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Macfadyen S; Tylianakis JM;Letourneau DK;Benton TG; Tittonell P; Perring M;Gómez-Creutzberg C; **Báldi A**; Holland JM; Broadhurst L; Okabe K; Renwick AR; Gemmill-Herren B; Smith HG (2015) The role of food retailers in improving resilience in global food supply. GLOBAL FOOD SECURITY, 7: pp. 1-8. doi:10.1016/j.gfs.2016.01.001

The original published pdf available in this website:
http://www.sciencedirect.com/science/article/pii/S2211912416300025

# The role of food retailers in improving resilience in global food supply

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**Abstract**

We urgently need a more resilient food supply system that is robust enough to absorb and recover quickly from shocks, and to continuously provide food in the face of significant threats. The simplified global food supply chain we currently rely upon exacerbates threats to supply and is unstable. Much attention has been given to how producers can maximise yield, but less attention has been given to other stakeholders in the supply chain. Increasingly, transnational food retailers (supermarkets) occupy a critical point in the chain, which makes them highly sensitive to variability in supply, and able to encourage change of practice across large areas. We contend that the concentration in the chain down to a few retailers in each country provides an opportunity to increase resilience of future supply given appropriate, scale-dependent interventions. We make ten recommendations aimed at reducing variability in supply that can be driven by retailers (although some of the interventions will be implemented by producers). Importantly, resilience in our food supply requires the restoration and expansion of ecosystem services at the landscape-scale.

**Keywords**

Vulnerability, resilience, ecosystem services, sustainable intensification, landscape, supermarkets

**Highlights**

- The global food supply system we currently rely upon is unstable.
- Changes to production practices are necessary to increase resilience to threats.
- Retailers are ideally placed to mandate for change across large areas.
- Resilience in our food supply requires the restoration of ecosystem services.

## 1. **Introduction**

Our daily lives increasingly depend on a well-functioning global food production and delivery system. With rapid population growth in some regions, demographic and geo-political change, set against changing climate patterns and extremes, resilience of global food supply is paramount. Even small shocks early in the supply chain can amplify through the global agri-food system impacting people who are geographically distant from the disturbance (Puma et al., 2015; Suweis et al., 2015). For example, a drought period in 2007-08, coupled with low stocks and export restrictions, led to food price inflation sparking food riots in many places (Berazneva and Lee, 2013; Galtier, 2013). Significant crop (and post-harvest) losses due to weeds, invertebrate pest and disease outbreaks have continued over the last 40 years, despite increased use of pesticides (Oerke, 2005; Stokstad, 2013). Additionally, many countries have reached the limit of available land suitable for agricultural, with significant areas of this land now so degraded that returning it to productivity will be both difficult and costly (Smith, 2013; Strassburg et al., 2014). Without adaptive changes to the global agri-food system, climate change is expected to reduce crop yields in regions that are required to produce more in the future, and to increase variability in productivity in other regions (Challinor et al., 2014; Wheeler and von Braun, 2013).

We urgently need a more resilient food supply system that is robust enough to absorb and recover quickly from shocks, and continuously provide food in the face of significant internal and external threats (Suweis et al., 2015, see text box 1). These threats range from local factors such as pest outbreaks, pesticide resistance, extreme weather events, and political instability, to global threats such as climate change and changes in land use. In addition, threats outside the supply system (in the demand chain, Gilbert 2010) can interact and lead to price variability. Inputs such as water and agrochemicals are currently over-used in many production contexts whilst pesticide and antibiotic resistance threatens the effectiveness of these inputs. Increased reliance on inputs at the expense of natural ecosystem processes increases environmental externalities (Pretty et al., 2001), but also makes farming more vulnerable to changes that influence the price and availability of inputs. Without significant changes these factors may induce increased spatial and temporal variability in future food supply.

The purpose of our article is to highlight ways in which stakeholders along the food supply chain can contribute to reducing production variability by adopting more sustainable practices. We focus on the role of retailers, as they provide the link between producers and consumers, and therefore have an ability to influence decision-making at both ends of the food supply chain. Furthermore, their reach has increased in recent years in terms of accessibility for consumers in developing countries, and sourcing products or ingredients from producers around the world. We highlight 10 practical recommendations to improve resilience in food supply systems to a range of threats. The conceptual foundations of resilience in ecology are often applied to agro-ecosystems (text box 1), and here we use that foundation to explore ways in which we can reduce production variability. One of our main conclusions is that implementing certain intervention strategies at the landscape-scale is necessary to achieve the desired outcomes.

