Chapter 1: AGRICULTURAL RISKS AND RISK MANAGEMENT

Risk and uncertainty are ubiquitous and varied within agriculture and agricultural supply chains. This stems from a range of factors including the vagaries of weather, the unpredictable nature of biological processes, the pronounced seasonality of production and market cycles, the geographical separation of production and end uses, and the unique and uncertain political economy of food and agriculture sectors, both domestic and international.[1]

The above statement represents the day-to-day realities of life for hundreds of millions of farmers in developed and developing countries around the world. However, the impacts of realized agricultural risks are not peculiar to farmers alone. The companies and service industries that supply the farmers, the processing and logistics companies that move the produce from farm to the markets (that is, the wider supply chain), and ultimately the consumer all suffer to one extent or another.

Agricultural risks can range from independent (for example, localized hail losses or an individual farmer's illness) to highly correlated (for example, market price risk or widespread drought). Managing risks in agriculture is particularly challenging, as many risks are highly correlated, resulting in whole communities being affected at the same time. Clearly, given the widespread nature of resultant loss, financial recovery is particularly difficult and challenging. For governments, the fiscal implications of social safety net payments or the rebuilding of damaged infrastructure can be serious. For insurers, sudden losses suffered by a large number of policyholders places a strain on their reserves and financial stability. For farming communities, there is often no other option than to sell assets, normally at distressed prices.

Although this paper addresses only a certain type of risk (weather) and a specific method of seeking to manage it (insurance) and a specific type of insurance product (weather index) and in a particular economic context (developing countries), we shall briefly discuss in this chapter the following:

- Risks prevalent at the farm level
- Risks prevalent within supply chains
- Assessment of risk
- What is entailed in risk management

1.1 FARM-LEVEL RISKS AND CONSTRAINTS

Risks faced by farmers are numerous and varied, and are specific to the country, climate, and local agricultural production systems. These risks and their impacts on farmers are widely researched and classified in the literature and therefore we will not seek to cover the issues here.[2] The key risks faced by farmers are shown in table 1.1.

Additionally, farmers face constraints that do not enable them to either improve or increase their production and revenues. Examples of such constraints are limited access to finance, dislocation from markets, poor access to inputs, lack of advisory services and information, and poor infrastructure (for example, irrigation or rural roads). These constraints are generally worse in low-income countries, where public goods and private sector service delivery are often poorly developed.

The importance of noting the difference between a risk and a constraint is that often the latter are a function of the former. For example, many argue (and it would seem logical) that access to finance (in terms of both cost and availability) for farmers in developing countries would improve if the potential financiers were able to be assured that the risks inherent with agricultural production had been managed, thereby reducing their repayment risk.

Of course, many constraints are often not driven by one underlying risk alone. Taking access to finance once more as

1 See Jaffee, S., Siegel, P., and Andrews, C. (2010). "Rapid Agricultural Supply Chain Risk Assessment: A Conceptual Framework." The World Bank. Washington. D.C.

2 For a synthesis of risk management literature see Barnett, B., and K. Coble (2008). "Poverty Traps and Index-Based Risk Transfer Products." *World Development* 36:1766–1785.

TABLE 1.1: Key Risks Faced by Farmers

RISK	EXAMPLES/ FACTORS	EFFECTS
Weather risks	Rainfall or temperature variability or extreme events	Lower yields, loss of productive assets or income
Biological risks	Pests, disease, contamination	Lower yields, loss of income
Price risks	Low prices, market supply and demand, volatility	Lower prices, loss of income
Labor and health risks	Illness, death, injury	Loss of productivity, loss of income, increased costs
Policy and political risks	Regulatory changes, political upheaval, disruption of markets, unrest	Changes in costs, taxes, market access

Source: Authors.

an example, even if the underlying weather risk is managed through the purchase of an insurance product or installation of irrigation, this still leaves the financier running a number of risks. For example, the farmer may simply sell the product and not repay the bank, or prices may fall to such an extent at harvest that the revenue is insufficient to repay the loan amount, or perhaps the crop was destroyed by locusts and there was no crop left to sell at the due repayment date.

