definitions;
   - The definition of the properties of landscape elements as obligatory regulatives, i.e. bans, limits, allowances for the ecologically optimum organisation and utilisation of the territory;
   - The landscape-ecological planning as the obligatory result of surveys and analyses, as tool for ecologically optimum organisation and utilisation of the territory;
   - The ecologically optimum utilisation of the territory is defined as obligatory regulative;
   - The territorial system of ecological stability ÚSES , which includes the definition and localisation of biocentres, biocorridors, and interactive elements as obligatory regulative for territorial plan on regional and community level.

   Beside many other provisions, the Act also defines the obligations of other planning tools to respect the results of the territorial plans as frame and base.

3. **Executive sectoral planning and management tools**
   These traditional, generally well-functioning tools are to execute the concrete demandsof the sectors to the territory through planning and projection. The result of integrative efforts is the implementation of landscape-ecological principles and data in two ways: firstly, through the obligatory recognition of the territorial plans, which includes both LANDEP and ÚSES; secondly, through the recognition of the results of the ÚSES elaborated specially as obligatory base for these sectoral plans.

The legal bases of these tools are:

- **For nature conservation**: Act No. 543/2002 Z.z. on nature and landscape conservation, which defines the limitations of nature conservation for all sectors. Moreover, as a new proactive concept of nature conservation, the Act also defines the territorial system of ecological stability ÚSES as the system of biocentres, biocorridor, and interactive elements. ÚSES has become the obligatory part of several other sectoral planning.
- **For planning and projecting agricultural land**: Act No. 330/1991 Zb. on land arrangement and consolidation, implemented based on several new amendments, defines ÚSES as obligatory part of land arrangement and consolidation projects. ÚSES might play the role of a cause for new land arrangement project.
- **For forestry planning**: Act No. 326/2005 Z.z. on forests provides for the protection of nature and nature resources, e.g. it defines three basic groups of forests: timber productive forests, protective forests aimed mainly to protect waters and soils, and forests of distinctive determination, particularly forests in nature conservation areas.
- **For water planning and watershed management**: Act No. 364/2004 Z.z. on waters comprises a number of provisions respecting the Framework Water Directive of EP/EC 2000/60/EC. The key part of the Act concerning integrated management is watershed planning, where the cooperation of different planning tools is mandated. The landscape-ecological principles are implemented through the implementation of plans to consider ÚSES.
- **For flood protection management**: Act No. 7/2010 Z.z. on flood protection recognises flood protection as a real integrative activity requiring cooperation of all sectors. Amongst others, it defines the needed data for integrated landscape-ecological information base, the implementation of ÚSES, and integrated watershed management as the harmonisation of different planning tools. Although newer amendments have slightly changed the original wording of the Act, the basic integrative sense of the act remains.

In ideal case, these tools move the landscape-ecological and integrating principles to concrete physical territory. Moreover, the above-mentioned tools must respect the territorial plans (described above) as integrative frame and base for other plans. However, there are still problems with practical cooperation of these tools as well as with the concrete implementation of this transfer.

4. **Tools for assessment and regulation of impact on the environment**

In Slovakia, environmental impact assessment and integrated prevention and pollution control are not oriented towards direct management of landscapes but towards control and assessment of the impact of the sectoral spatial activities. We therefore consider them as important tools for regulation.

The legal bases of these tools are Act No. 245/2003 Z.z. on Integrated Prevention and Pollution Control, and Act No. 7/2010 Z.z. on Environmental Impact Assesment (E.I.A.) and Strategic Environmental Assessment (S.E.A.), both as amended.

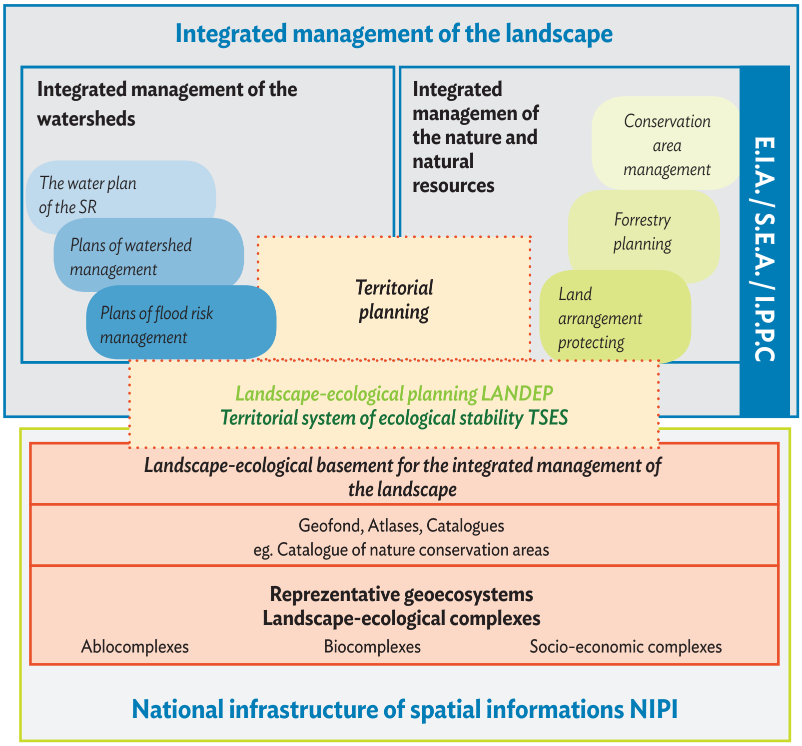
One of the key landscape-ecological elements of these tools is the obligatory consideration of ÚSES.

The logical sequence of those tools – from informational base, through physical frame and execution up to assessment and control – is crucial for their integration. An ideal scheme of such sequence is shown in Figure 1. The key elements in realising integrative approach to landscape management, i.e. the integration of the sectoral planning procedures, are:

- An integrated GIS-based spatial (not sectoral!) information system;
- Landscape-ecological planning for transfer of landscape ecological principles and data to other planning processes as tool for ecologically optimum organisation and utilisation of the territory;
- A spatial (territorial, physical (not sectoral!) planning as a legal, obligatory frame for each sectoral plan, as stated in the provisions of Agenda 21;
- Sectoral planning respecting the results of over-sectoral spatial (physical, territorial plans).

In Slovakia, the key integrative ecological element is the territorial system of ecological stability ÚSES defined by law. ÚSES is determined as obligatory in the above-described management tools.

Figure 1: Relations of the Tools for Integrated Landscape Management in Slovakia



Source: Authors.

Conclusion: Problems of Implementation

As described, the methodical and the legal bases of the integrated management of landscapes in Slovakia are at quite proper level. Nevertheless, the integrative principles in practice is not yet satisfactory because of problems of different character. In terms of methods, the concept of integration is variously understood by different sectors and rarely as real integrative decision-making on optimal subdivision of the whole landscape for each sector.

The danger of simplification, formalisation, and over-politicisation of the approach should be avoided as this can weaken and flatten the professional consideration of the geo-system concept as material base. Therefore, the need to enhance trade-offs among sciences, policies, and sectors is obvious. Likewise, this needs changes in education. Integrated management is not one single topic of study but a systematically organised set of topics that requires a balance between scientific (geographical and biological disciplines, landscape ecology, environmental disciplines), technical (industrial, agricultural, forestry, construction knowledge), as well as social science topics (law, economics, management).

The other problem is the lack of political will for integration. Publicly, nobody objects to integration. However, resistance of the sectors to be integrated under any trans-sectoral planning prevails. Also, the aversion to accept nature and landscape limitations as obligatory regulations still exists. Sectors, companies, communal authorities, and other interest groups consider integration only if it offers (short-term) profits.

Nevertheless, new real landscape situations, particularly climatic change, will increase pressure on natural resources, which will increase competition among sectors in the landscape. Therefore, the demand towards implementation of integrated approaches will increase and, consequently, the implementation of different integrative approaches will develop in the near future.

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CHAPTER 12

WOMEN AS DRIVERS FOR A SUSTAINABLE AND SOCIALLY INCLUSIVE DEVELOPMENT IN MOUNTAIN REGIONS – THE CASE OF THE AUSTRIAN ALPS

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Introduction

To a large portion of the world's population, mountain regions provide indispensable goods and services like fresh water, hydropower, preservation of biodiversity including agro-biodiversity, disaster risk reduction, and space for recreation and tourism. Mountain regions cover 22% of the world's land surface and are home to more than 900 million people, representing 13% of the global population (FAO, 2015a). By providing key environmental services and amenities, mountain ecosystems play a decisive role in the world's development. The resilience of mountain regions, however, has declined due to the negative impacts of changes in land use and to climate change such as land and forest degradation, as well as the increasing number of natural disasters (FAO, 2015b). Furthermore, market integration, extended tourism activities, and changes in human lifestyle patterns and aspirations have accelerated these developments.

The need to preserve mountain environmental assets and to improve local livelihoods was clearly expressed in Chapter 13 of the United Nations Conference on Environment and Development's Agenda 21 in Rio de Janeiro (UN, 1992):

Mountain ecosystems are, however, rapidly changing. They are susceptible to accelerated soil erosion, landslides and rapid loss of habitat and genetic diversity. On the human side, there is widespread poverty among mountain inhabitants and loss of indigenous knowledge. As a result, most global mountain areas are experiencing environmental degradation. Hence, the proper management of mountain resources and socio-economic development of the people deserves immediate action.

The attention given by international forums to sustainable development of mountain regions has increased significantly since the 1990s. For instance, the Alpine Convention, an international treaty between Alpine countries and the European Union (EU), was founded in 1991 to support sustainable development and the protection of the Alps (Alpine Convention, 1991). This is beside other agreements like the Andean Community (1969), the Carpathian Convention (2003), or initiatives in the Balkans and Dinaric Arc and in the Caucasus Mountains (Church, 2010; Hugill, 2012). Many other international documents, like 'The Future We Want' (UN, 2012) or 'Agenda 2030 for Sustainable Development' (UN, 2015), state that sustainable mountain development has to be a global priority.

Besides the increasing natural hazards and disasters, additional risks like inequitable land rights, low accessibility, resource grabs, dire poverty, and starvation are affecting a vast extent of people and livelihoods in mountain regions (Wehrli, 2014). Almost 40% of the mountain population – urban and rural – in less developed countries (LDCs) are considered vulnerable to food insecurity. The numbers are even more shocking if only mountain people are regarded as those who live in rural areas. While the global average of people with food insecurity in LDCs is one in eight, almost half of those who live in rural mountain regions of LDCs are vulnerable to hunger and face poverty and malnutrition (FAO, 2015a).

Mountain regions must also be seen as a gendered space, which means that the living conditions, resources, power relations, and perspectives for a good livelihood are unequally distributed between men and women. A gender analysis in this context involves the critical examination of taken-for-granted assumptions about living conditions and development. Beside the given context that mountain regions are inaccessible, isolated, and remote – as many scholars stress in their research – a gender-analytical critique will challenge these assumptions and examine the manifold powerful discriminatory practices, discourses, and norms that work against women in particular (Verma, 2014). The structural discrimination of women in many mountain regions is caused by patriarchal societies, social and cultural norms, and difficult economic situations. Therefore, gender discrimination, gender exploitation, and disenfranchisement of women persist. Feminist research revealed that gender relations play a critical role in the management of natural resources, and that women tend to be systematically disadvantaged in terms of access to resources, decision-making, and ultimately, power relations (Molden et al, 2014), although they bear the burden of a substantial part of the productive work and most of the reproductive work.

Manifold legal, normative, and economic arguments underline the importance of gender issues and of women's involvement in the development of mountain regions (Oedl-

Wieser, 2015a). Firstly, it is simply a democratic principle that women who represent more than half of the rural population are represented adequately in the political decision-making bodies in the regions (descriptive representation). Gender equality is widely endorsed as a central policy goal by governments and international organisations across the world. It is increasingly framed as central to the realisation of modernisation and economic efficiency (Squires, 2007). Secondly, from a feminist perspective, it is necessary that the needs and interests of women find their expression in development programmes and measures (substantive representation). There is often great scepticism of stakeholders regarding the possibility and necessity of linking gender equality issues to measures and projects in mountain development processes. The missing gender awareness and gender competence as well as individual and institutional resistance may prevent an effective implementation of gender equality. Thirdly, it is a far-reaching loss for mountain development discourses and processes if the manifold potential, knowledge, and expertise of women are not utilised. Fourthly, enhancing the discourse about gender equality in mountain regions can raise the people's awareness of women's potentials and problems and can help transform conservative views in gender role models.

A study by Food and Agriculture Organization (2011) revealed that if women in agriculture would have the same amount of land and same access to productive resources as men have, they could increase yields on their farms by 20%–30% and the production gains of this magnitude could reduce the number of hungry people in the world by 12%–17%. If women control additional income, they spend more of it on food, health, education, and clothing for their children than men do. This has positive implications for immediate well-being as well as long-lasting human capital formation and economic growth.

The relevance of rural women in the reproductive and productive sphere of agriculture, their knowledge of the value and use of local plant and animal resources for nutrition, and their role in preserving agro-biodiversity have been highlighted and appreciated in many international documents like CEDAW Article 14, Agenda 21, Rio+20, and Agenda 2030 (UN, 1979, 1992, 2012, 2015).

Despite the acknowledgment of women's contribution to agricultural production, climate change adaptation, and ensuring sustainable livelihoods and environments in mountain regions, there are hardly cross-references made in international documents between women's agenda and mountain regions development. This can be demonstrated very well when looking at the Rio+20 document-outcome entitled 'The future we want' (UN, 2012). The mountain issue is treated in paragraphs 210–212 and the issues of gender equality and women's empowerment are discussed in paragraphs 236–244, but there is almost no linkage between these issues.