## 2. Characteristics of our current global food supply system

The food supply chain consists of many inter-connected stakeholders (producers, processors, packagers, distributors, transportation companies, wholesalers, supermarket retailers and consumers, Fig. 1) who will all benefit from, and must contribute to, a more resilient global food supply system. The simplified global food supply chain we currently rely upon exacerbates threats and is potentially highly unstable. This supply chain, which producers around the world deliver into (Fig. 2), encourages uniform production practices (Allison and Hobbs, 2004) that are highly efficient in "good years" but can also be maladaptive under changing conditions (Bennett et al., 2014). For example, inputs such as pesticides are often used to protect crops from damage, regardless of whether a pest is present, or if the overall risk of pest outbreaks has reduced due to climate change. Changing production practices, to those that are more sustainable using the recommendations we outline below, but may carry more risk for the producer in the short-term. Therefore, it is important that other stakeholders in the chain understand these risks and do not leave it up to producers along to bring about change.

Food retailers occupy a critical point in the food supply chain (Fig. 1), which makes them highly sensitive to variability in supply, and well-positioned to encourage change of practice across large areas (Burch et al., 2012; Konefal et al., 2005). There has been a "supermarket revolution" especially in developing countries over the past 20 years (although this has only just started in parts of Africa) (Reardon et al., 2012). As an example, in Thailand about 85% of people now have access to, and regularly purchase food from, supermarkets, compared to 47% ten years ago (Kelly et al., 2014). There has been a concentration and multinationalizing of retailers (Burch et al., 2012, and also processing and wholesale stakeholders, Reardon 2015). We contend that the concentration in the chain down to a few retailers in each country provides an opportunity to increase resilience of future supply given appropriate, scale-dependent interventions.

Many valid recommendations have been made for increasing food supply and reducing waste, and there is growing recognition that despite adequate food production, inequity in distribution ensures that malnutrition persists (Godfray et al., 2010). However, much of the focus of the global food security discourse has recently been about growing average yields, and has emphasized the role of highly productive, large-scale agriculture systems without much regard to their vulnerability to external shocks (McKenzie and Williams, 2015; Shen et al., 2013). Thus, our specific focus here is on reducing variability in production as a consequence of changing environmental, social, and market conditions since this variability has the potential to cause significant social and economic impacts (see text box 1). Resilience to threats in our food supply system, we contend, is often crucially related to under-pinning ecological functions that allow for enhanced delivery of ecosystem services within sustainable agri-food system (Bennett et al., 2014; Yachi and Loreau, 1999).

## 3. Resilient food systems necessitates a landscape-scale perspective

To increase resilience of production and supply, stakeholders should encourage, and in some cases mandate, sustainable practices with an emphasis on co-ordination at the landscape-scale (text box 2). Success of such practices frequently requires their implementation at the landscape-level. For example, area-wide pest management is required for: effective deployment of insect mating confusion pheromones, the removal of alternative host plants or sources of weed seeds, the maintenance of non-transgenic or unsprayed refugia for susceptible pest genotypes that delay the development of pesticide resistance, and the maintenance of vegetative habitat to support viable populations of arthropods that provide pollination and pest control services (Tscharntke et al., 2005). Longer-term interventions that improve ecosystem services such as water purification, flood control, and soil erosion prevention also need to be implemented at landscape-scale or greater to achieve the desired outcomes for sustainable food supply (Rodriguez-Loinaz et al., 2015). Government-directed policy initiatives often struggle to implement change at the landscape-scale (and in a global market) and instead focus on individual landowners to effect change.

Landscape-scale management requires local collaboration among landowners, which can otherwise be threatened by the ‘tragedy of the commons’ or lack of mechanisms for collective decision-making (Lant et al., 2008). We argue that food retailers operate at the interface between producers and consumers and consequently, hold a critical position to overcome this dilemma and influence production practices at the landscape scale (Jennings et al., 2015), while also shaping consumer attitudes to environmental costs of production, and thereby increasing demand for sustainable products (Lazzarinin et al., 2001). Consumer access to food through supermarkets has increased dramatically in recent years (Kelly et al., 2014), yet in some countries only a few food retailers sell to consumers (Fig. 1). This concentration of source products or ingredients from thousands of producers and traders around the world (Fig. 2), through a limited number of retailers, thus provides an opportunity for them to improve resilience to shocks in food supply.