The issue of the existence of multiple risks in agriculture should be well noted. All too often, the apparent management of one major risk leaves stakeholders (although rarely the farmers) with the impression that the overall risk profile has been managed. However, this is often not the case; even when farmers and their partners have managed their own direct risks, indirect risks can cause losses. For example, an outbreak of aflatoxin in maize in a given country may lead to the imposition of an import ban by potential buyers. Even though farmers and the supply chain they are involved with may have well managed this risk and their maize is aflatoxin free, they will suffer from the country's market access restrictions.

Equally, even if a farmer has managed contamination risks in her own basket of goods, should the processor fail to control its crop collection or processing activities correctly, then the farmer may well suffer due to the exclusion of the processor from the market (there being no other buyer for the farmer's produce). Therefore, consideration of risk throughout a supply chain enables a more comprehensive assessment and management of risks.

1.2 SUPPLY CHAIN RISKS

Supply chains facilitate the flow of physical products, finance, and information. An agricultural supply chain encompasses all the input supply, production, postharvest, storage, processing, marketing and distribution, food service, and consumption functions along the "farm to fork" continuum for a given product (be it consumed fresh, processed, or from a food service provider), including the external enabling environment. These functions typically span other supply chains as well as geographic and political boundaries and often involve a wide range of public and private sector institutions and organizations.

The underlying objective of agricultural supply chain management is to provide the right products (quantity and quality), in the right amounts, to the right place, at the right time, and at a competitive cost—and to earn money doing so. Logistics and communications are embedded in all of these flows, and poor logistics and communications are often major constraints that can exacerbate underlying risks in many agricultural supply chains. For governments, there may be broader objectives involved, especially where the supply chain is especially strategic for trade or critical in the domestic food system. Risks within the supply chain are shown in table 1.2.

Given the complexities of agricultural supply chains and the products that they work with, there is little surprise as to the extent of the risks. One factor that complicates the situation and increases the number of risks within these supply chains is the perishability of the products involved and also the fact that many of them are intended for human consumption (which means that more controls are required in order to ensure human safety). Effective management of these risks generally requires the close cooperation of the various supply chain actors and a degree of sophistication and flexibility that is often not found in developing countries.

1.3 RISK ASSESSMENT

Although being aware of a risk is clearly important, before one can consider managing it, one must actually assess the risk being considered. Risks (and their impacts) are assessed by quantifying three main variables: hazard, vulnerability, and exposure.

- **Hazard** is the categorization of the type of risk being considered—for example, weather, price, pest, policy, or market. The quantification of the hazard is then undertaken by assessing three subvariables:
  - Frequency: How often or likely is the risk to occur?
  - Severity: What are the likely fiscal impacts of such a risk if it occurs?

TABLE 1.2: Major Risks in Agricultural Supply Chains

TYPE OF RISK	EXAMPLES
Weather	Periodic deficit or excess rainfall, varying temperatures, hail storms, strong winds
Natural disaster (including extreme weather events)	Major floods, droughts, hurricanes, cyclones, typhoons, earthquakes, volcanic activity
Biology and environment	Crop/livestock pests and diseases; contamination caused by poor sanitation, humans, or illnesses; contamination affecting food safety, natural resources/environment, or production and processing
Market	Changes in supply or demand that impact domestic or international prices of inputs or outputs; changes in demand for quantity or quality attributes, food safety requirements, or timing of product delivery; changes in enterprise or supply chain reputation and dependability
Logistics and infrastructure	Changes in transportation, communication, or energy costs; degraded or undependable transportation, communication, or energy infrastructure; physical destruction, conflicts, or labor disputes affecting transportation, communication, energy infrastructure, and services
Management and operations	Poor management decisions; poor quality control; forecast and planning errors; breakdowns in farm or farm equipment; use of outdated seeds; lack of preparation to change product, process, markets; inability to adapt to changes in cash and labor flows
Policy and institutions	Uncertain monetary, fiscal, and tax policies; uncertain regulatory and legal policies or enforcement; uncertain policies on trade, market, or land and tenure systems; governance-related uncertainty; weak institutional capacity to implement regulatory mandates
Politics	Security-related risks; uncertainty associated with sociopolitical instability within a country or in neighboring countries; interruption of trade due to disputes with other countries; nationalization or confiscation of assets

