The World Bank

Agriculture and Rural Development Discussion Paper 47

Rapid Agricultural Supply Chain Risk Assessment:

A Conceptual Framework

Steven Jaffee
Paul Siegel
Colin Andrews

The World Bank

Agriculture and Rural Development
Discussion Paper 47

Rapid Agricultural Supply Chain Risk Assessment: A Conceptual Framework

Steven Jaffee
Lead Economist, World Bank Agriculture and Rural Development Department

Paul Siegel
Consultant, World Bank LAC Agriculture and Rural Development Department

Colin Andrews
Social Protection Specialist, World Bank Social Protection Team

1818 H Street, NW
Washington, DC 20433
Telephone 202-473-1000
Internet www.worldbank.org/rural
E-mail ard@worldbank.org

Cover photo: Ray Witlin - Sifting grain, India.

Table of Contents

List of Tables

List of Figures

List of Boxes

Executive Summary

Risk and uncertainty are ubiquitous and varied in agriculture and in agricultural supply chains.[1] The range of influencing factors includes the

- vagaries of weather;
- unpredictable nature of biological processes;
- pronounced seasonality of production and market cycles;
- geographical separation of production and end uses;
- unique and uncertain political economy of food and agriculture sectors, both domestic and international.

Frequently, attention is focused on addressing one type of risk that particular stakeholders face (e.g., the weather risk facing farmers or the price risk facing traders), even though supply chain actors are typically interdependent and need to manage several types of risk. This paper provides a conceptual framework and set of detailed guidelines for conducting a system-wide assessment of risk, risk management, and vulnerability within agricultural (commodity) supply chains. Such assessments would collect and compare risk factors and response opportunities involving the broad range of supply chain participants, including private and public sector support service providers and the broader enabling environment (e.g., macroeconomic, trade, and regulatory policies).

The application of these agricultural supply chain risk assessments should be valuable as

- part of subsector or value chain competitiveness and strategy development processes;
- an input into the identification and formulation of investment or capacity-building projects related to agricultural commercialization, rural finance, export promotion, and the like;
- an input into sectoral policy and regulatory reform processes.

The assessments are designed as consultative and time-bound processes geared toward providing a first approximation of key vulnerabilities and areas requiring priority attention in investment and capacity building. A combination of quantitative data and qualitative information is sourced and analyzed, with stakeholder consultations acting as a key component. Detailed guidance notes are provided to facilitate sectoral and spatial-mapping exercises, risk characterization, and identification and stakeholder interviews.[2] The guidelines assume a "rapid" assessment process, involving a small study

or industry team and spanning a period of approximately three months. The assessment tool is designed to deal with crop-based (rather than animal product) supply chains. The broad categories of risks to be investigated include weather, price, logistics, infrastructure, sanitary/phytosanitary, environment, labor, and policy.

1. Introduction and Rationale

1.1 Objectives and Overview

This paper describes the methodology for a Rapid Agricultural Supply Chain Risk Assessment (RapAgRisk), developed by the Agricultural Risk Management Team (ARMT) of the World Bank.[3] The primary objective of RapAgRisk is to help decision makers understand the risk exposure of agricultural supply chain participants and to improve risk management strategies for selected commodity systems. RapAgRisk provides a system-wide approach for identifying risks, risk exposure, the severity of potential loses, and options for risk management either by supply chain participants (individually or collectively) or by third parties (e.g., government). The aim of the assessment is to understand the wide range of bottlenecks and choke points that affect the participants and functions related to a given agricultural commodity system. The assessment encompasses direct supply chain participants, private and public sector support service providers, and the broader enabling environment (e.g., macroeconomic, trade, and regulatory policies).

The focus on risk assessment is motivated by the growing attention to agricultural[4] risk from national governments, international agencies, financial institutions, producer organizations, consumer organizations, and other agents in the private sector. Also, recent food safety "crises," the outbreak and spread of avian influenza, major swings in food and other commodity prices, and growing concerns about climate change are among the many shocks and emerging trends that are raising the profile of agricultural risk and interest in more effective and sustainable risk management strategies and approaches.

RapAgRisk is devised as a consultative and time-bound process to be carried out by a small team over an estimated three-month period. The assessment draws on available data and collects additional data and qualitative information through stakeholder interviews and dialogue. The methodology described in this paper has been designed to collect qualitative and quantitative information for selected agricultural supply chains, beginning with input supply; extending through farm production, assembly, processing, and logistics; and ending with the final consumer. A set of guidelines is available to facilitate the identification and characterization of different risks and to structure stakeholder exercises.[5]

The following sections offer an operationally focused framework for undertaking assessments of risk and risk management capability within agricultural supply chains in developing countries. The paper is structured as follows. Section I outlines the approach and rationale of the risk assessment. Section II describes a conceptual framework, outlining the nature of agricultural

supply chains, characterizing the main types of risk that participants encounter in those supply chains, and characterizing the range of measures that can be taken to manage such risks. Section III provides a road map and selected guidelines for conducting supply chain risk and risk management assessments. A complementary guidelines document[6] then provides detailed guidelines and suggestions for the conduct of fieldwork and stakeholder interactions.