## 4. Recommendations to improve resilience

We highlight 10 recommendations that can be implemented by stakeholders along the supply chain (Fig. 1), to reduce variability in supply and improve recovery from shocks. Examples of interventions based on existing knowledge and technologies that support these recommendations are given in Table 1. We focus just on these ten as they have significant research underpinning them (as identified by conversations amongst the authors), and are likely to improve sustainability and resilience across a range of farming systems. Retailers are well equipped to proactively maintain predictable flows of produce by implementing (or incentivising producers and consumers to implement) many of these recommendations, and this is likely to improve the resilience of their business and the sustainability of agricultural production. Likewise retailers can influence consumer decision-making at a range of scales to re-inforce sustainable production practices. Some retailers already have existing sustainability standards and some of our recommendations will be encompassed by these (but see text box 1). Our recommendations are:

1. ***Mandate practices that maintain and restore soil resources*.** Global degradation of soils threatens food supply. However, regenerative management interventions have demonstrated potential to improve soil-microbe interactions, increase yields and ensure sustained high productivity that is less vulnerable to the extremes of water logging and drought, with the additional benefit of helping to mitigate climate change by increasing soil organic carbon (Alliaume et al., 2014; Holland, 2004; Lal, 2004).
2. ***Protect water resources*.** Increased variability in rainfall, reduced water quality and increased competition for water resources threaten the production of irrigation-dependent crops (Mancosu et al., 2015). To prevent water-borne contamination of produce, or human conflict under extreme water scarcity, interventions include rainwater capture and storage, conservation tillage, vegetative buffers against agricultural run-off entering waterways, and expansion of efficient irrigation infrastructure.
3. ***Identify marginal or low productivity land and encourage its removal from high-input production.*** Degraded and less productive parcels of land with high input costs relative to yields can be conserved to support the environmental benefits increasingly demanded

by society. Connectivity of these patches at the regional-level supports producers' social licence to operate and benefits biodiversity-based ecosystem services. We should investigate strategies for integrating these areas across the landscape, and using them to create multifunctional agricultural landscapes (Renting et al., 2009).

***4. Ensure producers use agrochemicals judiciously.*** Reduced pesticide-use reduces the evolution of pesticide resistance in insects and weeds (Stokstad, 2013), harm to non-target organisms, environmental contamination (Pelosi et al., 2013), and residues on food. Consumer demand for reduced health risks will require producers to adopt strategies that replace chemical inputs, where possible, with the activities of naturally occurring ecosystem service providers as in conservation biological control and adoption of area-wide pest management strategies against mobile pathogens. Increased nutrient-use efficiency and better targeting of nutrient input to areas where nutrient deficiency is recognized as the limiting factor has the potential to reduce farmer costs and limit runoff into waterways (Grafton and Yule, 2015).

***5. Encourage landscape-scale diversification.*** A diverse crop portfolio protects farmers from price- and environmental-volatility and provides trade opportunities for smallholder farmers, thereby helping to ensure farm business resilience (Abson et al., 2013). Moreover, landscapes that integrate crop, livestock and forestry systems with natural set-aside areas experience a higher, and more resilient, provision of ecosystem services such as crop pollination and pest control (Kremen and Miles, 2012; Liebman and Schulte, 2015; Tscharntke et al., 2005). Finally, diverse landscapes improve the efficiency of resource flows among landscape components, such as winter feed for stock or use of stock manure as fertiliser.

6. ***Encourage sustainable livestock management practices.*** Global demand for livestock produce is growing. Supplying this demand means meeting increasing consumer demand for evidence of humane livestock conditions, whilst improving the sustainability of fodder production, reducing the risk of disease outbreaks (which may spread across continents) and preparing for the consequences of growing antibiotic resistance (Eisler et al., 2014; Martin and Greeff, 2011). Accounting for the full environmental costs of livestock production practices, and if applicable, offsetting these costs using interventions in other regions, is critical to future improvements.

7. ***Identify future crops and products and help prepare farmers***. As climate changes make some crops non-viable in certain regions, production may need to shift to new crops, forage plants and livestock breeds that are better-suited to future conditions (e.g. bambara nuts, moringa, perennial grains), or to "rediscovered" traditional agricultural products that can be marketed to a new generation of consumers. Perennial cultivation, with many benefits for soil health and sustainability, will need a careful and supportive articulation with markets (and consumers), differing from annual production systems that can more readily switch crop-types (FAO, 2013). Often producers have already identified potential new products, but require support to develop them into marketable commodities.