Source: Jaffee, S., Siegel, P., and Andrews, C. 2010. "Rapid Agricultural Supply Chain Risk Assessment: A Conceptual Framework." The World Bank. Washington. D.C.

  - Spatial extent: How widespread would the impact of the risk be—one person? one village? one country?
- **Vulnerability** is an estimation of what the impact of the realized risk would be given the assets affected by the event and taking into account the current ability to manage the impact.
- **Exposure** is the identification of the location of crops, livestock, and farm holdings that may be directly impacted by the hazard. Interdependency in the supply chain leads to indirect exposure for other parties.

Clearly this process of risk assessment involves the use of a number of assumptions and variables, so risk modeling is increasingly used as a tool to allow the development of probability estimates for financial losses. It should be noted that agricultural risk assessment is particularly dependent on the relationship between the timing of the loss event and the agricultural calendar. This is largely due to the fact that crop or livestock vulnerability varies according to the growth stage and season. In addition, risk assessment in agriculture is further complicated by the fact that vulnerability is heavily influenced by many local variables, such as soil, crop varieties, cultural practices, irrigation, and drainage. The use of and access to local knowledge and information is therefore essential to the interpretation of agricultural risk within a given area.

1.4 AGRICULTURAL RISK MANAGEMENT

1.4.1 Approaches

Having first become aware of a risk and then having assessed it, the next issue is how the party (or parties) at risk can seek to manage that risk. It should first be noted that risk management should be planned on an ex-ante basis (that is, before realization of an event); this is what is considered in this paper. Some ex-ante plans provide (financially or otherwise) for actions on an ex-post basis (for example, insurance payouts and government relief programs). Managing realized risks on an ex-post basis only is not considered to be risk management—after all, if something has already happened, it is no longer a risk (although a future reoccurrence might be). There is a great deal of literature on the subject of risk management and a surprisingly large amount of differing terminology in use. For the purposes of this paper and for the work of the Agricultural Risk Management Team (ARMT) at the World Bank, three clear approaches to risk management are considered:

- **Mitigation** is the lessening or limitation of the adverse impacts of hazards and related disasters. Risk mitigation options are numerous and varied (for example, crop and livestock diversification, income diversification, soil drainage, mulching, use of resistant seeds, avoidance of risky practices, and crop calendars).
- **Transfer** refers to the transfer of the potential financial consequences of particular risks from one party to another. While insurance is the best-known form of risk transfer, in developing countries the use of informal risk transfer within families and communities is extremely important.
- **Coping** refers to improving the resilience to withstand and manage events, through ex-ante preparation and making use of informal and formal mechanisms in order to sustain production and livelihoods following an event. Although we have noted that coping is an ex-post activity, it is possible to plan and to prepare for coping activities on an ex-ante basis. This is often fiscally beneficial, as the ability to quickly respond to events often reduces losses.

A fourth approach is that of **risk avoidance** or **risk prevention**. However, this is rarely possible in agricultural production, especially in developing countries where there are very few alternative sources of nonfarm employment.

1.4.2 Approaches: Informal Versus Formal

Farmers and their associated supply chains in developing countries have developed a range of informal and formal approaches to manage risk, and these are evident at the household, community, market, and government levels (see table 1.3). At the producer end of the supply chain, there is generally more reliance on informal approaches, whereas the later links in the chain tend to rely on more formal (and financially based) risk management approaches.