1.2 Approach and Limitations

The target audience of the risk assessment process includes World Bank staff, country-level stakeholders involved in selected agricultural commodity systems, development agency decision makers, and developing country policy makers. RapAgRisk is devised to support broadened industry and value chain strategy formulation efforts, as well as the identification and formulation of proposals for investment, for capacity building, and for policy and regulatory reform in relation to strategically important agricultural supply chains.

This type of analysis complements other types of risk assessments, including

- Household or area-based risk assessments, typically focused on the vulnerability of different types of households, the application of (typically) informal risk-sharing and -coping mechanisms, and the need/scope for supplementary social protection measures;
- Hazard vulnerability assessments, typically highlighting the potential exposure of national infrastructure and major population groups to natural disasters (e.g., earthquakes, hurricanes, other extreme weather events);
- Financial risk assessments, focused on the possible budgetary and other macroeconomic impacts of major "shocks."

Agricultural supply chain risk assessment is thus an intermediate-level assessment, providing specificity to factors that could weaken the competitiveness, sustainability, and other performance results of key agricultural supply chains (or subsectors), which, in turn, could threaten the achievement of broader economic development and social stability objectives. Agricultural supply chain risk assessments should add value in various contexts, including

- modules in broader subsector, or value chain, analyses and development and growth strategy processes;[7]
- constraint and opportunity analyses undertaken in the identification and formulation of development projects focusing on area development, agricultural commercialization, rural finance, export promotion, and the like;
- the planning, implementation, and monitoring of sectoral reform programs, including those involving shifts in the commercial, regulatory, and other government roles in particular sectors;
- investment appraisals by private and development finance institutions or strategic assessments of the quality and risk exposure of agricultural lending portfolios;

- where stakeholders seek to highlight the prospective impacts of particular risks or trends (e.g., specific weather events or a projected climate change) and identify prospective mitigating measures, perhaps in relation to their objectives.[8]

1.3 Changing Risk Landscape

Risk and uncertainty are ubiquitous and varied within agricultural supply chains. These result from a range of factors including the

- vagaries of weather;
- unpredictable nature of biological processes;
- pronounced seasonality of production and market cycles;
- geographical separation of production and end uses;
- unique and uncertain political economy of food and agriculture, both domestic and international.

Given the pervasiveness of risks and massive structural changes in global and national agri-food systems, farmers, agribusiness firms, and governments face new challenges in the design of risk management strategies. Long-standing tools for managing traditional risks have usually included interventions from governments, such as the management of strategic food reserves, the implementation of price stabilization schemes, heavily subsidized crop insurance, and credit guarantee programs. (See Box 1.) The effectiveness and/or financial sustainability of many interventions has been problematic and has tended to be incompatible with changing patterns in agri-food systems, highlighted, for example, in the World Development Report 2008 (World Bank 2008.)

Broad structural, demographic, and institutional changes, some associated with globalization and the uptake of new technologies, will continue to alter the risk landscape, risk management practices, and their efficacy for different agri-food supply chains. Major changes underway include the

- rapid urbanization and growth of domestic food markets, with this growth frequently outpacing service infrastructure and the need for market- and health-related regulatory frameworks and enforcement capacities;
- liberalization of domestic and global factor and product markets, opening up new opportunities for market entry and supply chain relationships, yet exposing farmers and firms to new risks while forcing them to shoulder the burden of risks previously ameliorated by government programs;
- major scale-back and/or disengagement of public sector funding and involvement in providing technical, financial, and logistical support services, resulting in changes in the supply for such services, along with an increased need for proactive actions by the public sector to guarantee the availability of affordable access by small enterprises;
- changes in demographics, incomes, tastes and preferences, consumer demand, and patterns of world trade, all of which present major opportunities for market-oriented production and marketing activity and which increase concerns and oversight for managing production and

Box 1: Finding Space for Market-Based Risk Management Solutions

Among developing countries, long-standing tools for managing traditional risks usually included interventions by governments, such as the management of strategic food reserves, the implementation of price stabilization schemes, heavily subsidized crop insurance, and credit guarantee programs. The effectiveness and/or financial sustainability of many such interventions have been problematic, and they tend not to be compatible with emerging strategies for factor and output market liberalization. Although often initiated with a pro-poor bias, in many cases the poor have not been the primary beneficiaries. Developing and applying more market-based risk management solutions was a primary objective of the creation of the Commodity Risk Management Group (CRMG) in 1999, which has been located in the World Bank's Agriculture and Rural Development department (ARD) since 2001.

CRMG/ARD's work initially focused on diagnosing impacts of price volatility on producers in specific commodities and countries. Feasibility studies and pilot projects followed, with the aim to assist farmers and farmer groups to adopt price-risk management measures. Facing various constraints, CRMG/ARD shifted its focus to providing technical assistance with price risk management at the meso level (e.g., banks, commodity traders) and macro level (local and national). In parallel, CRMG/ARD began to address weather risks, pursuing an innovative index-based approach to insurance (based on use of rainfall data and crop production models) to facilitate compensation for yield losses and linking this initiative with finance by banks and/or traders (see World Bank, 2005). Various pilot projects have demonstrated the potential and limitations of applying this approach, and parallel work has explored new applications of index insurance products and nonfinancial instruments (e.g., warehouse receipts).