8. ***Support the farmers of the future.*** The average age of farmers is increasing in many countries as young people migrate to urban areas or face professional barriers (e.g., land

prices and availability). Whilst this issue goes beyond food retailers, there is a critical need for retailers to recognise the impact of this shift on the resilience of their business. Interventions include encouraging support networks for farmers, ensuring that the rural way of life is profitable (through fair pricing), lobbying governments to support sustainable land tenure agreements, and encouraging retailers to better understand farmers aspirations and production constraints (de Snoo et al., 2013; Farmar-Bowers, 2010).

9. ***Identify products (and their ingredients) that are produced in high-risk regions.*** Risks of disrupted supply in some regions may be generated by local environmental (e.g. climate change) or social/political instability (Lagi et al., 2011) (Fig. 2). Solutions will require either policy mechanisms to reduce risks, production specifically tailored to build local sustainability and resilience to withstand environmental risks (Rossing et al., 2014), or carefully planned alternative sourcing by retailers and food manufacturers from a wider spectrum of producers.

10. ***Identify products (and their ingredients) that have costly environmental externalities - mitigate these externalities.*** Trade-offs between increased productivity and the environment may negatively feedback to production and ultimately generate an unsustainable and low-resilience supply (e.g., through soil degradation, loss of pollination services, inefficient water use) (Matson et al., 1997). In some cases this could be ameliorated through improved management practices; in others, product substitution must be considered. True cost accounting, including the cost of negative externalities in the prices of agricultural produce, is one means of creating incentives for change (Pretty

et al., 2001). Importantly, consumers should have access to the provenance, and estimated environmental costs, of products and ingredients in products sold by retailers, so they can make informed choices.

## 5. The role of retailers

The fundamental basis of many of the 10 recommendations is the restoration and expansion of ecosystem services in agricultural landscapes. Encouraging producers to move away from input-driven agricultural decision-making is challenging and retailers have a role to play in this transition process. Retailers have the power to issue production mandates that can lead to wide-scale change of practice. The scale of implementation of these production mandates and specific interventions (e.g., Table 1) is critical, as is the farming context in which they take place. Crop failures occur when mutually disruptive practices are employed in individual farming operations, such as monocultures that homogenize resources for specific pest species, landscape-wide use of the same varieties that facilitate disease spread, uniform spray tactics that harm pollinators and soil biota and select for pesticide resistance, or planting times that assist pest or pathogen build-up. Coordinated, long-term interventions are necessary for sustaining the provision of ecosystem services that buffer against these threats. Importantly, some of these interventions can be implemented now through relatively simple changes. For example, many strawberry producers in California still use methyl bromide soil fumigants to control diseases, nematodes and weeds, despite it being banned in other crops. The transition away from this practice is foreseeable, and is already taking place through individual growers who have begun to implement anaerobic soil disinfection, a promising alternative treatment involving microbial shifts after carbon inputs and flooding (Butler et al., 2014). Encouraging all growers to find alternative approaches could be aided by purchase premiums offered by retailers and associated education of consumers.

Standards and policies dictated by retailers already have a global reach, influencing production practices in terms of food safety, quality and environmental impacts (Burch et al., 2012). However, many small-scale producers cannot meet standards or price points, and must operate independently using local markets (Konefal et al., 2005). These local markets should be viewed as collaborators, not competitors of big retailers. In many instances, local markets use complementary food distribution systems such as food hubs, community-supported agriculture or farmers' markets. Farmer to farmer movements and agroecological farming models support local consumption and export crops in parallel supply chains outside of the mainstream markets, and may provide innovative examples for resilience in the face of climate change and market fluctuations (Babin, 2014). In addition smallholder farmers in certain contexts may require different management strategies to improve resilience to shocks that we have not addressed properly here.

## 6. Conclusions

Our food supply system needs to be and can be made more resilient through the implementation of appropriate interventions at the appropriate scale, but this should not be left up to producers or government policy alone. Stakeholders, such as global food retailers and consumers, also have a key role to play in ensuring resilience in our global food supply system to a range of current and future threats. If the 10 recommendations outlined here were adopted as a road map for resilience by transnational retail companies there would be significant changes in the way large areas of agricultural land are managed in the future. These recommendations may also help shift consumer perceptions around the true costs certain products. These interventions, based on currently available knowledge and technology, could lead to more sustainable agricultural landscapes over a relatively short time frame.