Clearly, informal approaches at the household level are related to the key hazards faced. For example, livestock are an important form of savings for the many households where drought is a risk, although this is an imperfect approach, as there may well be no feed available for the animal due to the drought and therefore it will be necessary to undertake "distressed" sales. Savings, buffer stocks, off-farm income, family networks, and informal borrowing also play a role. Community-level approaches, such as mutualization and mutual help, are normally informal or semiformal, although they can develop more formal structures as they become larger and more established.

More market-based, formal approaches include such things as formal savings, formal lending, and also insurance. Unfortunately, partly due to the number of risks prevalent at the farm level, access to credit tends to be severely restricted for agricultural borrowers. This problem is compounded by the fact that the majority of farmers have very low levels of collateral availability. Where more formal market arrangements exist (particularly for cash crops), farmers can benefit from some formal approaches. For example, contractual arrangements can lead to a packaging of credit and insurance services. With such contracts there may be the potential for advance price agreements and collateral enhancement through warehouse receipts.

1.5 WHICH RISKS? AND MANAGED BY WHOM?

As we suggested in the beginning of this chapter, it is not only farmers who are affected by agricultural sector risks.

TABLE 1.3: Risk Management Tools

SEVERITY OF RISK	POTENTIAL RISK MANAGEMENT MECHANISMS			
		HOUSEHOLD/COMMUNITY	MARKETS	GOVERNMENTS
	Nonspecific	Sharecropping Farmer self-help groups Water resource management	New technology Improved seed	Irrigation infrastructure Extension Agricultural research Weather data systems
	Low	Crop diversification Savings in livestock Food buffer stocks	Formal savings	
	Moderate	Labor diversification Risk pooling (peers, family members) Money lenders	Formal lending Risk sharing (input suppliers, wholesalers)	State-sponsored lending
	High/ Catastrophic	Sale of assets Migration	Insurance	Disaster relief State-sponsored insurance

Source: Authors.

In addition, it is also clear that different levels of the supply chain, or agricultural sector, have varying capacities (both financial and technical) to manage risks and that these are partly dependent on the severity of any given risk. As a consequence, the actual tools that are available to or used by the different stakeholders tend to differ. In table 1.3 we have provided some examples of the different tools according to severity and stakeholder.

1.6 PUBLIC-BASED EX-POST VERSUS MARKET-BASED EX-ANTE RISK MANAGEMENT TOOLS

In agricultural risk management, a distinction is necessary between measures that aim to create and foster the management of risk by *markets* (particularly insurance, savings, and formal lending) on an ex-ante basis and the management of risks by *government* (particularly emergency humanitarian relief, compensation for catastrophic events, and reconstruction of public goods) normally on an ex-post basis. Facilitating the use of market-based approaches can reduce the needs and scope for government interventions and thereby decrease the costs incurred by government in ex-post coping activities. For this reason, many governments are active in the promotion of market-based risk management and insurance (although they are normally operated through public-private partnerships). Examples of such activity are government subsidies, information and extension, and legal and regulatory measures, including those for insurance.[3]

However, when disasters strike or when there are losses that were not managed by the agricultural sector stakeholders, government intervention will be necessary, partly because not all risks are insurable and partly because not all farmers or stakeholders can or want to access commercial insurance. This latter issue of severity and requirement for government intervention raises the last main issue for this chapter: risk layering.

1.7 RISK LAYERING

The process of risk assessment and identification of risk management options also requires segmentation of levels of risk that can or should be retained by the farmer, managed by informal or community means, or transferred by instruments such as insurance. Risk layering, as this strategy is known, considers the practical and viable roles that can be played by the different levels of the agriculture sector or supply chain: farmers (micro level); processors, retailers, financiers, and insurers (meso level); and government (macro level). The main determinant in the development of the strategy is the ability of each level to manage with the given risk (either physically or financially). In addition to enabling any given risk to be shared among a number of parties (and thereby reducing the fiscal burden on any one party), the retention of risk at the differing levels also seeks to ensure that the parties will continue to act in a manner that seeks to actively manage the risk. If one party were totally absolved of a risk, then they might act in a manner that actually increases the likelihood or negative impact of the realized risk (there being no incentive to do otherwise).