Regarding the decisive role of women in mountain regions, it seems curious that there is no reference to the critical importance of this inter-relationship. In this context, Verma et al. (2014) stress a bigger problem: the gender blindness of most research on natural resource management, sustainable mountain development, and gender relations in decision-making bodies. From a feminist point of view, it is necessary to highlight the needs and achievements of mountain women so that these are reflected and integrated in public policy and in decision-making agendas (Zimmermann, 2002; Schmitt, 2014; Anand and Josse, 2002; Oedl-Wieser, 2014).

On account of the glaring disadvantages of women living and working in mountain regions and their valuable knowledge and agency, this paper outlines their role as drivers for sustainable and social inclusive development in mountain regions. After an introduction, the relevance of mountain farming will be discussed in general to address the negative impact of climate change on men and women in mountain regions. This will be followed by highlighting the decisive contribution of women in mountain farming in the Austrian Alps in the field of pluriactivity and (social) innovations. The conclusion emphasises both the vital role that women are playing in the economic, social, and ecological sphere of mountain regions and the need for more appreciation of their manifold activities and efforts for a sustainable and social inclusive mountain development.

Negative Impact of Climate Change on Mountain Farming

Over the centuries, mountain people have developed unique, resilient, and sustainable production systems adapted to their local environments, which favour the production of niche and mountain-specific products and services (FAO, 2015a, b). Mountain regions and their population are disproportionally affected by climate change and its various impacts on nature and socio-economic development which are increasing natural disasters, food and energy crises, water scarcity and desertification, as well as loss of biodiversity, degradation of ecosystems, out-migration, and the growth of urban areas (FAO, 2011). Furthermore, human pressure is constantly rising in mountain regions all over the world through changes in land use, intensification of agricultural production, and growing conflicts of interest within industry, tourism, transport infrastructure, settlements, and ecosystems (Euromontana, 2016; Oedl-Wieser and Schmitt, 2017).

For instance, the European Alpine region is expected to be considerably affected by global warming in the 21st century. This refers not only to rising temperatures (+2°C), but also to changes in the seasonal cycle of precipitation, global radiation, and humidity, to changes in temperature and precipitation extremes, and closely related impacts like floods, droughts, snow cover (drastically decreased below 1,500 m–2,000 m), and natural hazards such as floods, debris flows, landslides, and rockfalls associated, amongst others, with glacier and permafrost retreat. This change in climatic parameters and related quantities will have a considerable impact on ecosystems, agricultural production, and Alpine societies, and will challenge their resilience (Gobiet et al., 2014).

Through the provision of positive externalities, mountain farming contributes to maintaining settlement structure and shaping cultural landscapes in areas which otherwise would lose significant parts of their development potential (Dax, 2009). However, mountain farming has also negative externalities like land-use change, increased concentration of milk production in the mountain valleys, abandonment of alpine pastures, and afforestation which are caused by intensification of agricultural production and increased competition (Oedl-Wieser and Schmitt, 2017). Mountain farming is largely family farming which encompasses all the activities within the realms of agriculture, forestry, fisheries, pastoralism, and aquaculture that are predominantly reliant on family labour. All over the world, mountain regions with their dispersed patches of usable land at different altitudes with different climates and with often highly fragmented landscapes as well as narrow limits for mechanisation are most efficiently and effectively managed by family farms (FAO, 2013; Hovorka and Dax, 2009).

While mountain farms in LDCs are producing mainly for family consumption, mountain farms in Europe are increasingly determined by policies that emphasise, to a larger extent, the role of landscape preservation. Furthermore, agriculture is often not the only economic activity anymore because the family is performing a wide range of activities on and off their farms that go far beyond food provision (Dax, 2009). As most of agricultural production in mountain regions in LDCs is subsistence production, it plays a key role in ensuring household food security and avoiding malnutrition and starvation.

Worldwide, the demand for high-quality traditional food and crafts produced in mountain areas such as coffee, cheese, herbs, and spices as well as handicrafts and medicines, is on the rise. Small-scale mountain agriculture cannot compete with lowland production, but it has the potential to tap into niche markets such as organic, fair trade, or high-end quality ones, and fetch premium prices (FAO, 2015). The contribution of family farming to sustainable development in mountains thus differs a great deal from continent to continent, from region to region, but commonalities can be seen in that family farms in mountains help to shape mountain landscapes and provide ecosystem services which are vital for development far beyond mountain areas (Hurni et al., 2014; FAO, 2013).

Women and their Role in Ensuring Sustainable Livelihoods in Mountain Regions

All over the world, scholars and stakeholders in politics do not give enough attention to the production of food crops for domestic consumption, which is essential for household food security and environmental protection. The main focus is often on the intensive farming sector and export-oriented crops. In spite of this, analyses reveal that small-scale farmers, particularly women, play a key role in promoting sustainable methods of farming based on traditional knowledge and practices. Women often have knowledge about the value and use of local plant and animal resources for nutrition. They try to find strategies to adapt to the impact of climate change in their roles as plant gatherers, home gardeners, herbalists, informal plant breeders, and seed custodians. In many cases, they experiment with and acclimatise indigenous species and thus often become experts in plant genetic resources (IAASTD, 2009).

In general, the gendered division of labour in agriculture influences the way resources are used and where the benefits of these resources flow. Men's and women's different roles in family, on the farm, and in the community in terms of labour, property rights, and decision-making processes generate different knowledge and skills in relation to agriculture, biodiversity, and ecosystems. Besides caring for the family, women farmers perform tasks such as planting, transplanting, hand weeding, harvesting, picking fruits and vegetables, small livestock rearing, and postharvest operations such as threshing, seed selection, and storage. On the other hand, mechanised work such as land preparation, irrigation, mechanical harvesting, and marketing is generally a male task. This may increase women's and girls' manual and time burden, which tends to keep girls out of school, and holds their productivity below their potential (IAASTD, 2009).

It must be taken into consideration that the status of farm women in mountain regions varies enormously, even within a region (Anand and Josse, 2002). In many contexts, cultural and legal conditions are hindering women from strengthening their agency like patrilineal inheritance systems, restrictions for women to own property, or women's ability to move freely, which also limit their chances to survive natural disasters. Although awareness of mountain farming and the difficult living and production conditions have been growing in international development discourse, the problems seem to get worse in view of global economic and social change. Even in the most remote places, these changes have eroded traditional mountain livelihoods, changed gender roles, led to a loss of crucial local knowledge, and driven many mountain inhabitants to migrate to lowland areas and urban centres in search of employment and income (Wehrli, 2014).

The growing out-migration of men and young adults has increased the number of female-headed households in many mountain regions. It has also shifted the mean ages of rural populations upwards, resulting in considerable shrinkages in rural labour force. Extended workload, lack of knowledge about agricultural production schemes, and increasing responsibilities are in many cases causing an overburdening of mountain women, which leads to negative effects in food security and service provision (IAASTD, 2009; Anand and Josse, 2002; Molden et al., 2014). Considering the manifold challenges of farming and good livelihoods in mountain regions, it seems that sustainable and social inclusive mountain development issues do not receive the attention and priority they deserve in international discourse. To address the current challenges, it needs to support the economic, ecological, social, and cultural aspects of mountain environment and society.

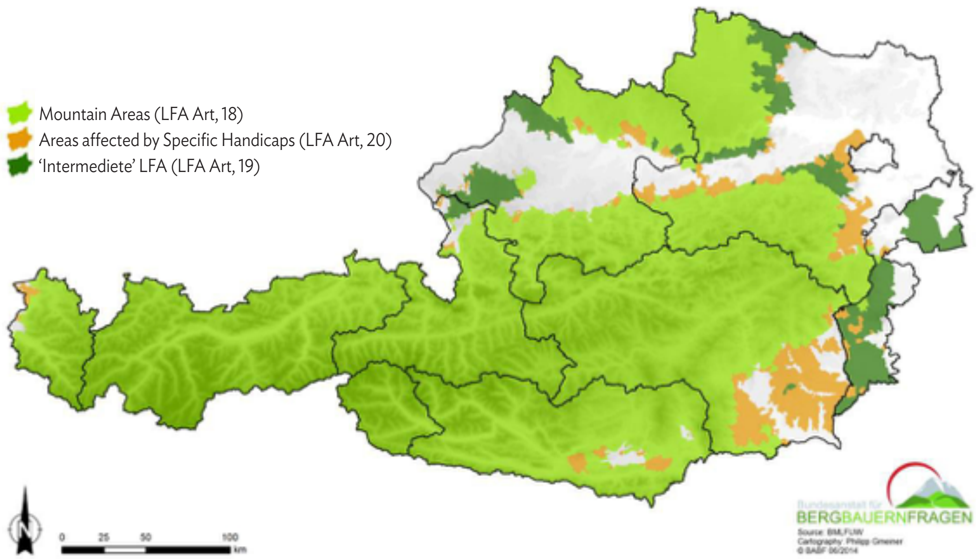
Despite some progress made in national and international policies since the first World Conference on Women in 1975, intensified efforts and actions are necessary to implement gender equality as integral in agricultural policies and practices as well as mountain development processes. Therefore, it is necessary to look at women's access to education, information, and technology, and to enable improvement of women's access to ownership and control of economic and natural resources. Analyses and experiences show that enhancing the role of women in adaptation and disasters risk reduction will lead to more resilient mountain regions (Verma et al., 2014; StartClim, 2013). It is decisive that adaptation programmes in food security and managing natural resources are gender-sensitive and responsive to the different and multiple roles women and men play in various spheres of natural resource management, as well as their households, communities, livelihoods, and customary and statutory institutions and relations at local, national, regional, and global levels (Mountain Partnership s.a.).

Women's Role in Agriculture in Mountainous Areas – The Case of the Austrian Alps

The Alps are a coherent mountain region covering 190,568 sq km across eight European countries, with a population of 14 million people. This mountain range disposes of rich heritage of cultures, traditions, place-based know-how, and shows manifold economic activities. The Alps provide goods and services like water, hydroelectricity, cultural landscape, agricultural products, handicrafts, recreation sites, and are a hotspot of biodiversity, with many endemic species (Mountain Partnership, 2012). Mountain farming plays an important role in maintaining attractive landscapes, although agricultural production is often very challenging through small-scaled structures, natural obstacles, less possibilities of mechanisation, poor accessibility, and limited production alternatives.

Austria is characterised by a high proportion of less-favoured regions mostly classified as mountain regions. The mountain regions comprise 70% of the Austrian territory (see Figure 1) and 58% of the utilised agricultural area. The area of permanent settlement in the mountain regions is also very limited. Mountain farms are characterised rather by a small-scaled structure, with a high proportion of part-time farming and are operated primarily by family labour input. In terms of local food production, environmental impacts, and threats of land abandonment and natural hazards, multifunctional mountain farming has been discussed as a subject of major national concern since the 1970s (Dax, 2009). Since that time, mountain farming support was conceived as one of the main instruments of structural policy in Austria aimed at the prevention of land abandonment, to preservation of the farming population and maintenance of cultural landscapes. Multifunctional mountain farming is also an important basis for tourism since many regions in the Alps are winter tourism hot spots (Hovorka and Dax, 2009).

Figure 1: **Mountain Areas in Austria**

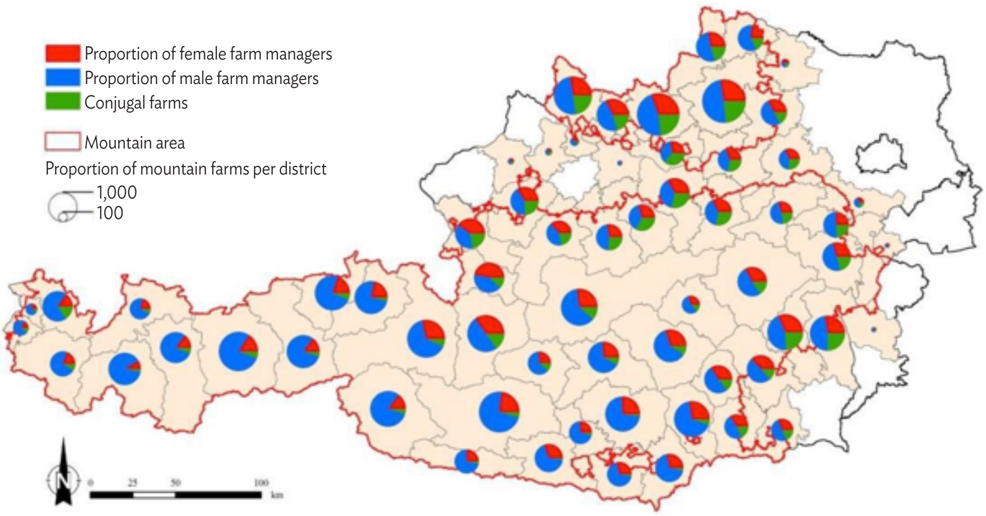


Source: BNLFUW.

Farming in the Austrian Alps has a long tradition and there exists a lot of tacit knowledge of processing milk and meat, especially on alpine pastures. Therefore, the management of alpine pastures, which represent extremely sensitive ecosystems, is of great importance in the multifunctional context. This is not only relevant for tourism development but also significant from the point of view of society as a whole as maintaining biodiversity, protection against natural hazard, issues of nature protection, and general environmental performance are the main aspects of social demand (Groier, 2011; Oedl-Wieser, 2007). Despite these manifold effects for society, one has to consider that there are many threats against mountain farming caused by winter tourism, urbanisation trends in mountain valleys, and, often, unlimited infrastructural developments.

Mountain farming is by its nature multifunctional. The concept of multifunctionality recognises agriculture as an activity producing not only commodities like food, feed, timber, agro-fuels, medicinal, or ornamental plants, but also non-commodity outputs such as environmental services, landscape amenities, and cultural heritage (IAASTD, 2009). Through the provision of positive externalities, mountain farming contributes to maintaining settlement structure and shaping the cultural landscapes in areas which otherwise would lose significant parts of their development potentials. Thus, the support for mountain farming is core for the positive direct and indirect effects in safeguarding sensitive ecosystems and maintaining multifunctional landscapes in mountain regions and prevention against threats of land abandonment and marginalisation processes.