**Acknowledgements**

This paper was developed as part of workshop hosted by CSIRO in Brisbane sponsored by the Organisation for Economic Co-operation and Development's (OECD) Co-operative Research Programme on Biological Resource Management for Sustainable Agricultural Systems. In addition to the authors, Gary Fitt, Nancy Schellhorn, and Saul Cunningham were also involved in discussions that led up to this paper. JMT and CG are funded by the Ministry of Business, Innovation and Employment, NZ (C09X1307) and JMT by a Rutherford Discovery Fellowship. KO is by the Environment Research and Technology Development Fund (S-9) of the Ministry of the Environment, Japan. AB is funded by the MTA Lendület program, LIBERATION FP7 project and the Hungarian Scientific Research Fund (OTKA NN101940). HGS was funded by Formas and LIBERATION FP7. MPP was partially supported by an ARC Laureate Fellowship awarded to R.J. Hobbs. Daniel Macfadyen was instrumental in the graphic design of the figures. The icons in the figures

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**Text box 1. The concept of ecological resilience**

The term resilience is used in a variety of contexts but can often be vaguely defined and difficult to quantify. In ecological systems resilience is described as the ability of a system to absorb changes in state variables and so persist after a disturbance (Holling, 1973). In social–ecological systems, such as agriculture, resilience can be defined as the ability of the system to withstand stress factors while maintaining productivity, and the capacity to learn and adapt (Folke et al., 2010). Thresholds of disturbance, at which an ecosystem switches to another state, can be used as a measurement of resilience (Standish et al., 2014). Here we talk about resilience in terms of production variability, and the ability of agro-ecosystems to maintain stability in production levels even in the face of disturbances. The replacement of ecosystem services with artificial inputs such as pesticides, fertilisers, and irrigation is one way to reduce production variability in the short-term. However, these practices come with a range of environmental externalities (Pretty et al., 2001) that eventually lead to negative feedbacks and ultimately a reduction in productivity. Allison & Hobbs (2004) use land-use change in the Western Australian agricultural region as an example of how you can apply a framework based on resilience theory to examine capacity for change and renewal to a large-scale social-ecological system. More recently resilience thinking is being applied real-world species conservation and ecosystem management decisions.

**Text box 2. What does a resilient global food supply system look like?**

For our food supply system to be “resilient” it must be able to withstand shocks, or recover quickly from those that occur (Holling, 1973). Food security is defined as when people, at all times, have access to sufficient, safe, nutritious food to maintain a healthy and active life

(FAO, 2008). A resilient food supply system is therefore critical for delivering food "at all times". The recent global food price spikes have illustrated that the food supply system we currently rely on is fragile (Berazneva and Lee, 2013; Galtier, 2013) and this leads to transitory periods of food insecurity for some, and chronic food insecurity issues for others. At the global-level our food supply system is vulnerable to self-propagating disruptions due to the fact that many countries rely on imports for staple foods and often will stop exporting to other countries during a crisis to protect domestic supply (Puma et al., 2015). One way to increase resilience in this context is to increase redundancy at the production level. If production of certain commodities are interrupted in one region, other regions can potentially make up for the losses. A second way is to reduce the risk of wide-scale production losses due to extreme weather, pest outbreaks, or other events. Whilst food retailers cannot stop such events they can help to ensure that agricultural landscapes are managed in such a way to improve robustness to these shocks. Often these management interventions (Table 1) need to be implemented at the landscape-level to achieve the desired outcome. Resilience is one component of sustainability in this context. A discussion of the inter-connectedness of these two concepts is beyond the scope of this article, however we do observe that there is a strong relationship between management practices aimed at improving sustainability and those that help build resilience in production landscapes.

**Table 1**. Examples of intervention strategies that may be used by stakeholders in response to the 10 recommendations made above to improve resilience in the food supply chain. The second column highlights the potential threats that could be minimized using the intervention strategies outlined in the third column.