A good example of this risk layering and risk retention is traditional auto insurance, where the policyholder has a deductible and a no-claims bonus. The deductible and bonus serve two functions. First, policyholders remain liable for minor damages to their vehicles, which are the most frequent sources of loss. Second, the policyholder is provided an incentive to drive in a responsible manner, avoiding causing losses to others. The net effect of this is that insurers are seeking only to accept transfer of the second tier, larger (but much more infrequent) losses on which they are able to charge reasonable premiums and for which they are able to make sufficient financial provisioning.

A more detailed example of risk layering for weather risk insurance is considered in Chapter 2.

1.8 WEATHER RISKS IN AGRICULTURE

As we have mentioned, the risk that we are discussing in this paper is weather. Obviously, given the vast variety and complexities of global climates, it is difficult to generalize when discussing weather-related risks. The impacts of a given weather event differ according to the specific agricultural system, variable water balances, type of soil and crop, and availability of other risk management tools (such as irrigation). Additionally, the negative impacts of weather events can be aggravated by poor infrastructure (such as poor drainage) and mismanagement.

From a weather risk management standpoint, there are two main types of risk to consider. These relate to (1) sudden, unforeseen events (for example, windstorms or heavy rain) and (2) cumulative events that occur over an extended period (for example, drought). The impacts that either of these types of risk have vary widely according to crop type and variety and timing of occurrences. Key weather risks are shown in table 1.4.

3 See Mahul, O., and C.J. Stutley (2010). "Government Support to Agricultural Insurance." The World Bank. Washington, DC.

TABLE 1.4: Main Weather-Related Risks Affecting Agriculture

HAZARD	COMMENT
Drought (rainfall deficit)	• Crop varieties adapted to mean rainfall and water balance • Rain-fed agriculture predominates globally • Annual or multiannual • Key risk to livestock
Excess rainfall and flood	• Excess rainfall causes direct damage and indirect impacts • Riverine, flash, coastal floods • Watershed management, drainage, irrigation have impact on flood
High temperatures	• Impact on evapotranspiration and related to drought • Seasonality and vulnerability to crop stages
Low temperatures	• Frost (short-term low temperatures, early and late season damages) • Freeze (winterkill) • Growing degree days (lack of warmth during season)
Wind	• Cyclonic severe events (hurricane or typhoon) • Frontal windstorm • Local windstorm and tornado
Hail	• Localized, but may be severe

Source: Authors.

1.9 RELATIONSHIP BETWEEN WEATHER AND YIELDS

Short-duration extreme weather events (such as hail, windstorm, or heavy frost) can cause devastating direct damage to crops in the fields. Assessment of these damages can be undertaken immediately by physical inspection. On the other hand, while the final outcome of cumulative events can be devastatingly obvious, much of the damage already occurred earlier during a stage of crop development. However, correlations of the weather event and damage are often difficult to model, except for the most extreme events. In the case of cumulative rainfall deficit (drought), the best correlations exist for rain-fed crops grown in areas where there is a clear sensitivity of the crop to deficits in available water, and clearly defined rainy seasons. An example is maize production in southern African countries, such as Zambia and Malawi. Less-clear relationships are found in areas of higher and more regular rainfall or less-clear seasonality, or where other influences, such as pest and disease, are important causes of crop losses. If partial or full irrigation is in place, the relationships become much less strong. Rain-fed production in the tropics (where rainfall is higher and less seasonally marked) is an example where correlations may be less easy to establish. However, droughts are also a feature of tropical crop production, where both floods and droughts can occur in the same year. In sum, making generalizations is risky.