Figure 2: Farm Management in Mountain Areas in Austria, by Gender and Conjugal Farms



Source: BMLFUW, 2016.

The mountain regions in Austria are characterised by high environmental quality, large forests, and environment-friendly agriculture; 24% of the mountain farms are organic farms (BABF, 2016). Many initiatives have been established in the last 20 years which combine organic production and regional marketing like *Bio vom Berg* (Organic productions from the mountains) in Tyrol or *Zurück zum Ursprung* (Back to the origins) in Styria. Most of the farms in Austrian mountain regions are pluriactive, meaning that in addition to agricultural activities, off-farm work, and other activities such as food processing and marketing, agri-tourism (85% of the agritourist farms are located in mountain regions), farm pedagogics, green care, and machinery ring services, handicrafts, and energy generation are carried out by family farm household members.

In particular, these activities are oriented towards an increased value added through the strategy of high-quality mountain products. In times of diversification and tertiarisation, women are often the engine for the development of new, innovative, and sustainable modes of production and activities on farms (Oedl-Wieser and Wiesinger, 2010; Schmitt, 2010). In Austria, 30% of mountain farms are managed by female farmers, as shown in Figure 2 (BMLFUW, 2016).

Farm women's contribution is essential both for the agricultural sector and for the development of rural regions in general, and particularly for mountain regions. On the one hand, farm women are involved in all spheres of work on the farm: productive and reproductive (housework, child care, and elderly care) and, on the other hand, are contributing to family income as well as to civil society and social life in rural areas through their manifold activities. Despite this important contribution of women, it is astonishing how underestimated and weakly appreciated this involvement is in the agricultural decision-making bodies and in the political sphere in general (Oedl-Wieser, 2014). Furthermore, farm women and women in mountain regions possess much knowledge about traditional food processing and cultivation of old local seeds of cereals and vegetables (Oedl-Wieser and Schmitt, 2017; Oedl-Wieser, 2015b).

The prevailing responsibility of women in Austria for private unpaid care and household work (traditional gender roles are still widespread) makes them very influential players in the food system both as care suppliers and consumers. They have to decide every day which kind of food to buy and to cook. Analyses show that women are more aware about carbon footprints, the impacts of global food chains, or animal welfare issues than men, and that they have more sustainable dietary habits. Although women's food provisioning endorses their subordinate gender role, it also tightens family ties and maintains cultural traditions that are at the heart of many women's identity (Allen and Sachs, 2007; Oedl-Wieser and Wiesinger, 2010).

Considering the role of women as producers of food in mountain regions, one can say that they possess rich traditional knowledge about the processing of high-quality food products, and that women are often the driving force for a sustainable or organic way of production. Local food in mountain regions is very often related to specific and unique raw material characteristics as well as traditional and locally adapted technologies of production and processing (Schermer, 2010). In Austria, on 41% of farms involved in professional direct marketing, the farm woman is the responsible person for this branch. The increasing consumers' demand for regionally produced food meets with alternative marketing networks like farm shops, farmer markets, direct delivery, or mail order schemes (Blasi et al., 2015; Kupiec-Teahana et al., 2010).

Farm women are often regarded to be more able to bring in new incentives to the agricultural system as they have a propensity for innovation and are successful in quickly adapting their offer to the market demand (Zirham and Palomba, 2016; Farnworth and Hutchings, 2009; Oedl-Wieser and Wiesinger, 2010). Farm women are often combining their on- and off-farm expertise to develop new activities on the farm. The following examples from mountain regions in Austria show that women have followed innovative ways in establishing new branches on the farms and are revitalising old knowledge and contributing to biodiversity in their mountain region.

Examples for Diversification

Case: 'School on the Mountain – Kalchkendlalm' (Rauris, Salzburg)

The Kalchkendlalm is located in Rauris Valley in the Pongau district of Salzburg and is an old cultural site. Some parts of the building are more than 400 years old. In 1996, the old buildings on the Alpine pasture were restored and the female farmers offered bread baking and milk processing courses. Furthermore, this alpine hut is the venue for reading events and writing courses with authors as well as for seminars and symposia. Many courses are visited by school classes from the region. The aim of these activities is to revive the culture of the farmers and farm women of the region and make it understandable and tangible for the visitors[1].

Case: 'Good fruits – fruit gardens' (Absam, Heiligkreuz, and Raitis in Tyrol)

The fruit gardens in Absam, Heiligkreuz, and Raitis lie in Tyrol about 900 m above sea level and are cultivated organically. Some trees in the orchards are nearly 100 years old. A short time ago, the fruit gardens were taken over by a woman who now processes the fruits to products such as juices, jams, or chutneys, which she sells in a local shop for organic products which she co-founded with other farmers. In the medium term, both the fruit gardens and the shop will be managed according to the concept of community-supported agriculture. In general, in the case of community-supported agriculture, several private households partly bear the costs of a farm, for which they receive products from the farm all over the year or products for a lower price[2].

1 (http://www.schule-am-berg.at/)
2 (http://www.gutefruecht.at/)

Examples for Preserving Biodiversity

Case: 'Lungauer Arche' (Lungau, Salzburg)

The association Lungauer Arche was founded in 2010 by a group of female farmers in the district of Lungau, together with farmers who were interested in local varieties of crops, vegetables, and herbs. They wanted to preserve and share the traditional knowledge in the mountain region. Within this association, different activities were established: Herbal Region Lungau, Slow Food Lungau Travel, preservation of the traditional and local breed Lungauer Winter Rye, etc. Female farm women offer herbal walking tours and courses on milk processing on an alpine pasture and bread baking[3].

Case: 'Alchemilla herb women' (Großes Walsertal, Vorarlberg)

The 'Alchemilla herb women' is a group located in the Biosphere Reserve Großes Walsertal which aims to bring to the fore the hidden knowledge of farmers and farm women about alpine herbs. Over the past centuries, through sustainable agricultural practices and careful treatment, a big variety of herbs have developed in the alpine valley Großes Walsertal. The Alchemilla herb women are processing herbs to products like tea, sweets, herbal syrup, and body care products. They want to share their knowledge about the alpine herbs with other people and make it tangible for visitors. Therefore, they offer different herb walking tours in the Biosphere Reserve Großes Walsertal[4].

Case: 'Male and female mountain farmers are observing biodiversity'

The project *Schau ma auf der Alm* (Mountain farmers are observing biodiversity) started in 2014 and currently has 45 participants. During the vegetation period, the male and female mountain farmers document the development of selected indicator species, learn more about the relationships between land-use management and biodiversity, and thus become experts in their own alpine meadows and pastures. The main goal of this educational measure is to strengthen the awareness and understanding of biodiversity in alpine pastures. They are also guided to share their acquired knowledge to interested visitors in a comprehensible and memorable way. The purpose is to promote awareness of the peculiarity of the mountain landscape and the importance of alpine farming[5].

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[3] (http://www.tauernroggen.at/de/home.html)
[4] (http://www.grosseswalsertal.at/Alchemilla/)
[5] (http://alm.biodiversitaetsmonitoring.at/)

Case: ‘Preservation and breeding of old farm animals in the mountain area’ – Pfauenziege (Rauris Salzburg)

For many centuries, farmers and farm women have produced a big variety of breeds of farm animals in mountain regions through continuous selection. Considering the natural and climatic conditions carefully, races adapted for the mountains like the Pfauenziege (peacock goat) were bred. However, structural change and intensification processes in agriculture have led to a massive loss of racial diversity. For more than 20 years now, a female breeder from Rauris in Salzburg has been making great efforts for the conservation and breeding of peacock goats. As good feed converters with modest feed requirements, this breed offers the best prerequisites for landscape care in the mountain regions. Because of its pronounced maternal instincts, it is also very well suited for mother goat keeping. However, structural changes and intensification processes in agriculture have led to a massive decline in the stock. The female breeder has set herself the goal of preserving and breeding peacock goats, searching all over Austria for phenotypically similar peacock goats to re-establish a purebred stock[6].

These examples indicate that farm women in mountain regions are contributing in various ways to agro-biodiversity, producer–consumer alliances, civil engagement, and maintenance of traditional agricultural techniques in the Alps. They are drivers for sustainable and social inclusive forms of agriculture in the ecologically very sensitive mountain regions, and provide social spaces for exchange of (old) knowledge and experiences.

Conclusions

Women living in mountain regions of the world are facing structural discrimination caused by patriarchal traditions, customary laws, and strongly gendered social organisation. They mostly lack control over productive resources and are exposed to unfavourable conditions for agricultural production and difficult economic situations. Considering the many challenges of farming and good livelihoods in mountain regions, it seems that sustainable and social inclusive mountain development issues do not receive the attention and priority it deserves in the international discourse. Apart from gendered structural inequalities, vulnerability, and invisibility of women, it must be stressed that women in mountain regions are not only passive victims but also own quite a lot of valuable knowledge and agency.

6 (http://www.arche-austria.at/index.php?id=111)

Gender analysis is a valuable tool for visualising the disadvantaged situation but also the potentials of women in mountain regions. Scholars should pay more attention to women's role in sustainable mountain farming, to their contribution to rural food supply chains, and to their part in climate change adaptation as well as disaster management. A sustainable and social inclusive mountain development is only possible through the utilisation of far-reaching productive and social competences as well as valuable knowledge of mountain women. Further research is urgently needed in mountain regions all over the world to explore the specific cultural and environmental characteristics and analyse gender roles and gender relations, which are often inequitable and detrimental to women.

A more dynamic development of mountain regions can be fostered by acknowledging, appreciating, and understanding the vital role of women in the economic, social, and ecological sphere. It is necessary to take a look at their resilience, strength, and power which are an enormous potential for mountain regions. Experiences have shown that efforts of policy interventions often do not address the local realities of women and men and are therefore inappropriate in improving their situation. If sustainable and social inclusive mountain development should be intensified through policy intervention, it needs to identify innovative strategies which build on women's and men's experiences and knowledge. Furthermore, it is important to find a common language and an approach to promote awareness and action for gender equality in mountain regions.

After decades of limited progress towards a higher appreciation of the role of women in mountain regions, it is necessary to push initiatives to support committed actors and women networks. Learning more of the status and the role of mountain women in different countries and regions is decisive in furthering support for women as potential agents of change and letting their strengths, vulnerability, and progress be seen by the world. Several factors are required to ensure that women will be an integral part of sustainable mountain and social inclusive development in the future: more mountain-specific and local research through gender lens, tailored trainings, and awareness raising for women's own potentials; support to women's access and control of resources; assistance with entrepreneurship; information and raising awareness of the rights of women; and finally, networking amongst mountain women all over the world. Furthermore, funding initiatives should be provided by transnational (UN organisations, the EU), national, and regional authorities. Civil society organisations that are active on mountain regions (e.g. CIPRA, CONDENSAN) should also pay greater attention to women's issues in mountain regions. As often experienced, transformation in gender power relations in mountain regions is a rather difficult task because gender equality processes are inherently political and demanding. Due to these circumstances, it is necessary that mountain women's issues and needs are reflected and integrated to a larger extent in research, public policy, and worldwide decision-making agendas. Since the turn of the century, there were several conferences on women's issues in mountain regions like the Bhutan Conferences (2002, 2012),[7] Utah Conferences (2007, 2011, 2015),[8] and an Alpine Convention Conference (2017)[9] organised under the Austrian presidency. In the adopted declarations of these conferences, the status quo and the urgent need to improve the situation of women in mountain regions all over the world are clearly expressed. However, it needs the strong commitment of transnational, national, and regional authorities and organisations to enhance the situation of mountain women and the livelihood of their families.

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CHAPTER 13

MOTIVATION CROWDING AND ECOLOGICAL RISKS IN VINEYARDS – THE CASE OF THE AUSTRIAN AGRI-ENVIRONMENTAL SCHEME ÖPUL

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Introduction

Agriculture has an impact on a wide range of ecosystem services and climate change, while it is also considered as the economic sector most affected by climate change and natural disasters (Environment Agency Austria, s.a.; Longbottom and Petrie, 2015; Riegler and Hinterberger, 2010; Soja et al., 2010). This also holds true for viticulture, which is affected by risks and disadvantages arising from late frosts in spring; extreme weather events such as storms, heavy or few rainfalls, hail, higher temperatures (Bonada and Sadras, 2015), and, in general, a wider climate variability resulting in loss of quality, erosion (Prosdocimi et al., 2016; Vršič et al., 2011), grape rot, or other crop failures (Environment Agency Austria, s.a.). Vines depend on comparatively high rates of fertiliser, plant protection application, and intensive management activities such as tillage or pruning. These interventions, in turn, can affect environmental quality and vulnerability to natural disasters (e.g. Coulouma et al., 2006; Guidoni et al., 2012; Kieninger and Winter, 2014; Longbottom and Petrie, 2015; Riegler and Hinterberger, 2010; Sharley et al., 2008; Soja et al., 2010; Viers et al., 2013).

Since the late 1980s (European Commission, s.a.), conditional payments such as agri-environmental schemes (AES) and other payments for ecosystem services have been providing monetary incentives for land users to adopt more environment-friendly practices to improve the quality of the environment and to combat ecological risks in the European Union (EU).Complementing legal restrictions, education and awareness raising, zoning, and other policies constitute an important component of a bundle of diverse risk governance strategies. The Austrian variant of AES called ÖPUL (Austrian programme for an environment-friendly agriculture – Österreichische Programm für umweltgerechte Landwirtschaft) has been implemented since 1995. It is one example of a European AES covering objectives such as the promotion of land use and farming practices that improve the quality of the environment, reduce greenhouse gas emissions, maintain landscape quality, and implement environmental and nature conservation policies at the national and provincial levels (BMLFUW, 2016). Viticulture has also been targeted by ÖPUL as response to increased carbon emissions (e.g. Longbottom and Petrie, 2015; Soja et al., 2010), dropping ecosystem services (Riegler and Hinterberger, 2010), carbon sinks (Brunori et al., 2016), increased use of pesticides (Renaud-Gentié et al., 2014) and fertilisers, soil degradation (Bazzoffi et al., 2006), and erosion, as well as an increasing vulnerability to natural disasters (Coulouma et al., 2006; Guidoni et al., 2012; Riegler and Hinterberger, 2010; Sharley et al,. 2008; Viers et al., 2013).