| *Recommendation* | *Threats or negative changes* | *Examples of interventions to increase resilience* |
|---|---|---|
| **1. Maintain and restore soil resources** | Loss of productive land due to erosion and salinity, yield losses from crop disease owing to reduction in microbial diversity needed for pathogen suppressive soils. | Apply minimum or conservation tillage and other interventions that build soil organic matter.<br>Repair degraded soils via re-vegetation initiatives, green manures and application of organic matter.<br>Reduce soil erosion by maintaining year-round plant cover (e.g. cover crops, wind breaks).<br>Use precision agriculture to ensure nutrient inputs/irrigation are matched to the conditions and crop requirements. |
| **2. Protect water resources** | Production losses from insufficient water supply for crops, food contamination from microbial movement in water, and groundwater pollutants. | Match crops to water availability.<br>Manage soils and habitats to hold water, prevent water loss and mitigate pollution.<br>Build infrastructure for holding and distributing water (e.g. improved irrigation channels, drip systems).<br>Protect riparian corridors by implementing spray buffers, re-vegetation, and fencing from livestock. |
| **3. Remove marginal land from high-input production** | Loss of customers, shift of customers to other food supply chains. | Invest in conservation interventions – like habitat restoration, traditional farming on non-productive land and in strategies for integrating these interventions across the landscape or within multifunctional landscapes.<br>Financially support conservation interventions aimed at iconic farmland species and habitats (e.g. traditionally managed grasslands). In some contexts low-intensity farming can support biodiversity conservation.<br>Develop habitat conservation interventions that also support the provision of ecosystem services.<br>Improve guidelines on land tenure in marginal lands such that farmers have security to make environmentally sustainable investments (i.e., support mobility). |
| **4. Use agrochemicals judiciously** | Pesticide resistance, loss of natural pest control, unacceptable level of residues on food.<br>High inorganic fertilizer prices. | Encourage farmers to use the appropriate quality and quantity of agrochemicals.<br>Provide training and support for integrated pest management and area-wide management strategies.<br>Interventions to enhance or maintain biodiversity-mediated pest control, such as hedgerows, perennial non-crop habitat in farming landscapes.<br>Educate consumers to recognize and accept cosmetic damage to fresh produce and to focus more on the health and environmental aspects of food. |
| **5. Encourage** | Dwindling or | Encourage farm businesses to produce a diversity of crop types |

| | | |
|---|---|---|
| **landscape-scale diversification** | unsustainable supplies of synthetic chemical inputs.<br>Increasing threats from pest and disease outbreaks in homogenous landscapes. | and varieties.<br>Support farming systems that integrate livestock and crop production.<br>Use manure and leguminous cover crops to improve soils.<br>Return waste/by-products from crops/food processing to livestock.<br>Encourage agro-forestry. |
| **6. Encourage sustainable livestock management practices** | Livestock production becomes prohibitively costly through thresholds such as antibiotic resistance, pasture loss, or increased cost of imported feed. | Encourage mixed forage systems.<br>Match stocking levels to available forage to prevent land degradation from erosion and over-grazing.<br>Support certification for humane livestock standards that avoid pathogenic conditions and lower disease incidence.<br>Encourage pastoral production through development of new forage mixes and livestock breeding programmes.<br>Develop new sustainable feeds that are locally derived. |
| **7. Identify and prepare for the products of the future** | Our current products are not well suited to future environmental and societal conditions. | Invest in Research, Development & Extension activities around newly emerging products that have the potential to be sustainably produced under future environments.<br>Work with producers who have identified a potential new product to overcome marketing constraints.<br>Assist in the development of "demand forecasting" strategies for certain agricultural industries.<br>Articulate how these new products differ from existing products (e.g., perennial grain crops). |
| **8. Support farmers of the future** | Farming is not considered an attractive lifestyle or career path, changing demographic trends in many rural areas that we don't fully understand. | Develop policies for negotiating with producers that respects their role as farmers and land-stewards.<br>Ensure that the capability to continue farming in a region is present by sponsoring learning opportunities for champion farmers and promoting other education initiatives.<br>Be aware and knowledgeable of the local context and community attitudes and cultural differences when negotiating with farmers around interventions. Recognise and value the traditional knowledge of some producers.<br>Encourage sustainable land tenure agreements. |
| **9. Identify products that are produced in high-risk regions** | Disruption to supply by hurricanes, workers strikes, warfare, or production delays from worker shortages, and disease epidemics. | Initiate alternative sourcing for products from these regions, or identify and support local alternative products and incentivize long-term sustainable production practices that support local livelihoods and reduce vulnerability to risks. |
| **10. Identify products that have significant and costly environmental externalities** | Production practices cause resource degradation that undermines stability of production. Product supply dependent on practices harmful to non-target organisms. Consumers avoid products because of | Ensure all supply chains are evaluated by retailers and are transparent to consumers. True cost accounting.<br>Identify products sourced from locations with hard trade-offs with the environment. Can these be sourced from a more desirable location or produced in a different way?<br>Encourage an increased use of seasonal local products and wean consumers off year round supplies of certain products.<br>Circulate sustainability advisory lists (as is done with seafood) to indicate which products are the best choices, acceptable, and best to avoid. |

real or perceived environmental and/or social costs.