1.10 WEATHER RISK MANAGEMENT APPROACHES

As noted, risk mitigation, coping, and transfer are the key strategies in agricultural risk management. Also, as discussed, these strategies can be applied at the household, community, market, and government levels. Examples of how these strategies apply in weather risk management are given in box 1.1.

KEY POINTS

- Agriculture is associated with many types of risk that expose farmers, agribusiness entities, and governments to potential losses.
- Many approaches can be employed to manage agriculture-related risks, and often several need to be applied within an overall risk management framework.
- Risk management strategies involve risk mitigation, risk transfer, and risk coping.
- Formal (market-based) approaches (including agricultural finance and insurance) allow disciplined financial management of risks but are often challenging to implement in developing countries and may not be suitable for managing extreme risks or disasters.
- Informal approaches are much more frequently found at the farmer level in developing countries. They include savings, household buffer stocks, community savings, and nonformalized mutuals.

BOX 1.1: Weather Risk Management: Strategies and Levels of Operation

Because weather so strongly impacts their livelihoods, farm households and their communities are motivated to develop and improve strategies to cope with and manage weather risks. Risk management strategies available to households can be grouped into three categories.

1. **Households and communities** employ risk management strategies that include crop and labor (on and off farm) diversification, risk-pooling arrangements among peers or family members, sharecropping, investing in semiliquid assets such as livestock or buffer stocks, farmer self-help groups, and loans from moneylenders.
2. **Markets** create mechanisms to help farm households manage weather risks, including new technology; improved seed varieties; formal financial services, including savings, lending, and insurance; risk-sharing arrangements with input suppliers and wholesalers; and information technology tools.
3. **Governments** make investments to help farm households manage weather risks. Governments can provide state-sponsored lending and insurance services; infrastructure, including roads, electricity, and water; educational services; research and development funding to improve technology used in agriculture; weather data and information systems; and disaster relief. Yet, because government resources in lower-income countries are limited, many households will not have access to most of these services. For example, disaster relief is often slow in coming and may not reach the households most in need. Thus, government help can be useful when households receive it, but in many cases, may not be something on which households can rely.

While many of the strategies described above can help households cope with the impact of low and moderate weather risks, these strategies are likely to be ineffective in the case of larger weather shocks. Major disasters render household strategies inadequate for several reasons.

First, diversification strategies will not adequately protect households in a major disaster that affects all sources of farm incomes. Crop diversification strategies may fail as households are likely to experience losses to both cash crops and subsistence crops because of catastrophic weather. Labor diversification strategies can also fail because labor income may also be tied to a good crop. Laborers who earn income from harvesting, transporting, or processing local commodities will also suffer from a catastrophic event that affects farm production.

Second, catastrophic weather events affect whole communities, causing intracommunity risk-pooling arrangements to break down. Strategies of reciprocity and risk pooling among neighbors and family members will fail if everyone is suffering from the same catastrophic event. Moneylenders, input suppliers, and wholesalers are also likely to have losses from defaults as the entire community is suffering. As households cope with losses, certain savings strategies such as owning livestock are also likely to break down as many households attempt to sell livestock at the same time, depressing local prices.

Finally, the development of formal lending and insurance services for agricultural production is also constrained by, among others, the risk of weather shocks as local lenders and insurers who operate in a single geographic area are often unwilling to extend loans and insurance to farmers because their losses would be too great if a catastrophic weather event occurred. Weather shocks can create high rates of loan defaults for bankers or indemnity payouts for insurers. Thus, many farm households lack access to formal credit and weather insurance because catastrophic risks are too high for local financial service providers.

Source: World Bank Agricultural Risk Management Training Materials.

- Insurance is a small part of an array of approaches and instruments that are available to help the financial management of risks through transfer to a third party.
- The risk-layering concept is useful for planning and structuring of risk financing and transfer. Layering risk allows systematic decisions for more efficient risk retention, mitigation, and risk transfer.