Numerous initiatives across the world illustrate the importance of enhancing environmental quality in vineyards. Vintners in Champagne, France, experiment with pheromone traps to reduce the amount of insecticides. In the Bottwarttal valley in Germany, the pilot study W.E.I.N for sustainable viticulture dates back to 2000 and, inter alia, experiments with replacing chemical pesticides, improving soil fertility, and reducing erosion through greening and using alternative cultivation methods. The Biodiversity and Wine Initiative in South Africa, in cooperation with the World Wildlife Fund, has, since 2004, been supporting the improvement of biodiversity (plants and species) through the implementation of voluntary environmental management plans (Riegler and Hinterberger, 2010). Other examples include Sustainable Winegrowing New Zealand (NZWINE, s.a.), Sustainable Winegrowing Program of California (CSWA, s.a.) or Forum per la Sostenibilità del Vino in Italy (2014, s.a.). The Austrian ÖPUL programme 2007–2013 provided (in the field of viticulture) compensation for erosion control through greening, organic farming, integrated production, and areas with high nature value (see also Section 5).

As external motivations, however, financial incentives interact with other motivational drivers such as values, norms, worldviews, informal institutions, or social expectations. Thus, we can see motivation crowding (crowding in of farmers not intrinsically motivated to contribute to conservation, crowding out of farmers' intrinsic motivations for conservation) within the spectrum of intrinsic (e.g. values, social expectations) and extrinsic (e.g. cash incentives, auctions) motivations (Deci, 1971; Deci et al., 1999). A lively academic debate is emerging around the question of to which degree external incentives are crowding out intrinsic motivations for pro-environmental behaviour (Evans et al., 2012; Steg et al., 2014; Vatn, 2010; Wunder, 2013). Associated long-term effects on vintners' values, behaviour, and practices, however, are paramount with regards to environmental quality and the design of environmental policies (Ferguson and Bargh, 2004; Marques et al., 2015; Orderud and Vogt, 2016).

Despite a growing body of studies on motivation crowding in different fields of AES and payments for ecosystem services (PES), e.g. Chan et al. (2017), Fisher (2012), Kerschhofer (2013), Linder (2016), Van Hecken et al. (2017), and Wegner (2016), inquiries for agricultural speciality crops such as grapes are yet missing. Therefore, the focus of this paper is twofold: we compare the motivation and actual practices of vintners who are participating in the ÖPUL scheme with non-participants, and we investigate indications for crowding in and crowding out effects amongst a group of vintners participating in the ÖPUL programme between 2007 and 2013. Specifically, we want to use and test the applicability of the framework by Rode et al. (2015) to better understand crowding-out and crowding-in effects of payments for AES in vineyards.

Theoretical Background on Motivation Crowding

Motivations for Scheme Participation and the Contested Role of Financial Incentives for Service Delivery

Budgets, some say, are policies in figures. In this sense, rising public payments for environmental services demonstrate the increasing importance of environmental concerns in the agricultural policy of the EU (Ingram et al., 2013; OECD, 2016). In agricultural contexts, conditional, direct payments are generally considered efficient and effective (Wunder, 2015). Different conditions and motivations for farmers' willingness to participate in AES have been discussed, for example, by Baur et al., (2016), Chan et al. (2017), Engel (2016), Engel and Muller (2016), Gneezy et al. (2011), Ingram et al. (2013), Ma et al. (2012), Rode et al. (2015), Van Hecken and Bastiaensen (2010), Vatn (2010), and Wunder (2015).

Engel (2016) provided a comprehensive discussion of different AES and payments for ecosystem services policy designs, building on the criticism that there is mixed evidence of which conditions are financial payments successful in terms of service delivery and that they are no panacea, and that many studies do not find any motivation crowding effects and in general lack rigour (Rode et al., 2015). Financial incentives for the delivery of environmental services are usually not based on results, i.e. the provision of the environmental service itself (e.g. decrease in erosion). They are rather based on the delivery of particular practices, which are considered beneficial (e.g. greening of vineyards at certain periods of the year, which is considered helpful in reducing erosion), usually with limited evidence on the effectiveness of these practices (Engel, 2016).

Contract types have been discussed from different perspectives: farmers consider longer contract durations as risky because these lower their flexibility to adapt to future market fluctuations and other changes and are therefore expecting higher payments (Ruto and Garrod, 2009). Baur et al. (2016) questioned if even 'sufficient' payments would provide incentives for prompt land use changes due to farmers' rather conservative cultural values resulting in deferred reaction to new incentives. As a more promising strategy, the authors propose to modify existing schemes rather than introduce news ones. Low or too low payments might even be counterproductive and result in higher risk for crowding out, thus the proposal to scratch too low funding due to potential adverse effects ('pay enough or do not pay at all') (Gneezy et al., 2011; Kerr et al., 2012; Vatn, 2010). However, other cases illustrate that lower levels of payments combined with triggers of intrinsic motivation might work under certain conditions (McKenzie et al., 2013).

Crowding-out Mechanisms

Rode et al. (2015) identified different mechanisms triggering crowding-out effects: reduced intrinsic motivation through the introduction of financial incentives, and aversion to change and control as well as frustration (see Table 1). The introduction of financial incentives might lower intrinsic motivation for service delivery, self-esteem, and the feel-good effect of delivering a value that has previously been recognised by the peer group or by society with non-monetary rewards. The presence of payment scheme makes it more difficult to distinguish if ecological services are delivered voluntarily (e.g. on moral grounds) or for economic reasons. Goodin (1994) described that actors who started following the principles and ethics of the market are characterised by fading moral obligations or responsibility which may result in frame shifting and/or changes in values and mindsets towards financial incentives. While 'frame shifting' is considered a temporal shift in focus (Bowles and Polanía-Reyes, 2012; Van Hecken and Bastiaensen, 2010), financial incentives and ongoing familiarisation with those payment schemes might also trigger long-term shifts in mindsets and values (Fisher, 2012; Frey, 1992; Rico García-Amado et al., 2013). These changes in socio-psychological patterns may result in lower degrees of service delivery after the end of the scheme compared to the situation before its implementation in case it is cancelled (Gneezy et al., 2011; Guerrero et al., 2013;

Steg and Groot, 2010; Van Hecken and Bastiaensen, 2010). If 'leading' farmers flexibly adopt more materialistic mindsets (Muradian et al., 2013; Vatn, 2010), this might not only be an issue at the individual level but might well interact with the perception of acceptable practices and norms or/and recognition conditions within peer groups.

Table 1: Crowding-out Mechanisms

Crowding-out mechanism	Explanation
1. Control aversion	Individuals with sense of autonomy and self-determination dislike the feeling of being controlled.
2. Frustration	Individuals are frustrated when they perceive regulations as a sign of distrust.
3. Reduced internal satisfaction (reduced 'warm glow')	Individuals no longer feel good about themselves for acting morally on a voluntary basis.
4. Reduced image motivation	Incentives undermine the individual's desire to present oneself as a 'good person' ('signalling') since others can no longer distinguish if one undertakes a social activity voluntarily or due to external incentives.
5. Release from moral reasonability	Compensating for environmental harm via monetary payments releases people from feelings of responsibility and guilt.
6. Frame shifting	An individual's attention is shifted towards a focus on economic reasoning (short term).
7. Changes in values of mindsets	The focus on economic reasoning affects attitudes and mindsets regarding conservation (long term).

Source: Rode et al., 2015.

Research also shows that farmers, compared to other groups, are quite consistent in their perceptions and routines, less open to changes (Baur et al., 2016), and strongly attached to their business and management styles (Beharry-Borg et al., 2013). Apart from the intrinsic motivation and general willingness to perform environmental services, their actual capacity to do bureaucratic and technological tasks (particularly for small or part-time farmers) and available labour, technological capacity is crucial as PES and AES require administrative efforts (e.g. writing applications, completing forms, documentation and monitoring). Frustration that might trigger crowding out also roots in standards that do not correspond with actual practices, contradict or conflict with values (Gneezy et al., 2011), or restrict the individual action space (Sommerville et al., 2010) and are of perception of being controlled by an external entity (Bowles and Polanía-Reyes, 2012).

Crowding-in Mechanisms

The current debate on motivation crowding builds on concepts such as self-determination (e.g. Ezzine-de-Blas et al., 2015) or the theory of planned behaviour linked to human–nature relationships (Braito et al., 2017; Van Dijk et al., 2016). The willingness to perform an environmental service is a consequence of a person's intention to accomplish it based on the conviction of ecological values and resulting ecological benefits (e.g. improved soil structure), respect for nature and environment (Rico García-Amado et al., 2013), and perceived beauty of nature or moral duty to protect nature and environment (Fisher, 2012; Kieninger et al., 2011, 2013). Those intentions are conditioned by a person's and/or group's attitude towards the performing behaviour, subjective norms and values, worldviews or beliefs (Daube and Ulph, 2016; Evans et al., 2012; Steg et al., 2014). Van Dijk et al. (2016) emphasised the role of identity in the intent to participate in activities that are more labour and time-consuming than regular activity. Inter-subjective recognition is crucial in the successful formation of self-identity and group recognition (Fraser and Honneth, 2003; Honneth, 1992; Mead, 1973). Thus, to understand farmers' attitude towards nature or pro-environment practices, it is important to comprehend the more general norms and values that are conditioning their integration into and social recognition of the particular peer group (Fraser and Honneth, 2003; Honneth, 1992). Agricultural production and delivery of ecological services are directly linked to norms, which define favourable or at least acceptable practices. Monetary recognition systems such as AES and PES are also redistributing resources for delivery of such services. The positive reinforcement of socially valued services and social recognition results in increased self-esteem, which is discussed as an important driver for crowding in. Various scholars, however, also stress the importance of peer and social groups in delivery of ecological services or group-based payment schemes (Van Hecken and Bastiaensen, 2010; Van Hecken et al., 2017). PES and AES are also signals that delivering environmental services is valued by outsiders and society (Frey, 1992) and they are expected to improve the general attitude towards ecological quality, environmentally friendly management practices, and the regulating institutional design (Sommerville et al., 2010). Overall, the academic debate on intrinsic motivation and crowding-in is diverse, sometimes inconclusive, and less researched than crowding out (Rode et al., 2015). However, there is considerable agreement amongst researchers that financial incentives always interact with intrinsic motivations (e.g. Engel, 2016; Van Hecken et al., 2017).

Table 2: Crowding-in Mechanisms

Crowding-out mechanism	Explanation
1. Enhanced internal satisfaction (self-esteem or 'warm glow') through social recognition	Individuals feel better about their behaviour when they perceive rewards as supporting and acknowledging their behaviour.
2. Reinforced positive attitudes or trust	Rewards can enhance people's general attitudes towards conservation and trust in regulating institutions.
3. Prescriptive effect	Individuals receive a 'message' indicating what constitutes desirable societal action, potentially in the longer-term changing perceptions, values, and norms.
4. Reinforcement achieved by compelling non-intrinsically motivated individuals to comply	Intrinsically motivated individuals can more easily act upon their motivation when they do not face a bad example or even exploitation of individuals who are not intrinsically motivated.

Source: Rode et al., 2015.

ÖPUL Measures and the Environmental Quality of Vineyards

In 2014 (the year of our survey), 7,177 or 84% of all vintners participated in at least one ÖPUL measure. In this section, we present these ÖPUL measures, which are also object of our empirical analysis.

Erosion Control

Through vegetation cover or the application of grass, bark mulch, or straw in vine rows, erosion control should help protect the soil against wind and water erosion and reduce the loss of nutrients into surface water (BMLFUW, 2013). With an inclination of ≥ 25%, vegetation cover has to be yearlong and is subsidised at €300–€800/ha, depending on the slope gradient. On slopes with < 25% inclination, it can also be kept just from 1 November until 30 April (€125/ha). Terraces are regarded per se as erosion control and can be kept open (BMLFUW, 2013). Spontaneous vegetation ('natural greening' in contrast to 'seeding') was only allowed as erosion control in ÖPUL 2007–2013.

Organic Farming

The goal of organic management is the promotion of sustainable management practices and this includes a ban on synthetic pesticides and mineral fertilisers to protect biodiversity and natural resources (BMLFUW, 2013). Eligibility criteria for the subsidy (€750/ha) include, inter alia, official certification from an organic auditing body and maintenance of landscape elements (BMLFUW, 2013).

Integrated Production

Integrated production in viticulture was subsidised with €400/ha (2007–2013) and in the ÖPUL transitional year (2014), with €350/ha (BMLFUW, 2013). In the 2015 ÖPUL programme, integrated production was replaced by herbicide and insecticide abstinence (each at €250/ha). The goal of this integrated production measure was the sensitisation of the participants in the field of fertilisation, plant protection, and soil health by restricting pesticides and fertilisation beyond legal requirements. The use of chemical-synthetic pesticides was only allowed on the basis of a positive list; regular inspections or indications of plant protection warnings; and the documentation of frequency and amount of pesticides, fertiliser, weeding, harvest, etc. (BMLFUW, 2013).