**Figure 1.** The simplified food supply chain typically comprises many stakeholders, but few organisations in the centre. However, where few organizations dominate a section of the food supply chain, their mandates have the power to influence production practices (top arrow) and consumer decisions (bottom arrow). The illustration (not to scale) is based on a study by the Dutch Environmental Agency (Hoogervorst et al., 2012). Five wholesale traders serve the 16.5 million Dutch consumers, therefore for every trader there is an equivalent of 13,000 producers, 1,300 manufacturers and 300 distributors; there is one trader for every five supermarket chains that retail through 880 supermarkets. We make 10 recommendations for ways in which these stakeholders can improve resilience of the food supply chain.

**Fig. 2.** Ingredients for any product are frequently sourced from a wide variety of countries. The provenance of ingredients for a chocolate bar produced in the UK is likely to extend across 4 different continents, based on the major exporting countries for each ingredient. Disrupted supply of any ingredient threatens the supply of the entire product, and is hence an incentive for adopting a broadly adaptive resilience framework (see recommendations 9 and 10).

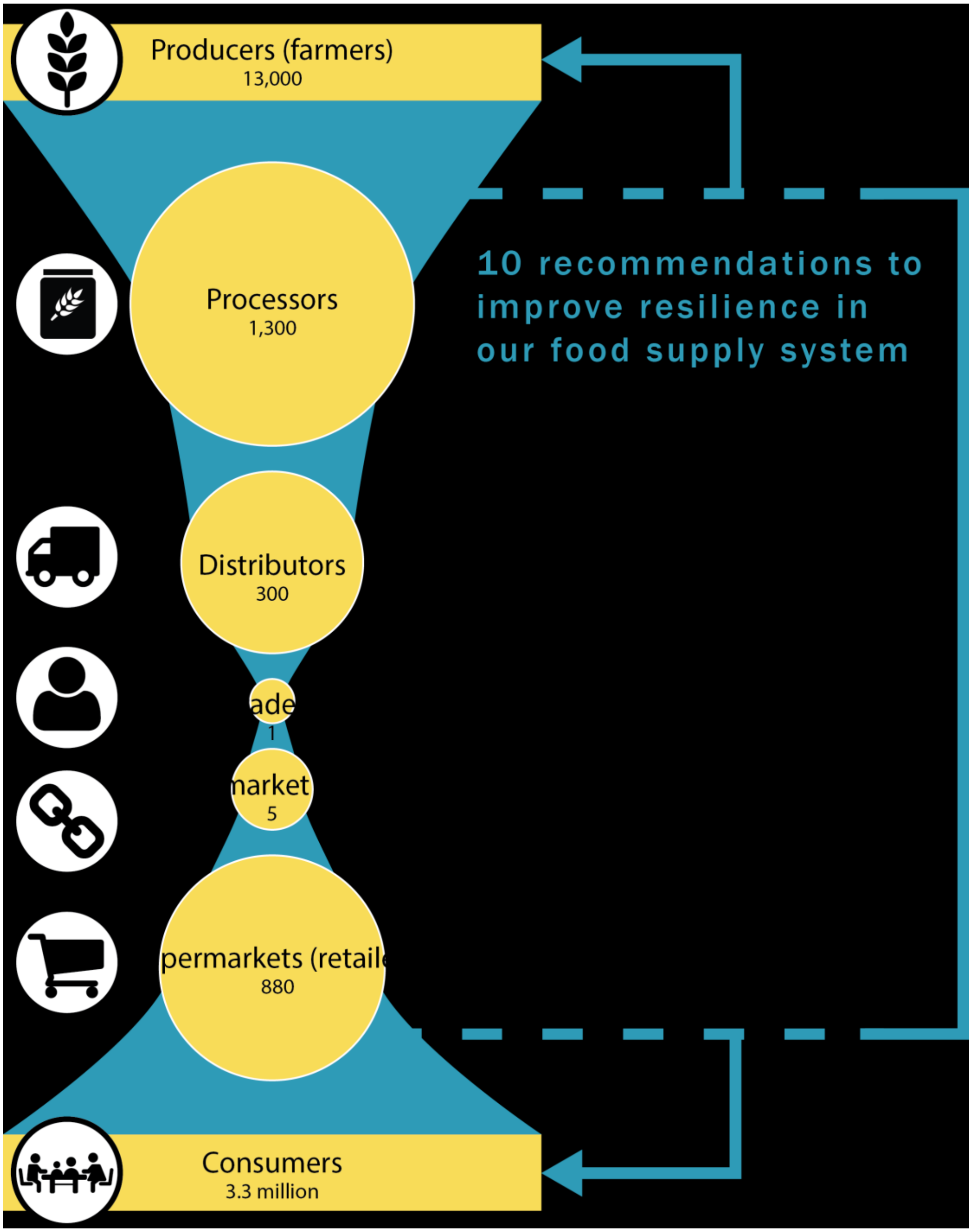
Producers (farmers)
13,000
Processors
1,300
Distributors
300
ade
1
narket
5
permarkets (retail
880
Consumers
3.3 million
10 recommendations to improve resilience in our food supply system