In its ongoing work, the CRMG/ARD (now called the Agricultural Risk Management Team) has become increasingly aware of the multiplicity of risks facing agricultural supply chain participants, the interdependence of these players (and their respective actions), the covariant impact of risk, and thus the limitations of so-called silver-bullet or one-size-fits-all solutions. There is an urgent need to better understand underlying conditions, including incentives, capacities, and opportunities for the management of risks throughout the supply chain.

market-related risks along with food safety and agricultural health risks (parallel trends are taking place within developing countries themselves, especially those with burgeoning middle class populations);

- changes in technology, with some increasing productivity and lowering costs and reducing production risks, which generate new concerns and potential commercial risks (e.g., genetically modified organisms [GMOs] or food irradiation) and whose adoption increases the financial risk of the users;
- shifts in the competitive structure of markets, with increased concentration in the processing, retailing, and food service industries, and the emergence of global supply chains that depend on more effective production control and logistics management, as well as compliance with a broader array of gatekeeper requirements (these trends further erode the bargaining power of primary producers);

- increased competitive advantage for production and marketing that can take advantage of economies of scale and agglomeration but that also might result in biases toward larger enterprises and more advantaged areas and regions, with huge policy implications for rural development and rural poverty reduction if these areas cannot be successfully integrated in the agri-food–monetized markets;
- emerging trends of climate change, which make weather forecasting more complex and prone to inaccuracies, necessitating reactive and adaptive risk management strategies by many players and, over the long term, shifting patterns of comparative advantage.

The RapAgRisk brings together these structural changes to consider the changing distribution of risks and returns within agri-food systems. The poverty dimension within agri-food systems is of particular significance because changes typically do not benefit small producers and firms. The achievement of governmental objectives—related to, say, inflation, economic growth, trade, social stability, and the like—may often be at risk due to the incidence of major shocks or bottlenecks in important food or commodity export sectors. To address these issues, the RapAgRisk assessment essentially asks, what can and will go wrong? In answering that question, *the proposed unit of analysis* for risk and risk management assessment is the supply chain, consisting of all the functions, players, and relations associated with the production, transformation, and distribution of a given food or agricultural product. (For example, the corn/maize supply chain includes input suppliers, producers, buyers, processors, and others, all the way to the final consumers of tortillas or breakfast cereals.) (See Box 2.)

Box 2: The Selective Management of Risks, Not the Management of All Risks

Supply chain risk management is the systematic (i.e., planned) process of managing the most damaging events that can negatively affect the supply chain, and their likely incidence and impact(s). One can adopt a systems-wide perspective; or adopt the perspective of one or more participants inside the supply chain (or "external" players such as financial and other institutions that provide services to supply chain participants). It is very difficult to "manage" risks in a supply chain as no one actor is in full control. An actor can try to understand, mitigate, and perhaps transfer risks to which it is exposed, but to achieve that for the whole chain requires collective action.

A *sine qua non* of effective risk management is that "You can not protect against every risk—nor should you try. But, if you can be quick to identify a potential problem, and have thought about the risk and possible risk responses—in advance, then you can mobilize options if it makes sense. The essence of risk management boils down to adequately appreciating the risks that a {farm or firm} is exposed to for different activities, and identifying the key "choke points" along the supply chain that would completely harm a business and the supply chain if disruption occurs. Identify the correct set of *ex-ante* measures to allow for protection, remembering to periodically reviewing and assessing what's happened. [Wharton School, 2006]

2. Conceptual Framework

2.1 Agricultural Supply Chains

"Supply chain thinking encourages a system-wide view of the chain—focusing as much on the linkages between technologically separable segments as on the management of processes within those segments" (King and Venturini 2005, p. 19). Thus, 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 (i.e., production-to-consumption) continuum for a given product (be it consumed as fresh, processed, and/or food-service-provided), including the external enabling environment. These functions typically span other supply chains, as well as geographic and political boundaries, and they often involve a wide range of public and private sector institutions and organizations.

Figure 1 presents a simple schematic description of an agricultural supply chain. Modern agricultural supply chains are networks that typically support three major flows:

- *Physical product flows:* The physical product movements from input suppliers to producers to buyers to final customers
- *Financial flows:* The credit terms and lending, payment schedules and repayments, savings, and insurance arrangements
- *Information flows:* Flows that coordinate the physical product and financial flows

Logistics and communications are embedded in all these flows, and poor logistics and communications are often a major source of risk facing an agricultural supply chain. 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. Governments may have broader objectives, especially when the supply chain has particularly strategic value for trade or is critical in the domestic food system. These broader objectives might relate to maintaining low inflation, sustaining social stability, stimulating sub-regional development, or attaining some similar goal. Agricultural supply chain risk assessments should be designed to illuminate the risks to the achievement of these and other performance objectives by farms, firms, and the supply chain as a whole.