Areas of High Nature Value

This measure should help maintain areas and structures that are of high value for nature conservation (BMLFUW, 2013). In viticulture, it is mainly relevant for the management of grasslands (i.e. mowing of the slopes) between wine rows. The requirement for participation is the confirmation of the project plan by a nature conservation department of a federal state (BMLFUW, 2013). Management has to follow exact protocol for each plot. Payment is individually determined for each area (BMLFUW, 2013).

ÖPUL measures such as mitigation of soil erosion, herbicide and insecticide abstinence, organic farming, or high nature-value areas help to increase the environmental quality of vineyards and climate. Herbicides have negative impacts on plants, arthropods (Sanguankeo and Leon, 2011), earthworms (Gaupp-Berghausen et al., 2015), and arbuscular mycorrhiza fungi (Zaller et al., 2014), which are important for nutrient uptake from soil. In addition, herbicides may cause environmental risks such as surface and groundwater pollution (Louchart et al., 2001) or residues in grape juice and wines (Ying and Williams, 1999). The removal of vegetation by herbicides or tillage reduces soil carbon content and consequently results in carbon sequestration (Zehetner et al., 2015), which also decreases atmospheric carbon dioxide regulation (Montanaro et al., 2017). Furthermore, due to periodic soil tillage and herbicide application (i.e. open soil), erosion has become a widespread problem in viticulture (e.g. Novara et al., 2011; Ruíz-Colmenero et al., 2011), threatening biodiversity (Montanarella, 2005) and the provision of multiple ecosystem services (Novara et al., 2013). The mitigation of soil erosion is mainly due to mechanical protection by vegetation cover. It is, therefore, of utmost importance to establish a fully developed vegetation cover during summer when heaviest rainfall events could cause huge erosion (Lieskovský and Kenderessy, 2014). The current ÖPUL erosion mitigation measure is frequently criticised for not being adequate enough in reducing soil erosion at the earliest date for soil tillage (1 May). In many cases, re-establishing vegetation cover in vineyard inter-rows comes too late with the advent of heavy summer rains. The effects of organic farming on plant diversity are unclear, as some studies showed positive effects (Gaigher and Samways 2014; Nascimbene et al., 2012), while others could not detect differences between conventional and organic vineyards (Bruggisser et al. 2010; Kehinde and Samways, 2014). However, as mentioned, the ban on pesticides in organic farming is beneficial for a range of taxa.

Material and Methods

Case Study Sites

The study took place in three Austrian wine-growing districts: Wachau, Wagram, and Leithaberg-Neusiedlersee (and mainly in the municipalities of Purbach am Neusiedlersee, Grossriedenthal, and Dürnstein). They were selected based on two criteria: representation of the two largest wine-producing provinces (Lower Austria, Burgenland) and existing contacts and established relationships with local representatives of the wine-growing communities, different actors, and stakeholders, so that trust was already built up for interviews and focus groups.

Wachau (Wu) is a 35-km long valley on both sides of the river Danube, located around 80 km northwest from Vienna, between the cities of Melk and Krems. It is one of the most renowned Austrian wine-growing regions. The six municipalities of Wachau hold a viticulture area of around 1.350 ha (ÖWM, s.a.a), managed by about 600 vintners (Feigl and Peyerl, 2011). Mainly due to its unique and highly aesthetical dry-stone walls, Wachau was awarded the European Diploma for Protected Areas in 1994 and was designated as UNESCO World Heritage Site in 2000 (AK, s.a.). Over a quarter of the vineyards are situated on terraces (AK, 2007).

The wine-growing region of Wagram (Wm) is a hilly mountain range along the north side of the Danube, located around 60 km northwest of Vienna. The nine municipalities in the region comprise vineyards of approximately 2,480 ha (Bauer et al., 2013) in the plains and on terraces, managed by more than 300 vintners (ÖWM, s.a.b). Grossriedenthal, one of the eight wine-growing municipalities of Wagram, was awarded the Lower Austrian Environment Price for nature-friendly viticulture in 1990 (interviews I 3, IP, Wm and I 12, IP, Wm).

Leithaberg-Neusiedlersee (3,576 ha, see Bauer et al., 2013) is located around 60 km from Vienna and situated on the west side of the lake Neusiedlersee. It stretches from a quite plain terrain to the rolling hills of Leithagebirge. The region, which partly belongs to Ferto/Neusiedlersee Cultural Landscape, a UNESCO World Heritage site, also includes Natura 2000 areas and nature parks. In contrast to the other two study sites, there are no terraces in this region.

Data and Methods

The research is based on a mixed-method approach, linking qualitative social science with ecological research to investigate the socio-ecological effects of ÖPUL (see Kieninger and Winter, 2014) on the ecological quality of vineyards. In this paper, we present the results on crowding-in and crowding-out effects from the qualitative social science part focusing on the vintners' perception and motivation of (non-)participation in the ÖPUL programme. Literature-based semi-structured interview guidelines were developed and fine-tuned after the first set of test interviews. The sample also included a group of seven lighthouse vintners (L!), i.e. vintners with outstanding biodiversity-supporting vineyard management. They were selected by the ecological specialists in our research team who had accompanied them in their ecological efforts for years. Overall, 78 persons were interviewed (20 Wu, 25 LN, 25 Wm, 7 L!, and one wine cooperative representative who, however, is not included in Figure 1. Interviews (consecutively numbered from I 1 to I 78) were coded and tape recorded. The parts relevant for the research questions were transcribed, coded, inserted in a database, and analysed (Flick, 2009). Quotations in this paper are cited with reference to the relevant study site (Wu, Wm, or LN) and the management style (organic, conventional, IP).

Figure 1: Vintners Interviewed, their Management Style, ÖPUL Participation, and Herbicide Use

Management form	L!	Wu	Wm	LN	Σ
Conventional	1	7	3	4	**17**
Integrated production (IP)	0	7	17	14	**38**
Organic	6	4	4	6	**20**
Organic conversion farm	0	0	1	1	**2**
Σ	7	20	25	25	**77**
Participation in at least one ÖPUL measure	5	12	23	20	**60**
Integrated production (IP)	0	7	18	14	**39**
Organic	5	1	4	5	**15**
Erosion control	3	11	21	16	**51**
Areas of high nature value	1	0	2	0	**3**
Herbicide application	0	15	14	10	**39**
No herbicide application	7	5	11	13	**36**
n.a.				2	**2**

Note: L! refers to lighthouse vintners of outstanding ecological performance.

Source: Authors.

After the interviews, 26 vintners, and representatives from wine cooperatives and the Federal Ministry for Agriculture, Forestry, Environment and Water Management met in a follow-up workshop to discuss the results of the study.

Results and Discussion

Based on semi-structured interviews and focus group discussions with vintners from three Austrian wine regions, we analysed crowding-in and crowding-out mechanisms of the agri-environmental measures of erosion control, organic farming, integrated production, and high-value areas. We tried to reduce response biases by asking neutral questions on motivations, attitudes, and behaviour without referring to crowding-out or crowding-in mechanisms. We also employed experienced interviewers to ensure a comfortable and open atmosphere for the interviewees who had been told that there were no right or wrong answers. We agreed that the sample of 78 qualitative interviews should be large and hopefully diverse enough to gain insights needed in answering the research questions and testing the framework. Looking at the framework by Rode et al. (2015), we identified all crowding-out (see Table 1) and crowding-in mechanisms (see Table 2) to also hold true for the Austrian ÖPUL implementation in vineyards. In addition, we identified some specific challenges for smaller and less specialised or part-time farmers regarding the administrative burden of ÖPUL participation.

Crowding-out Mechanisms in the Wine Regions Analysed

One of the main criticisms on ÖPUL expressed by about one-third of the interviewees is the perceived administrative burden linked to control aversion and frustration. Office work in general (e.g. the obligation to exactly follow protocols) is perceived as undesirable, tedious work, deterring them from what they actually want to do: *'I want to decide by myself what I do. I prefer being in the vineyard instead of in front of the computer'* (I 67, conventional, Non-ÖPUL, Wu). Smaller and part-time farms particularly struggle with the administrative burden. 'ÖPUL is impractical for a small family-owned farm because it is not so easy to conform to the directive all the time insofar as plant protection and keeping up the greening so long in the year are concerned. *ÖPUL is a pompous system with too much bureaucracy' (I 69, IP, Wu). 'This system promotes only the large ones. For small vineries, it is not worth the trouble. I have decided not to participate in this nonsense, with the absurdity of pseudo-examinations and training, queuing up for hours in front of some authorities for €1,500 a year. This was actually the reason why this system makes me angry because it only promotes large structures'* (L! 48, Demeter, Non-ÖPUL, LN).

These results are in line with Rode et al. (2015), showing that administrative burden and economy of scale as an important dimension in the groups' control aversion and frustration is especially important for special crops and/or smallholder agriculture. Several vintners perceive a gap between their actual practices and the required measures (however, no one questioned the aim of the measures). Referring to this policy–practice gap, there is a desire for more practicable and effective measures. A topic lively discussed in this context was the earliest ploughing date (1 May) for the erosion control measure: *'The supporting scheme is not good. Working on date* [predefined schedule] *is not possible; you have to follow nature. These guidelines have been invented by somebody that has never worked before in a garden* [in a vineyard]. *We participated in ÖPUL in the first programme period. Many vintners have opted out'* (I 70, conventional, Non-ÖPUL, Wu); or *'It doesn't work like it's designed on paper. Those sitting at the desks believe they know how we are doing it. They have no idea. They just went to school once and now they are prescribing to us what to do. They need to learn in practice, too'* (I 70, conventional, Wu), *'We have many steep locations. With an earlier ploughing date, the area would already be green until the severe storms come.'* (I 8, IP, Wm) or *'In view of the climate conditions, we were not able to keep up with the regulations for erosion control'* (I 71, conventional, Non-ÖPUL, Wu). Even the digitalisation of the area, as calculation basis for the ÖPUL payments, was criticised not only as highly time-consuming but also far distanced from the practice: *'Digitalisation is a high effort. Depending on the time of day, you have different land boundaries due to the shadow'* (I 78!, organic, LN).

The confrontation between policy measures and regulations on one hand and actual practices on the other is also paired with an ambivalent relation to Agrarmarkt Austria (AMA), the executive agency monitoring the programme's implementation: *'AMA behaves like the former major, large-scale land owners – with an arrogant behaviour'*. (I 7, organic, Wm) or *'AMA behaves in a top-down fashion'* (I 38, IP, LN). Controls and the pending risk of mistakes being identified and funding being reclaimed were also mentioned as a crowding-out factor: *'Another somewhat disadvantage with ÖPUL is the constantly hanging sword* [of Damocles] *above you. If you commit a mistake, you have to pay back the funding of 5 years. I am uncertain if that is helpful. I think this is one reason why so many are dropping out, because their argument is: why pay back when I do not get a lot of money anyway. I don't care at all then. This makes the scheme less attractive'* (I 26, IP, Wm). Reduced autonomy and responsibility in land management, mistrust, and administrative burden which disproportionally affects smaller farmers result in much frustration, despite the awareness that several measures (e.g. erosion control, especially in terraced vineyards or integrated production) do not require much extra efforts or loss in income: *'The measures that are required are things that I would do anyway, except that now I´m getting money for it'* (I 10, conventional, Wm), *'I am taking three quarters of all subsidies'* (I 7, organic, Wm), *'Anyway, I don´t have to do anything for erosion protection in the terraces,. I only have to green* *two plots since there are no terraces. But I would do it anyway, because in organic agriculture, I need to get nitrogen'* (I 76, organic, Wu).

Several interviewees even questioned the conservation impact of single measures, particularly integrated production where abstinence from herbicides is allowed, but also erosion control via greening that most of the vintners would do anyway because a closed vegetation cover is practicable when entering the vineyards for harvesting with machines even after rain, etc. The criticisms on integrated production are mainly expressed by organic farmers: *'In reality, the integrated production programme, has nothing included for nature. You are allowed to use herbicides twice a time, and if you don´t green your soil, it´s really your own fault if the soil is washed down* [by heavy rain]. *I would do it anyway. And on the market, you can only find ÖPUL-treatments anyway'* (I 17, organic, Wm). *'At present, ÖPUL has too few benefits for the environment. Useful measures would have an effect, but chemical companies are too strong'* (I 23, IP, Wm). *'Integrated production actually has nothing for nature'* (I 17, organic, Wm). The interviewees' scepticism on ÖPUL's effectiveness is in line with how the Austrian Court of Audit criticised the faulty evidence on ÖPUL's effectiveness (RH, 2013, 2016). Transparency on effects could also help to crowd in more farmers willing to contribute to conservation and who still do/or no more see the sense in specific rules: *'No herbicides in ÖPUL when you get money! Currently, ÖPUL latently promotes herbicide use'* (L! 49, conventional, Non-ÖPUL, LN). *'ÖPUL and the integrated production programme have a green label, but they are everything else but green. That´s why I want to drop out'* (I 41, organic, LN).

The case study also found ambiguous connections between some farmers' relationship with the monitoring executive agency and reduced internal satisfaction and image motivation. Some vintners expressed regret that the high workload of small-scale farmers or farming in difficult locations (e.g. vineyard terraces) are not being appreciated and recognised, which is crucial in developing intrinsic internal satisfaction for the accomplished work and services: *'High work load should be honoured. I work just as much as someone in 30-ha vineyard business that can work with machines and chemicals and is much more efficient. A small winery should be able to survive'* (I 23, IP, Wm). Organic vintners seem more sensitive if services do not deliver actual environmental benefits: *'Environmental and conservation funding should be beneficial for nature, not for window-dressing schemes'* (L! 75, organic, part-time farmer, Wu). However, intrinsic motivation also animates conventional farmers or integrated production vintners to avoid environmentally harmful practices: '[The programme] *herbicide 'abstinence' was cancelled and that is the reason why they* [i.e. the other vintners around] *are now spraying on a large scale. I myself do the weeding manually, that's why it looks nicer. All are thrown together'* (I 18, IP, Wm). The interviews indicate that lack of recognition is often addressed as hindrance to gaining sufficient satisfaction and image motivation from the work.