**Figure 1.**

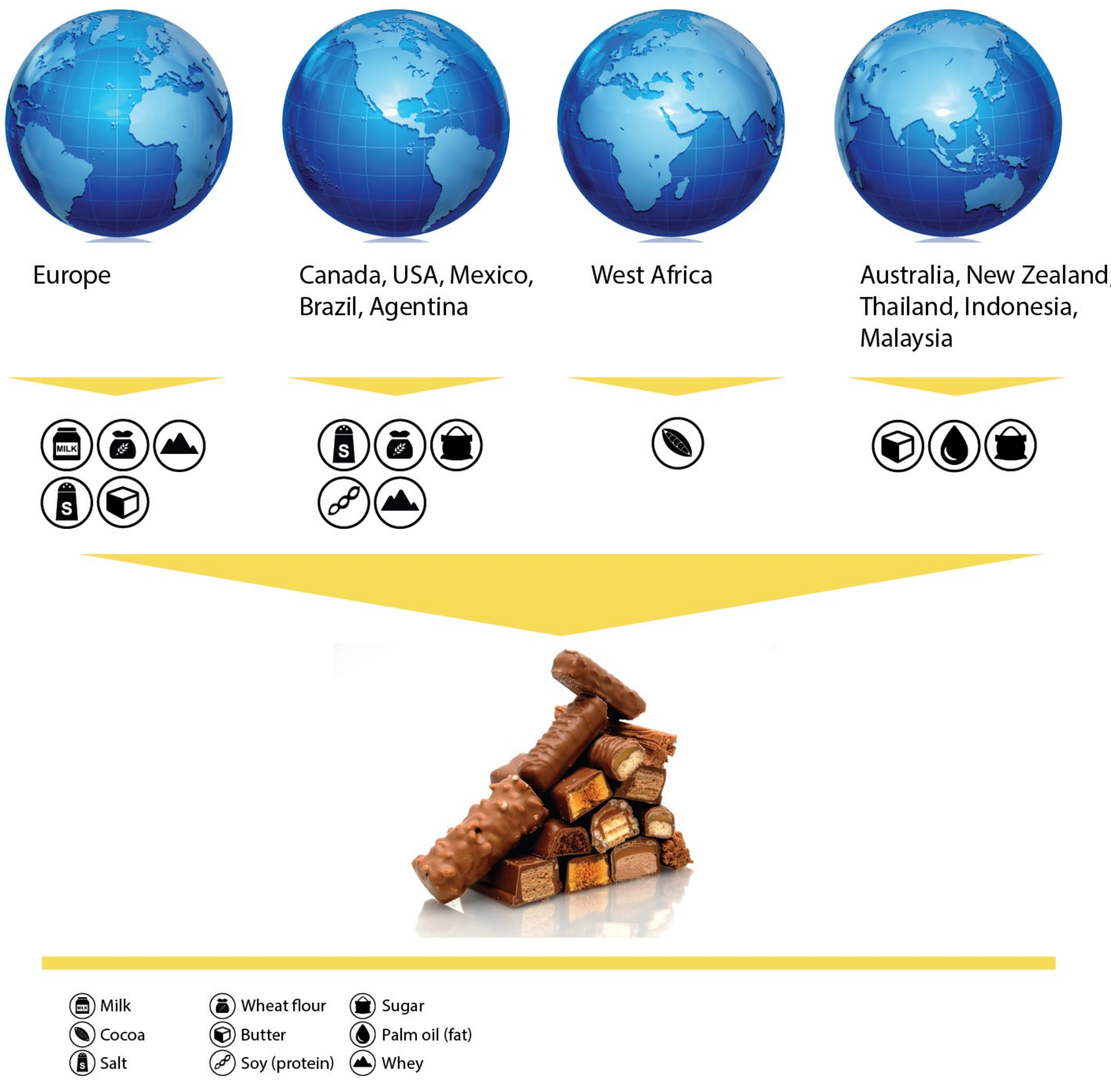
Europe
Canada, USA, Mexico, Brazil, Agentina
West Africa
Australia, New Zealand, Thailand, Indonesia, Malaysia
MILK
Milk
Cocoa
Salt
Wheat flour
Butter
Soy (protein)
Sugar
Palm oil (fat)
Whey

**Figure 2.**