Also as shown in Figure 1, supply chain participants can be located within or outside national borders. Even within national borders, participants and their activities can be spatially dispersed. Some participants and services are specialized, whereas others are involved in several different supply chains. Support service providers can be active in both the public and the private sectors. Logistical support services include transport, communication, and

information technology. Technical support includes not only a range of research and business development services, but also technical assistance and financial services. In the global economy, support service providers and the services themselves can easily cross national borders.

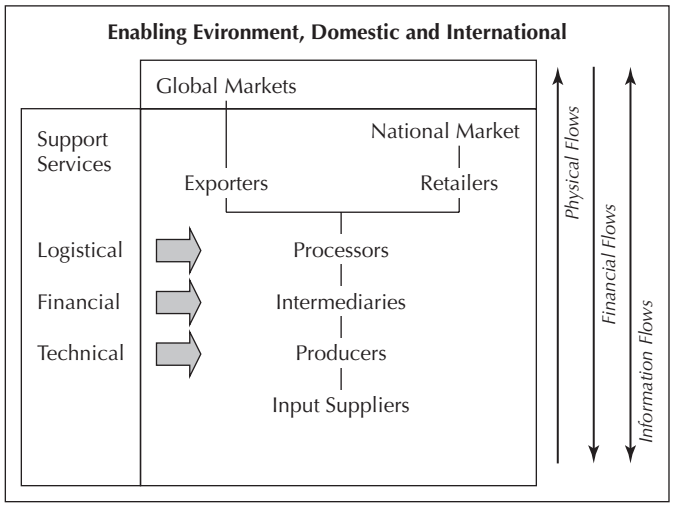
The agri-food system also includes farmers and a diverse range of firms, including backward-linked input suppliers and forward-linked intermediaries, processors, exporters, wholesalers, and retailers.

The main activities for direct supply chain entities are as follows:

- *Input supply:* The production and distribution of material inputs—such as fertilizer, seeds, packaging, and such needs—utilized in the primary production, processing, and/or trade of the focal commodity
- *Farm production:* The primary agricultural production through the sale of a raw commodity at the farm gate—either at literally the farm gate or at some other point where the farmer hands over ownership of the product to the next supply chain participant (Depending on the crop, some type of primary processing [such as the shelling or bagging of dry grain] may take place at the farm level.)
- *Processing:* The transformation of agricultural raw materials into one or more finished goods—through drying, canning, freezing, or many other methods (Raw commodities, of course, are also traded and distributed; thus this stage may not apply to every crop.)
- *Domestic and international logistics:* The delivery of marketed commodities to their final market destination

Figure 1 also maps out private and public sector entities that provide support services, such as finance and insurance, advisory services, and logistics and information. Conditioning the entire supply chain are the domestic and

Figure 1: Agri-Food Supply Chain Framework



international enabling environments. Domestic conditioning includes fiscal and financial sector policies, pricing and investment incentives and institutions, the regulatory and legal framework, and the like. The international, or global, enabling environment includes international trade regulations and agreements, other international protocols, and the policies or regulations of nations and trading blocs from whom the focal supply chain sources and to whom it sells inputs or products.

The framework in Figure 1 is necessarily simplified. In reality, supply chains are more complex with many participants. They involve product, finance, and information flows often traversing large geographical and international areas and with distinct intra- and inter-seasonal dimensions. Supply chains may

Box 3: Incorporating Risk into Supply Chain Analysis

In recent years numerous assessments have been made of individual supply or value chains in developing country agriculture, frequently as antecedents to investments by governments, donor agencies, or private enterprises. In a developing country, diverse objectives drive supply or value chain analysis. In some instances, the central purpose is to promote growth by understanding the competitiveness of the overall supply chain. One method of accomplishing this aim is to identify existing gaps or inefficiencies, primarily by analyzing the cost structure of the system and perhaps indicators of productivity at different levels; the next step is to seek ways to reduce those costs and/or raise productivity. A second, complementary purpose of supply or value chain analysis is to understand and improve the positions of certain stakeholders in the chain, typically smallholder farmers or SMEs (small and medium enterprises); interventions are then targeted at those players or at their interfaces with others. Still other approaches emphasize unlocking additional "value" for the entire chain or for individual players, say by achieving better differentiation of the chain's products or via vertical integration into processing, downstream marketing, and other activities.[9]

In supply chain analyses, success is measured in terms of the supply chain's performance, that is, the ability to deliver a product or service to end markets. Success, in turn, depends on a number of factors: i) access to critical support services, ii) how firms are organized vertically and horizontally and the structure of relationships among firms, iii) how firms access information, learning, and increased benefit flows, iv) the power over the terms and conditions of transactions, and v) the business enabling environment.

In the face of multiple potential risks, a critical consideration is the resilience of primary producers, of agribusiness entities, and of institutions for collective action, supply chain coordination, and public-private cooperation. One cannot understand a sector's current competitiveness and future potential without understanding its players' ability to anticipate and respond to shocks. A commodity sub-sectoral developmental strategy that ignores considerations of risk and risk management is incomplete.