For some vintners. ÖPUL represents a release from moral responsibility. They use participation in ÖPUL as an excuse not to do more from an ecological point of view: *'We already do more than what is required anyway'* (I 51, IP, LN). If they follow all ÖPUL requirements, e.g. use the 'right' pesticides from the 'ÖPUL list', they cannot commit anything that is 'against' nature: *'The* [allowed] *plant protection products are listed on an equivalent list and are tested for environmental compatibility'* (I 28, IP, LN). *'There is pre-sorting* [through the equivalent list]. *The aggressive sprays are sorted out so the beneficial organisms will not be completely destroyed'* (I 2, IP, Wm). In some cases, participation in integrated production was used to legitimise herbicide application. Some farmers (mainly organic but also conventional vintners) were very eager in using species-rich seed mixes, while others perceived that they were conscientiously fulfilling their 'duty' by using at least one hardy species as has been required for erosion control since 2014. As well, since terraces per se count as erosion control, vintners with terraces have no qualms removing vegetation cover during hot/dry season or greening just every second row.

Some vintners directly addressed frame shifting as well as the general change of values in mindsets, which could be triggered by financial incentives: *'Money persuades them all. Every farmer who gets something as a gift will take the money and do what they ask him to do, even if it's dull'* (I 10, conventional, Wm). They even pointed out that shifted mindset might be a problem in the long-term fulfilment of ecological measures in case ÖPUL is terminated: *'The disadvantage of subsidies is that you get used to them and it will become hard to do it without them'* (I 14, organic, Wm). Unfortunately, the data do not provide enough insights to understand long changes in social-psychological patterns. It is to be hoped that longitudinal research covering several decades of ÖPUL implementation will be more insightful in the future. However, some vintners seriously doubt that financial incentives are a promising way for delivering ecological services in the long run: *'The financial incentive is not the right way in a long-term perspective'* (L! 73, organic, Wm).

In summary, one can say that ÖPUL, in combination with several other policies and adjacent funding schemes, contributes to farmers' income and thus to viable farms that are needed for maintaining important agro-ecosystems such as small-scale and/or terraced vineyards. The interviewees questioned the sufficiency of the provided environmental service based on the huge administrative burden than on the compensation for extra work or forgone profit. Due to economies of scale, smaller farmers or farmers with less administrative capacity are particularly affected by these mostly fixed transaction costs. While none of the interviewees questioned the ecological goals, several of them questioned the effectiveness and practicability of the interventions prescribed to pursue these goals. Payments decrease vintners' vulnerabilities to variable quantity and quality of harvests or changes in consumer demand. However, as pointed out by Anderberg (this volume), this additional 'income' for organic farmers in developing countries might create new dependencies and might have unintended risk-related side effects such as psychological pressure of being controlled for mistakes in documentation or timing of management operations as well as lost autonomy and flexibility. Thus, short-term risk reduction can create new medium- or long-term risks. Farmers questioning the effectiveness of the measures but generally agreeing with the conservation objectives are in line with the warning by van Hecken et al. (2017) against centrally administered policies that reflect an overly simplistic notion of human–nature relationships as manageable systems which can be altered in predictable ways.

Crowding-in Mechanisms in the Wine Regions Analysed

The research illustrates that about one-third of participating and non-participating vintners endorse the importance and value of the ÖPUL programme for its contribution to environmental quality and impulse as an initial learning process. The positive perception of the value and beauty of nature and quality of the environment are mentioned in the interviews as important stimuli to develop an enhanced internal satisfaction: *'I also want a beautiful vineyard for myself. This includes plants in between* [the vine rows] *that visually please me. Because I am convinced that everything that you like, no matter if visual or acoustic – for example, bumblebees or other animals – gives me pleasure and this also impacts my other crops'* (L! 48, organic, Non-ÖPUL, LN). In literature, societal and peer recognition is widely discussed. Interviewees do not only wish for social recognition of a peer group, e.g. *'The big well-known vintners are all organic'* (I 42, organic, LN), but also recognition by experts and academia for the vintners' contributions to environmental quality. The recognition by researchers of floristic biodiversity triggered a change in management practice by one vintner: *'It* [the European birthwort] *was always there. Since we know that it is so rare, we do not cut it on purpose'* (I 55, IP, Wu). Another vintner, who had cut the rare European birthwort against the wish of his wife, envisaged to let it grow in the future after interaction with the ecologists of this study (I 23, IP, Wm). Some vintners recognise that 'strangers' see and appreciate things that seem normal/not special for them. For their professional work, they would appreciate a stronger societal recognition: *'Important would be the recognition for his area, telling him* [the vintner] *that his vineyard is nice'* (I 7, organic, Wm).

Reinforced positive attitudes towards nature conservation and/or trust (see Rode et al., 2015) in ÖPUL as a regulation institution was also confirmed in our interviews. Some vintners appreciate the ÖPUL rules as an adequate way to support them in their learning towards nature-friendly viticulture, e.g.: *'One is concerned, scrutinises the rules: Why so? Why this?'* (I 24, IP, Wm) *or 'Without money, you will not be able to do much. If that would not have been so* [i.e. getting subsidies], *I don't know if I would have done it* [i.e.

the measures]. *Now I would do it also so* [i.e. without money]' (I 46, organic, LN). Some interviewees also welcomed the controls by "Agrarmarkt Austria" AMA to secure the 'quality standard' and the correct implementation of the guidelines for nature protection: *'Control through AMA and leave sample are right because there are always black sheep'* (I 15, IP, Wm). On the other hand, a highly intrinsically motivated organic vintner opted out of ÖPUL' organic measure after herbicide residues of the conventional neighbours were found in his vineyard, resulting in big problems, image loss, and aversion and mistrust against controls (I 76, organic, Wu)

Although the bureaucratic effort (including mandatory management documentation) was criticised by more than one-third of the interviewed ÖPUL participants, some vintners also perceived the documentation as a good way of learning and of capacity building. The documentation, which they would not have compiled without ÖPUL, offers the opportunity to trace and check which steps and cultivation measures were applied the years before: '[The obligatory documentation] *is good so you have your plots under better control. For many* [i.e. vintners], *it is good to be more systematic, to know when what is in the vineyard'* (I 46, organic, LN). The same was mentioned for the obligatory soil analysis and spreader control for integrated production: *'Spreader control is good; otherwise, you would neglect it. Furthermore, the obligatory soil analysis is good, too, so, you have an overview'* (I 28, IP, LN).

Linked to intrinsic values and positive reinforcement, learning and capacity building were discussed in the interviews and in the workshop and considered by the vintners as important pillars and requirements for successful ÖPUL measures. In the programme, learning is anchored by mandatory training and professional education linked to ÖPUL participation. On the one hand, the case study indicates possible linkages between intrinsic motivation, a positive perception of learning, and the policy design of the ÖPUL scheme: *'In my opinion, the subsidy schemes should focus on knowledge generation. First, awareness raising, providing information – which has to be collected – then accompanying consultancy during the programme period and remuneration at the end'* (I 58, conventional, Non-ÖPUL, Wu). On the other hand, we also see that vintners link learning with reinforcement of attitude regarding service delivery: *'The more you do, the more you should be rewarded'* (I 21, IP, Wm).

Related to intrinsic motivation and positive reinforcement, we could also find preferences for a result-oriented policy scheme as it existed, for instance, in the Province of Lower Austria in the past: *'The subsidy could be even higher the more flora and fauna you have in your vineyard'* (I 50, organic conversion farm, LN) or *'"Eco-points" were good, since you got the points afterwards for what you did. Not like now* [in advance]. *That was better'* (I 20, IP, Wm). However, another interviewee questioned the long-term learning effect of result-based payments: *'Five euros for each grass-lily. That wouldn´t be sustainable, since the vintner would just start counting the grass-lilies even though he is not interested at all'* (I 7, organic, Wm). In this 'result-based' scheme, the actual result or the environmental condition of the vineyard would be the basis for the subsidy and not the practices for environmental quality. With this scheme paying for results and not for the implementation of prescribed practices, the current control of dates and management activities, which some vintners even consider as ineffective, would be obsolete. Moreover, a shift to a result-based compensation design would ask for baseline surveys and constant monitoring to control the improvement of the environmental condition. Providing this information might be difficul. The Austrian Court of Audit (RH, 2013, 2016) has repeatedly demanded evidence on the effectiveness of the present policy design to check the effective use of tax money in improving environmental quality, but without much success.

Rode et al. (2015) also listed the prescriptive effects and reinforcement achieved by compelling non-intrinsically motivated individuals to comply as important crowding-in mechanisms. On the one hand, the prescriptive effect for vintners, i.e. desirable societal action indications that should potentially lead to changing perceptions, values, and norms in the long term (Rode et al. 2015), appears in the above described social recognition and appreciation of the vineyard landscape as well as in the vintner's effort to preserve it under 'social pressure'. On the other hand, ÖPUL regulations themselves seem to have a prescriptive or coordinative effect: '[Integrated production] *is nature friendly and gives a certain framework within the plant protection products'* (I 55, IP, Wu). However, it is not easy to understand if and to what extent these normative structures also resonate with non-intrinsically motivated individuals. Maybe they would rather reinforce intrinsic motivations such as health or the desire to preserve nature even amongst non-participants: *'Erosion control is important for humus build-up. Organic management is important for self-protection and sustainability'* (I 9, organic, Wm), '[I don´t use herbicides] *because they are poisonous and I don´t want that they go into the soil, into the water'* (I 35, conventional, Non-ÖPUL, LN), *'Nature-oriented management, sustainability, is a concern for me. I am sceptical against chemistry. That is my business philosophy'* (I 61, conventional, Non-ÖPUL, Wu), *'Just what is necessary: the less pesticides, the better for the purse'* (I51, IP, LN) or *'I don´t do it* [i.e. the ÖPUL measures] *for the money*. [E.g.] *I even now* [after the termination of the integrated production measure] *don´t use herbicides at all'* (I 23, IP, Wm). However, some intrinsically motivated vintners recognise the fact that ÖPUL requirements are compulsory for all participants. Thus, motivated vintners feel more encouraged in their doing as they would be when confronted with bad examples of their colleagues: *'General abolition, general ban on green spraying. Understock injection is a deadly product!'* (I 45, conventional, Non-ÖPUL, LN). Therefore, they consider controls as important: *'The idea* [of such a measure] *is good, but the implementation would be complicated. Too complicated to control. There is a lot of misuse..'* (I 24, IP, Wm).

Regarding the long-term effect towards changed perceptions, values, and norms for a more environmentally friendly viticulture, we found two different perceptions. Some vintners reported that ÖPUL has been a stimulus for them to practice more sustainable viticulture: *'The programme itself is quite good. It is not necessary to drive into with every chemical mace. There is a learning effect from the beginning'* (I 56, IP, Wu), *'Formerly, everything was open* [i.e. open soil, vineyards were not greened]. *However, then came the change. Recently, because of the drought, every second row is open'* (I 10, conventional, Wm), *'The awareness for landscape-preserving measures could be increased therewith* [i.e. ÖPUL]. *But it still goes far too little however'* (I 73! organic, Wu). Some vintners continued to implement the measures (e.g. organic viticulture, erosion control, or the old measure of herbicide abstinence) from the 2000–2007 period even without subsidies. The majority of ÖPUL vintners underlined that in case of a programme stop, they would continue with parts of the measures even without funding. But there have also been observations that the 'positive' effects of ÖPUL disappear the moment the programme terminates. For example, one interviewee referred to the observed on-off participation of neighbours in the herbicide abstinence measure. This measure was implemented in the 2000–2007 ÖPUL programme, stopped in the 2007–2013 period, and was re-introduced in the next scheme. '[The] *herbicide abstinence* [measure] *was cancelled and that is the reason why they* [i.e. the other vintners around] *are now spraying on a large scale'* (I 18, IP, Wm). Schildberger et al. (2007) also came to this observation in their investigation on herbicide damage in Austrian viticulture. After the success of lower levels of herbicide use during the 2000–2007 funding period, the levels went back up to the level of earlier stages, after the compensation payment was cancelled in the 2007–2013 programme period. In general, it is difficult to understand how comparatively 'short-term' and/or changing ÖPUL measures affect social systems and socio-psychological patterns such as norms, values, or worldviews of farmers and rural communities in the long run (Fisher, 2012; Frey, 1992; Rico García-Amado et al., 2013). However, there are several indications that there have been learning processes on greening, erosion control, and, in some cases, also herbicide use in the study sites. These learning processes are positively reinforced by best practice of neighbours and peer recognition and maybe even long-term value change towards more sensitivity and responsibility towards nature embedded in mechanisms that are linked to identity and self-efficacy and internal satisfaction with farming (van Dijk et al., 2016). Thus, it seems that in some cases, payments have actually provided a spur for changing perspectives and rationalities and resulted in a broader structural change (van Hecken et al., 2017).

Concluding Remarks

Our results show that the framework of Rode et al. (2015) is applicable to understand motivation crowding of agri-environmental schemes targeted at vineyards. The research suggests that vintners are motivated not only by financial incentives but by a complex combination of different socio-psychological mechanisms that are intersecting and contingent, either reinforcing, aggravating, or hindering the delivery of environmental services. To address environmental quality and ecological risks in an effective policy design, it might be crucial to grasp the different combinations of mechanisms for motivation crowding. In our case study sites, we identified three types of vintners based on different crowding-in and crowding-out mechanisms:

1) The first group is not willing to participate in AES because of administrative burden, aversion to control, and desire for autonomy. Due to economies of scale, smaller farmers and less specialised farmers are confronted with comparable higher share of transaction costs. Some farmers of this group doubt the effectiveness of the measures, but none questions the ecological goals per se.
2) The second group flexibly reacts to financial incentives and appears to be susceptible to the risk of short-term frame shifting. Payments from AES are a welcome short-term additional income, more or less independently from the outline of the scheme. Therefore, they will stop the measure at the very moment the payments are terminated or lowered beyond a critical level.
3) The third group of participating vintners showed indications of changed perceptions, rationalities, values, and norms for a more environmentally friendly viticulture. A short-term economic motivation was followed by a long-term change in ecological motivation that was nurtured through, for example, social learning, peer recognition, experience, and good examples.