The approach proposed in this paper essentially asks, what can and will go wrong? In answering that question, one can consider the adequacy of existing risk management measures, supplemental measures, and capacity-building needs. Supply chain risk assessments are thus useful supplements to—and should be incorporated into—conventional value chain analysis.

also be divided into an array of sub-supply chains, traversing the farm-to-fork continuum for specific commodities or for closely associated commodities.

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, Romano, and Giannakis 2000), including the

- *Dyadic level:* The two-party relationship, such as between input supplier producer, producer and buyer, producer and financial institution
- *Sub-chain level:* A set of dyadic relationships, such as input supplier and producer, and buyer
- *Chain or network level:* The entire supply chain and network of operations (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.

2.2 Major Risks

An agricultural supply chain may be subjected to or experience multiple risks, with farmers and firms facing risks from different sources. Table 1 portrays different types of risk that may be encountered. As the following discussion indicates, such risks can impact the reliability, costs, and efficiency of production, processing, and marketing activities. In addition, we highlight where particular risks are generally idiosyncratic or covariate for the supply chain.

2.2.1 Weather-Related Risks

Non-extreme weather events (e.g., too much or little rainfall or too high or low temperatures) often affect agricultural supply chains for a single growing season and/or production cycle. However, such events can have systemic impacts on decision-making, productivity, and market options. Weather-related risks (especially those related to hail and wind damage and to high humidity or excess rain, leading to pests and diseases) are associated mostly with yield reductions, but they can also can affect the quality of products and disrupt the flow of goods and services. Non-extreme weather risks are usually associated with a very specific geographic location. In other words, they might directly impact only individual supply chain participants and differentially affect producers in a single community and/or producer group.

Localized impacts on the quantity and quality of producers' yield can, in turn, impact their demand for inputs and other support services and their ability to repay loans. They can also affect buyers and processors upstream in the supply chain. In addition, weather-related risks might impact logistics along the supply chain because of disruptions in transport, communications, and energy services. Importantly, although a localized drought can impact farmers in a given area, upstream buyers, processors, and traders might not be affected

Table 1: Categories of Major Risks Facing Agricultural Supply Chains

Type of Risk	Examples
Weather-related risks	Periodic deficit and/or excess rainfall or temperature, hail storms, strong winds
Natural disasters (including extreme weather events)	Major floods and droughts, hurricanes, cyclones, typhoons, earthquakes, volcanic activity
Biological and environmental risks	Crop and livestock pests and diseases; contamination related to poor sanitation, human contamination and illnesses; contamination affecting food safety; contamination and degradation of natural resources and environment; contamination and degradation of production and processing processes
Market-related risks	Changes in supply and/or demand that impact domestic and/or international prices of inputs and/or outputs, changes in market demands for quantity and/or quality attributes, changes in food safety requirements, changes in market demands for timing of product delivery, changes in enterprise/supply chain reputation and dependability
Logistical and infrastructural risks	Changes in transport, communication, energy costs, degraded and/or undependable transport, communication, energy infrastructure, physical destruction, conflicts, labor disputes affecting transport, communications, energy infrastructure and services
Management and operational risks	Poor management decisions in asset allocation and livelihood/enterprise selection; poor decision making in use of inputs; poor quality control; forecast and planning errors; breakdowns in farm or firm equipment; use of outdated seeds; lack of preparation to change product, process, markets; inability to adapt to changes in cash and labor flows
Public policy and institutional risks	Changing and/or uncertain monetary, fiscal and tax policies; changing and/or uncertain financial (credit, savings, insurance) policies; changing and/or uncertain regulatory and legal policies and enforcement; changing and/or uncertain trade and market policies; changing and/or uncertain land policies and tenure system; governance-related uncertainty (e.g., corruption); weak institutional capacity to implement regulatory mandates
Political risks	Security-related risks and uncertainty (e.g., threats to property and/or life) associated with politico-social instability within a country or in neighboring countries, interruption of trade due to disputes with other countries, nationalization/confiscation of assets, especially for foreign investors

because they can transact with producers in non-drought areas and/or import commodities to complement or substitute for locally produced products (whose supply is decreased). Thus, the overall supply chain might continue performing fairly well, whereas individual farmers (or groups of farmers) suffer from the risk.

2.2.2 Natural Disasters

Natural disasters can affect agricultural supply chains for multiple growing seasons and/or production cycles. These risks normally result in major short-term yield reductions, subsequent market price increases, and asset destruction that disrupts the flow of goods, services, and information. Frequently, natural disasters also affect productivity and market relations in the longer term. Extreme weather-related risks and natural disasters can also extend over a wide geographic area. Thus, they can simultaneously directly impact not only multiple participants in a supply chain, but also service providers and the external environment, albeit with different intensities. These risks invariably impact logistics along the supply chain, causing disruptions in transport, communications, and energy services. Such risks can seriously impact downstream or upstream participants in the supply chain, support service providers, and/or the external environment (national or international), thus having a ripple effect through the supply chain.