Schemes that allow for more experimentation with context- and farm-specific approaches could result in more diversity, better ecological outcomes, and, finally, in less ecological risks. As ÖPUL clearly cannot reach the first group of farmers, more research is needed to better understand how different strategies of risk governance, such as legal standards, information, capacity building, incentives, and reflective discourse might be best combined to bring a change. For example, the lighthouse vintners – who are not only ecologically but also economically successful – might serve as best-practice examples and become important allies in an integrated governance strategy. Scoping studies that are assessing different motivational mechanisms prior to design and rollout of AES might be beneficial to design well-functioning policies that are depending on the willingness and ability of diverse vintners to be implemented. Designing AES to improve environmental quality and to reduce environmental risks might be dysfunctional if designed as stand-alone schemes. Rather, they should be embedded in a broader risk governance approach that addresses different groups with diverging motivations.

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CHAPTER 14

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

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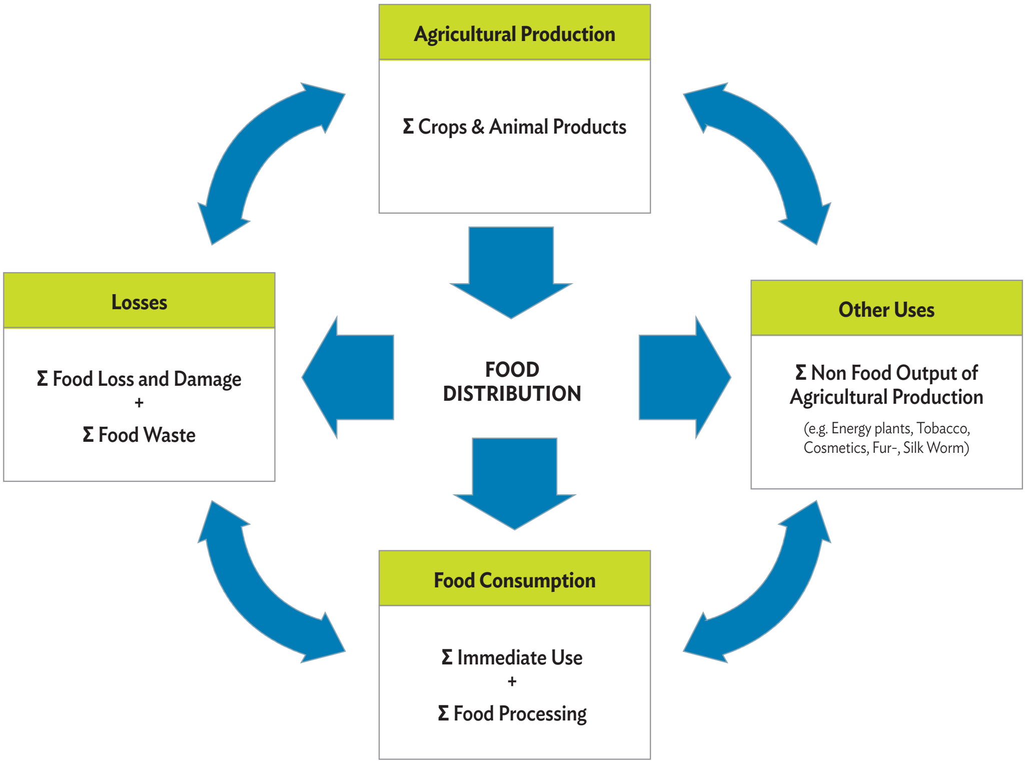
Introduction

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

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

The increase in disasters coincided with a 70% increase in traded agricultural goods in 2006–2016 (WTO, 2017) and a general trade increase from 12% of global gross domestic product (GDP) in 1970 to 31% of GDP in 2008 (IMF, 2009), a number that fell again to 29% of GDP in 2015 (World Bank, 2017). A high proportion of domestically produced food in the total food supply is of key concern for almost all countries despite the fact that more food is being imported. Food security is not only related to continuous success in productivity but also to safeguarding the current flow of resources, controlling the international trade of inputs, and providing an efficient global transportation network. The global energy prices fell by 45% in 2005–2015 (WTO, 2016). When the first General Agreement on Tariffs and Trade was negotiated in the 1990s (Saylor Foundation, 2017), special exceptions for agriculture were included, e.g. an allowance to use export subsidies. This enabled countries to keep prices of farm products high in the domestic markets. Those prices, however, generated a surplus of food which was dumped on international markets through export subsidies. Thereby, agricultural producers in developing countries were forced to compete with low-priced subsidised food from the developed world.

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



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The global food security system offers flexibility and trade-offs for most people around the globe. Some 90% of global citizens enjoy food security while 10% suffer from occasional or even permanent food insecurity or hunger (International Food Policy Research Institute, 2016). Comprehensive food security has become widely possible due to a combination of inexpensive external energy, fertiliser and material inputs, and sufficient internal land and water resources. It is a declared aim of the United Nations (2015) to eradicate hunger by 2030 and that more than 97% of the global population should become food secure within the coming 15 years. Accordingly, appropriate food production and food distribution policies should be in place to guarantee food availability for all consumers. Many ways to improve the efficiency between agricultural production and food consumption will have to be considered.

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

A second option is to change the ratio within the agricultural production of non-food uses and food consumption in favour of the latter. For example, grains can be feed for livestock or food for humans. In 2016, 1.03 billion tonnes of grains or 136 kg for every person on earth were used as feed for animals, an increase of 8% compared to the 2012 volume (Alltech, 2017). A high percentage of meat in a society's diet can also be considered as a hidden food reserve if people would again substitute meat with cereals. In addition, vegetarian diet is considered an efficient means to cut greenhouse gas emissions from agriculture (Hedenus et al., 2014). We should further question if cereal production is a good alternative for bioethanol production. In the case of India, it is considered a viable option for marginal lands while it is deemed that it should not compete with food production in densely populated areas (Srinivasan, 2009). In total, global cereal production amounted to 2.49 billion tonnes in 2016–2017 (FAO, USDA, 2017) or 328 kg per person. Considering 200 kg as the annual minimum requirement for one person, the amount produced implies that, theoretically, 12.45 billion people could get food by the current cereal production. Similar concerns exist with regards to food oil productions and conversion to biofuel. Lam et al. (2009) investigated into the production of biodiesel based on palm oil in Malaysia and how far this option is challenging food security. At least in the near-term future, increased production of palm oil for biodiesel is no threat to food security. Compared with other oil fruits used for fuel productions, palm oil has the highest efficiency with regards to energy input and output. Yet another concern is if wide application of non-food uses of agricultural products will increase food prices and availability. Ajanovic (2011) considers no food price increase for the second generation of biofuel plants. Also, the food-competing feed production will alter in parallel. However, even if all global agricultural harvests would be used for biofuel production, the annual transport energy demand could not be supplied with.

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

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

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

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

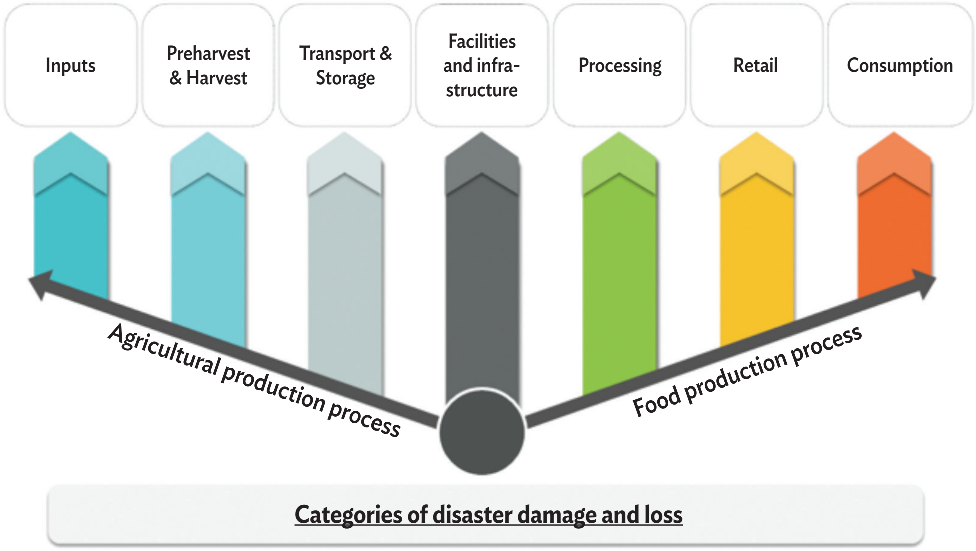
Relevance of Disasters on Agriculture and Food Security

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

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

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

Figure 2: Vulnerability of Food Value Chain to Disaster Damage



Source: Author.

A joint international methodology on how to assess disaster loss and damage in agriculture and food security is still missing (Cutter, 2017) but is likely to emerge in the next few years. Recently, the Food and Agriculture Organization (2017) came forward to lead in this issue after analysing disaster impacts in developing countries (FAO, 2015, 2016). Connected with huge food losses, natural disasters attack one or several components of the food security system: agricultural production, food production, food storage, food distribution, food durability, and more. Floods and droughts, the most common natural disasters, are primarily climate-induced. On the average, FAO counted 149 disaster events in 1980–1990 and 332 in 2004–2014. While the number of climate-related disasters more than doubled, the related damage was seven times higher. The average damage tripled with each disaster. One can expect a continuation of this trend with even more damage in the future. The total damage from these disasters in the first period was US$14 billion annually and US$100 billion annually in the second period (FAO, 2016). This is a rise of disaster damage from less than 1% (annual average in 1980–1990) to more than 3% of the total global agricultural production value (2004–2014) within one-third of a century. The situation is particularly dramatic in developing countries that are much dependent on the agricultural sector and vulnerable to droughts, in particular, where loss and damage from medium- to large-scaled disasters already account today for a 22% loss in agricultural production (FAO, 2015).

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

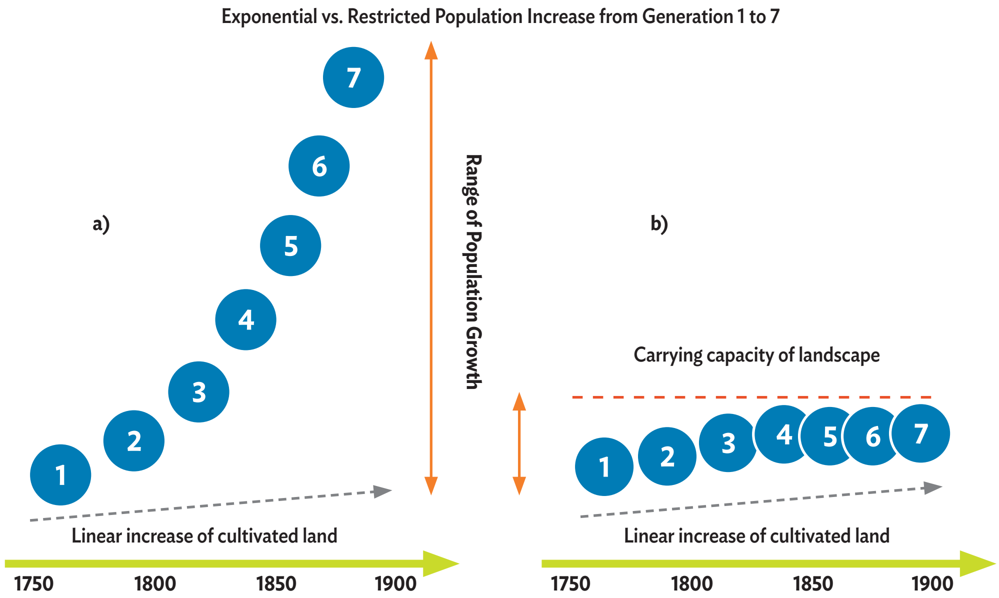
The Food Scarcity Threat

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

In Figure 3, the left side a) depicts an example of the exponential growth of population in a condition of limited arable land. This is typically for development in the centre of a region. We start in 1750 at generation 1. After six generations – each at 25 years average or some 150 years – the arable land has grown modestly while population has skyrocketed from the original value. Malthus intended to show his contemporaries the impossibility of such a development and that any society sooner or later has to break down due to famine and war. In fact, his doom model was – and still is – viable for urban areas. A precondition is that enough food can be imported from adjacent rural areas.

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

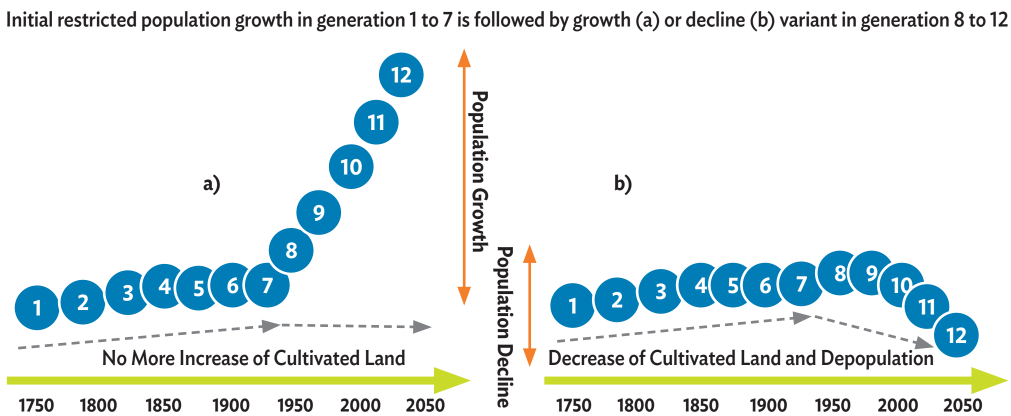
Figure 3: Land and Population in Dependence According to (a) Malthus and (b) Verhulst



Source: Author.