2.2.3 Biological and Environmental Risks

Biological and environmental risks affecting agricultural supply chains are ubiquitous and varied. Some are related mostly to production and/or postharvest reductions in quantity, but many are also related to quality losses. Most biological risks directly affect the supply chain in a single growing season and/or production cycle. They can also have systemic impacts on decision-making, productivity and market options. Biological risks are associated mostly with yield and quality reductions, but can they also disrupt the flow of goods and services. These risks are usually associated with a very specific geographic location in the short term but can move through the supply chain.

Localized impacts on the quality and quantity of producers' yield can, in turn, impact the demand for inputs and other support services and the producers' ability to repay loans; they can also impact buyers and processors upstream in the supply chain. In addition, these risks can impact the timeliness of the movement of goods along the supply chain because of disruptions related to testing and certification. The presence of certain plant pests or livestock diseases may impinge on international market access, not only for the farmers and firms immediately affected but perhaps for the entire country.

Environmental degradation (e.g., soil erosion or pesticide or factory effluent runoff into water supplies) could adversely affect future productivity, worker health, or downstream market access (where protocols for environmental management are in place). As more and more commodity supply chains now feature the tracking and recording of raw materials back to their original sources, downstream buyers can no longer claim that they don't know how these raw materials are

produced—that is, their environmental footprint. The adverse environmental footprint of some production practices therefore constitutes a potential commercial and reputational risk for downstream processors and distributors.

2.2.4 Market-Related Risks

Agricultural supply chains face important market-related risks that can have an effect for a single growing season and/or production cycle or for longer periods of time. Market-related risks exist for inputs and outputs and for the critical services that support supply chains, such as finance and logistics. Generally, market risks are related to issues affecting price, quality, availability, and access to necessary products and services. Of these, price risks are typically the most volatile, particularly in commodity markets where both local and global supply and demand conditions are constantly changing. Price uncertainty has a direct impact on decisions related to the selection of crops/enterprises and investments that are made in the hopes of maximizing profit.

Directly related to price risks are risks associated with quality. Quality is influenced by the availability of affordable inputs, delivered and applied in a timely fashion, and by decisions about production, postharvest, and processing practices. One of the characteristics of rural markets that many small-scale producers face is that premia for higher quality are not passed on *unless* sufficient volumes of supply are generated and aggregated to attract the quality-oriented buyer. The process of upgrading quality thereby requires organized, collective action, and such measures are fraught with institutional risk. Financing is required to invest in inputs and to improve production practices, but unfortunately funds are not always accessible and affordable. Producers cannot accept the financial risk of borrowing to upgrade unless the premium market is assured. Of the risks associated with decisions to borrow, the most serious is concern about the ability to repay loans. As a result, the changing market for financial products also has a direct affect on other functions in the supply chain. (Logistics-related risks are similar in this respect.)

Market-related risks vary constantly and are rarely associated with only one geographic location[10]. Aspects of market risk may directly impact individual actors in a supply chain and differentially affect producers in a single community and/or producer group. Managing such risks calls for opportunistic attempts to maximize returns based on current conditions. At the same time, the decisions made in a given season will impact the range of production, processing, and marketing opportunities available in the future.

2.2.5 Logistical and Infrastructural Risks

Agricultural supply chains increasingly face risks related to logistics and infrastructure that affect the availability and timing of goods and services, energy, and information. In turn, failures in logistics are transmitted throughout the agricultural supply chain and can impact product quality and traceability. Access to reliable and affordable transport, communications, energy, and information technology is crucial for decision making and productivity, for the selection of different enterprises, and for the choice of input and output markets.

Thus, logistics-related risks are closely related to price- and market-related risks, including the driving decisions on product lines and input use, which can affect future production, processing, and marketing decisions. For example, a lack of and/or poorly functioning infrastructure and services (e.g., power outages for processors) can affect quality. Although logical risks are usually associated with very specific geographic locations, they can differentially affect other participants in the supply chain. Conditions related to logistics can impact the demand for inputs and other support services, the ability to repay loans, and buyers and processors upstream in the supply chain.

For farmers and intermediary traders, the greatest sources of risk in this category are poor and perhaps seasonally impassable roads, intermittent trucking services, and faulty truck-loading practices (resulting in the damage and loss of product in transit). Also critical may be weak communications infrastructure and associated gaps in time-relevant market information, resulting in weakened commercial strategies and market bargaining power. The limited availability and access to well maintained market centers, collection stations, or other transaction points typically pose further logistical and infrastructural risks.

2.2.6 Managerial and Operational Risks

Individual chain participants and the chain itself face numerous managerial and operational risks, which are closely associated with human judgment and response—that is, errors of action and inaction, of commission and omission. These risks usually directly affect a single chain participant, but they can be transmitted throughout the supply chain. Managerial and operational risks are part and parcel of decision making by enterprises. They are mostly associated with productivity reductions, low product quality, and the unreliable delivery (of inputs and outputs or support services). Such risks might directly impact only individual actors in a supply chain, but they can also differentially affect producers in a single community and/or producer group. Yet operational failures by one entity may spill over to losses (or to lost market access) for many others. For example, farmer uses a cheap yet presently banned agrochemical, and residues for the pesticide are detected by regulatory authorities abroad. This single event could trigger harm to the reputation of the export industry and perhaps even its continued access to remunerative market segments.