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

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



Source: Author.

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

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

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

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

The Case of Austria

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

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

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

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

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

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

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

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

The Case in ASEAN Countries

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

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

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

Lao PDR = Lao People's Democratic Republic.

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

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

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

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

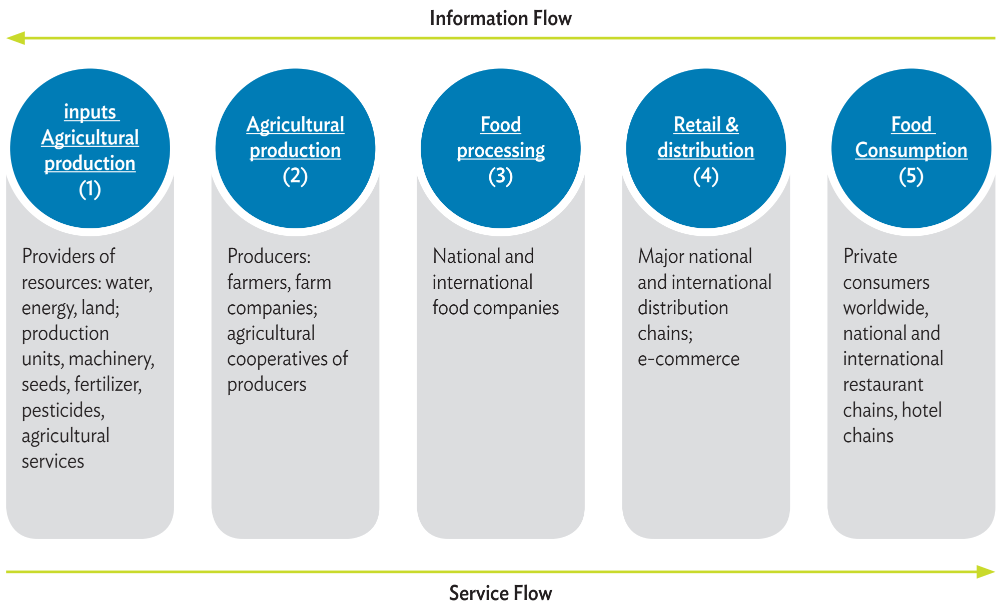
The group of poorest countries has yet to establish a sophisticated food processing and food distribution network. A high number in agricultural income is also associated with low national income. Many people produce food through subsistence agriculture using almost entirely local resources and human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

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

The Food Supply Chain

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

Figure 5: Actors in the Food Supply Chain



Source: Author.

The first group are stakeholders that relate to agricultural inputs. Any agricultural production is dependent on inputs. We need the provision of basic resources such as farmland with some 1.5 billion ha globally, the right amount of water resources, and energy in various forms such as gasoline and electricity. Then we need particular inputs such as seeds, fertilisers, pesticides, machinery, and production units like greenhouses, storage halls, and other built environment. Finally, we can name agricultural research and services as an input class. During the last decade after the financial crisis in 2008, farmland became an important post of speculation. Since then, every year, at least 10 million ha are sold from family farms to institutional investors at approximately US$500 per hectare (based on Deloitte, 2013). Climate-induced water problems challenge agricultural production and more frequent droughts and floods have increased price levels for agricultural commodities. Unpredictable price levels of energy may further aggravate the situation. Progress in agricultural research – like introduction of drought-resistant wheat varieties – allows countering some of the new threats. Decreased levels of fertilisers and pesticides due to precision farming allow important reductions in inputs. The development in smart farming may offer important new possibilities of even lower resource input.

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

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

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

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

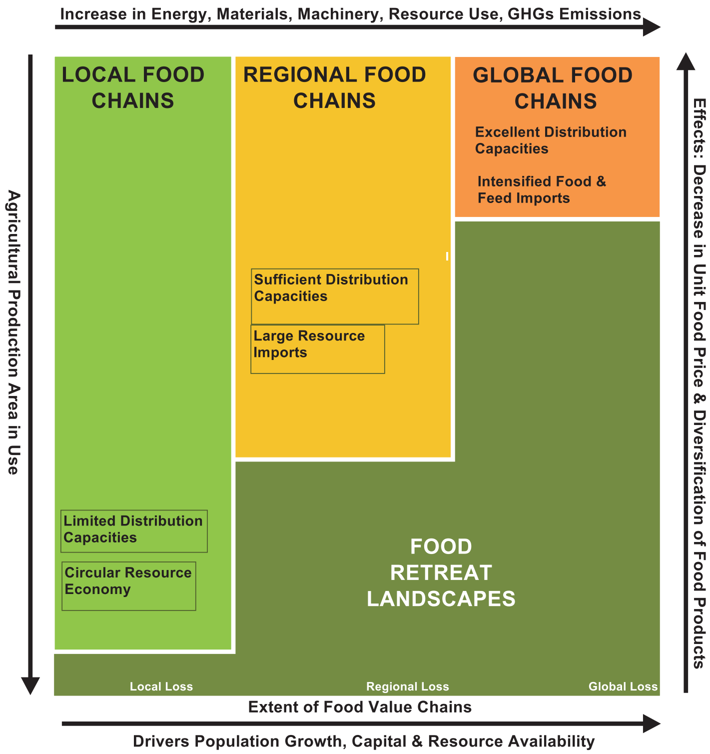
ASEAN countries, there is particular concern regarding certified food for religious groups, like halal food, that differ from organic food criteria.

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

Growing Distance, Capacities, and Resource Demand in Food Chains

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

Figure 6: Food Distribution Upscaling from Local to Global



Source: Author.

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

Increasingly, more food has to be imported and gradually, the situation symbolised in regional food chains (Figure 6) emerges. Food trade becomes more important. The capacity adjusts to higher volumes of the regional scale and increasingly more kinds of food are regionally available. In past decades since industrialisation, food production and food trade networks could grow according to regional or national possibilities. Regional dishes such as pizza in Italy/Europe or sushi in Japan/East Asia have developed dependence on regional interactions. Every region was for long time only sticking to endogenous food traditions simply because of no or limited interaction with the outside. The regional food supply chain has many more stakeholders. Specialisation in the food chain takes place according to managing inputs, agricultural production, food processing, retail, and consumption. Capital is needed to promote this specialisation that leads to higher capacities. The resource flows are increasing as well. Water availability for irrigation of agricultural fields is a way to boost agricultural productivity and, accordingly, population growth.

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

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

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

Change of Disaster Risk and Food Security Strategies in ASEAN

Development in Peripheral, Small, and Remote Local Areas

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

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

Development in Regional Centres

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

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

Wars and serious political crises could change the effects of disasters and food security. While droughts or floods have perhaps limited consequences in peaceful conditions, e.g. damaged infrastructure can be replaced easily in a normal trade situation, the situation can become catastrophic when there are trade restrictions. South Sudan experienced serious droughts in 2011, 2015, and 2016 amidst a civil war (Reliefweb, 2016). Agricultural production was disturbed and coincided with repeated droughts and extremely limited trading possibilities. Up to 5 million people, about half of the country's population, were severely food insecure leading to the starvation of an estimated 30,000 people. In the 1990s, North Korea experienced not only food insecurity but dramatic famine after flooding episodes in combination with the breakdown of trade connections with former partner countries (Lee, 2006).

Development on Global Scale

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

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

Change of Disaster Risk Strategies in ASEAN

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

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

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

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

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

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

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

Conclusions

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

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

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

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

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

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

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

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

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

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

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PART 5
KEY MESSAGES AND POLICY RECOMMENDATIONS

Food value chains at all levels are increasingly vulnerable due to natural disasters and developing business continuity is a key concern for the policy makers. The three major gaps that hinder business continuity after disasters are the information gap, science gap, and policy gap. A comprehensive and standardised accounting of losses in agriculture is needed. A more systematic integration of scientific disciplines is desirable. The prevention of negative consequences from natural disasters such as averting fatalities and harm to infrastructures is a key concern in international cooperation. Damage to agricultural production networks and food value chains is often not registered, and methods on calculating damage vary in individual countries.

Developing countries, in particular, suffer from loss and damage from disasters where the agricultural sector accounts for 25% of them. Damage within the food supply chain has to be classified into production damage, transportation damage, and storage damage. Disasters cannot be seen on market prices; the matching of small and large scales is imperfect. Global food value chains include richer and poorer countries with lower or higher dependence on the agricultural sector.

The provision – or non-provision – of instruments, plans, or institutional measures either by countries or political systems can ease or aggravate disaster impacts on food supply chains. Guidelines on tools development, data collection, and measurements (indicators-indexes) for making possible improved regional evaluations/comparisons of impacts, vulnerabilities, and local capacities such as the level of entrepreneurship or attitudes to handle natural hazards, should be elaborated with the participation of Organization for Economic Co-operation and Development, Economic Research Institute for ASEAN and East Asia, and Food and Agricultural Organization, and disseminated broadly in member countries.

It is difficult to predict the degree and severity of disasters and issue an appropriate warning time. The trend to the integration of production networks with markets according to 'just in time' and 'just in sequence' increases interdependencies. This also increases the vulnerability to disasters from far away. In particular, oligopolistic markets can exploit disasters for business advantages at the expense of other players. counteract national emergency relief funds.

An unsolved issue is the benefits and costs of individual and society. Private weather insurance schemes counteract national emergency relief funds. Some risks cannot be insured while others are compensated by the state without adequate premiums.

Policies for resilient value chains should be sensitive to the local/regional differences; allow and stimulate the strengthening of local capacities, sustainable farming, and niche markets; and take particular local vulnerability into account. Value chain analysis is a valuable tool for integrating wider multi-scalar perspectives in regional policy. Whenever possible, governments should undertake cost–benefit analysis of policy responses that address individual risks like droughts, floodings, storms, hail, and frost at the national and regional levels.

Women, in particular, play a dominant role in local food value chains. Most women stay on farms throughout the year while their husbands often leave for seasonal work. Strengthening the position of women can also increase disaster resilience. A viable economy is often the precondition for planning prevention or mitigation actions against disasters.

Considering a territorial approach on agricultural production networks, one can see a close interconnection between agriculture and tourism in rural areas. Authentic local and regional food production – often in combination with organic food production – is a means to increase the value of local and regional food chains..

A key concern for any value chain – the food value chain, in particular – is activity. In many rural areas, the level of activity becomes limited. Actions with citizens from the outside stimulate innovation and feedback from other sources.

Resilience to disasters can be altered by better soil and water management. This is connected to a wider application of organic or precision agriculture methods, the availability and use of sophisticated climate information, the legal enforcement of land, use, and environmental protection strategies. Organic agriculture is a measure for sustainability, disaster prevention, and a higher value of the product. The interrelationship between improved soil and water management and higher prices for organic products should be further highlighted.

Water availability has to be matched by sustainable quantities of water. Any guarantee of water use not coupled to the weather and climate will increase the vulnerability of the agricultural sector. Good soil management is essential for sustainable water management. High organic content in soil stores several times the amount of water than soils with an average content in soil organic matter. Avoided erosion is also disaster prevention and an increase in water capturing capacity.

Agricultural policy incentives should support production decisions that increase the resilience of agro-ecological systems and decrease the vulnerability to natural disasters. Problems observed are related to insurance subsidies or guaranteed prices which stimulate farmers to increase risk exposure.

Data-driven information helps stakeholders understand systems and processes and is a means to design scenarios and see the impact on system dynamics. The broad application of data-collecting instruments depends on their cost. It is expected that these instruments will become more affordable in the future. Particular forms of smart farming and ICT in agriculture – reaching from disaster information or warning to partly (glasshouse) or full (plant factory) environmental control – can avoid disaster loss and damage in agriculture. The costs of investments in ICT-related disaster prevention in agriculture are currently too high for most farmers. Therefore, state programmes should allocate some means to support private investments for technology-driven innovations.

APPENDIX:
ORGANISERS AND SPONSORS

TU Wien

TU Wien is one of the major universities in Vienna, Austria. The university finds high international and domestic recognition in teaching as well as in research, and is a highly esteemed partner of innovation-oriented enterprises. It currently has about 26,200 students (19% foreign students and 30% women), eight faculty members and about 4,000 staff members (1,800 academics). The university's teaching and research are focused on engineering and natural sciences. The education offered by TU Wien is rewarded by high international and domestic recognition. Technology.Tourism.Landscape is an interfaculty cooperation centre established in 2005 and integrated in the Landscape Unit of the Department of Urban Design and Landscape Architecture of the Faculty of Architecture and Planning.

Economic Research Institute for ASEAN and East Asia

The Economic Research Institute for ASEAN and East Asia (ERIA) was established at the Third East Asia Summit in Singapore on 21 November 2007. It is an international organisation providing research and policy support to the East Asia region and the ASEAN and EAS summit process. The 16 member-countries of EAS – Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand, Viet Nam, Australia, China, India, Japan, Republic of Korea, and New Zealand – are members of ERIA.

OECD Co-operative Research Programme

The OECD Co-operative Research Programme (CRP) supports work on the sustainable use of natural resources in agriculture, fisheries, food production, and forestry, and research into new technologies in these areas. Demand for food and feed is increasing worldwide. At the same time, there is greater pressure on land, water, and biodiversity. Agricultural innovation, including research and development, can help boost productivity growth and make more efficient use of available natural resources. Information about both conferences/workshops and fellowships funded in 2016–2020 can be found in the programme website.