2.2.7 Public Policy and Institutional Risks

Policy and institutional risks have major direct and indirect impacts on shaping incentives and decision making in agricultural supply chains. These risks also have a major impact on the structure of the agri-supply chain, on the relationships among individual actors, and on the distribution of rewards and risks in the supply chain and with support service providers and government. Also, these risks are associated with public-private sector dynamics: anticipated "changes in the rules of the game," uncertainty about changes in the rules themselves, and uncertainty as to whether the rules will be enforced efficiently, equitably, and transparently.

Public policy and institutional risks have systemic impacts on decision making and productivity, as well as on market options. Because incentives can change

(including the distribution of rewards and risks in the supply chain), these risks can result in changes in yield quantity and quality, even leading to disruptions in the flow of goods, services, information, and cash. Sometimes these risks are allocated either to benefit or to tax a specific supply chain and/or geographic location. Thus, they might not only directly impact certain participants in a supply chain and/or support service providers, but also differentially affect producers in a single community and/or producer group. Impacts on individual chain participants can, in turn, have unexpected ripple effects throughout the supply chain.

2.2.8 Order of Risk Magnitudes

As is evident, the incidence and severity of the different types of risks encountered in agricultural supply chains vary considerably among countries and among locales within countries, depending on underlying climatic conditions, geography or topography, demographics, and agrarian and industry structures. The relative importance of different types of risks also varies among supply chains for different commodities, resulting from specific technical properties (e.g., perishability or storability), prominent features of their markets, and trends in regulatory developments and consumer preferences (Jaffee 1995).

Table 2 provides a so-called order-of-magnitude illustration of the relative importance of different types of risks potentially affecting an export-oriented supply chain from a developing country whose primary market orientation is toward higher-income industrialized countries. The different types of risk are assigned a rating of high, medium, or low. Some of these risk ratings are substantially different for certain categories if the focal supply chain is exporting to neighboring or other developing countries. For example, concerns about sanitary and phyto-sanitary risks and about environmental or social dimensions of production could be decidedly lower.

Although this type of categorization has its limitations—and several individual ratings are clearly debatable[11]—the formulation signals that agricultural supply chain risk assessments need not and should not devote equal attention to the broad range of potential risks. For most commodities, certain types of risk are expected to be more prominent and others less so. This proviso should affect the relative emphasis given to different types of quantitative and qualitative analysis. For example, the volatility of international market prices (including periodic sharp downturns in prices) is a prominent source of risk for producers and traders of most grain and oilseed commodities, as well as traditional beverage and industrial crops. For some industrial crops and for a range of perishable, higher-value products, price risk is less important; the higher-order risks more commonly relate to logistics and to compliance with food safety and/or plant and animal health requirements.

2.3 Transmission of Risks

Attention is usually focused on individual participants in the supply chain. Yet, as explained, it is important to examine how risks and risk response are transmitted throughout the agri-food supply chain. Some adverse events

Table 2: Prominent Risks Affecting Developing Country Commodity Supply Chains Involved in Trade with Major International Markets

	Type of Risk				
	Price Volatility of Commodity	**Loss of Product (Quality) Due to Logistical Breakdown**	**Market Access Constrained by Sanitary and Phytosanitary Concerns**	**Adverse Weather Disrupting Production**	**Market Concern with Environmental or Social Dimensions of Production**
Coffee	H	M	L	M	L
Cocoa	H	M	L	M	M
Oil Palm	H	M	L	M	M
Cotton	H	L	L	L	L
Rice	H	L	L	M	L
Tobacco	M	L	L	M	L
Sugar	M	L	L	L	M
Maize	H	M	M	H	L
Spices	M	L-M	M	L-M	L
Groundnuts	M	M	M	M	L
Tea	L	M	L	H	M
Fruit	L	H	M	M-H	L
Vegetables	L	H	M	M-H	M
Cut flowers	L	H	M	L-M	M
Beef	L	H	H	M	M
Fish	L	H	H	L	M

(i.e., idiosyncratic supply chain risks) are experienced only locally by particular supply chain participants. Other participants may be unaffected, or they may be beneficiaries (due to lower prices for their own inputs or higher demand for their services). Other risks (i.e., covariate supply chain risks) have snowball effects, impacting prevailing conditions of factor and product market demand and supply for other parties. How supply chain participants go about managing the risks that they face can help or hinder the risk management efforts of other participants. Thus risks and risk management in a supply chain are linked, requiring a systems approach that considers the distribution and transmission of risk.

Supply chain risk assessment focuses on the distribution of risks among individual participants and their transmission between participants. Table 3 provides a simplistic rendering of how different risks, experienced by primary agricultural producers, can transmit themselves to the operations of input suppliers and entities involved in the collection, processing, trading, and final distribution of food and agricultural commodities. Risk can be transmitted in other patterns too. For example:

- A sustained power outage for a processor may transmit effects backward in the chain in the form of reduced market opportunities for farmers and brokers, and it can transmit consequences forward to unfulfilled trade orders and, subsequently, half-empty retail shelves.
- Alternatively, the power outage could affect the processor's stored raw materials or other (perishable) ingredients, resulting in a contaminated food product that causes consumer illness and a product recall, thereby affecting traders and distributors.
- When an exporter encounters an interruption in demand or an unexpected steep price increase for international logistics, the backward effect may take the form of reduced demand or lower prices for farmers, intermediaries, and/or processors. A sharp price drop may discourage farmers from planting the crop the following season, resulting in multiyear reductions in exports or in exaggerated movements in supply cycle highs and lows.
- The inundation of a production area (say, for groundnuts or maize) by unseasonal rains and flash floods may have multiple repercussions. Intermediary traders may have difficulty accessing the production area, reducing the timeliness of availability of the crop for processors and millers. The wet conditions may result in improper crop drying or storing, rendering part of the crop noncompliant with buyer requirements (e.g., moisture content) and/or contaminating part of it with a fungus or bacteria, spelling subsequent rejection by regulatory authorities abroad.
- An unusual plant pest outbreak may occur just prior to harvest time. In the main growing area, farmers salvage the crop by extensively spraying a pesticide that is banned in Europe. The biological risk is thus managed, but high residues of the pesticide show up in the delivered crop. Traders are unable to sell the crop to Europe, where buyers and the regulatory authorities are monitoring pesticide residues. The crop is then sold at a large discount domestically or in other less demanding export markets; large unsold stocks are built up.

These are just a few examples. Many other hypothetical and real examples of risk transmission can be identified. What these examples illustrate is the need to more fully understand the potential inter-linkages among risks that derive from the interdependency of supply chain participants and functions. Also, some of these examples indicate that, in some circumstances, the risk management measures taken by certain parties actually generate additional or different risks for other supply chain members. Also, risks can be transmitted between supply chains. Volatility in one supply chain may affect other supply

Table 3: Risks Impacting Farmers and the Transmission of Impacts to Agro-enterprises

Risk	Input Suppliers	Farmers	Buyers	Processors	Traders	Distributors
Weather-related risks	Demand for inputs Repayment for inputs on credit	Planting decisions Yield and quality Income decline	Availability, price, quality of products Logistic costs	Availability, price, quality of products Logistic costs	Availability, price, quality of products Logistic costs	Availability, price, quality of products Logistic costs
Natural disasters	Demand for inputs in this and subsequent year Repayment for inputs on credit	Yield and quality Farm asset loss Longer-term output and income decline	Availability, price, quality of products Logistic costs	Availability, price, quality of products Logistic costs Costs to develop alternative supply sources	Availability, price, quality of products Logistic costs Loss of market contracts	Availability, price, quality of products Logistic costs Costs to develop new supply sources
Biological and environmental risks	Demand for inputs Repayment for inputs on credit	Input use Yield and quality Production costs Income decline	Availability, price, quality of products Need to screen or test supplies	Availability, price, quality and safety of products Brand reputation Market access	Availability, price, quality of products Brand reputation Market access	Availability, price, quality of products; Brand reputation; Product liability Need to procure from alternative sources
Market-related risks	Demand for inputs Repayment for inputs on credit	Planting decisions Input use Yield and quality Income decline	Availability, price, quality of products	Availability, price, quality of products	Availability, price, quality of products	Availability, price, quality of products

Table 3: Risks Impacting Farmers and the Transmission of Impacts to Agro-enterprises (*Continued*)						
Policy and institutional risks	Demand for inputs Repayment for inputs on credit	Planting decisions Input use Yield and quality Ability to sell	Availability, price, quality of products Operating costs Ability to intermediate	Availability, price, quality of products Availability, price other products Need to procure from alternative sources Operating costs	Availability, price, quality of products Need to procure from alternative sources Operating costs Ability to sell	Availability, price, quality of products Need to procure from alternative sources Operating costs
Logistics-related risks	Demand for inputs in current and subsequent year (or season)	Input access and use Yield and quality Postharvest losses Income decline	Availability, price, quality of products Availability and price of other products Operating costs	Availability, price, quality of products Availability and price of other products Operating costs	Availability, price, quality of products Availability and price of other products Operating costs	Availability, price, quality of products Availability and price of other products Operating costs
Management and operational risks	Demand for inputs in current and future years	Inappropriate planting decisions and input use Reduced yield and quality	Availability, price, quality of products Operating costs	Availability, price, quality, and safety of products Product liability Operating costs	Availability, price, quality of products Operating costs Product rejections and market access	Availability, price, quality of products Operating costs Loss of brand reputation; market or regulatory sanctions

chains for complementary or substitute products and lead to shifts in production, marketing, and consumption patterns.

Volatility or disruptions in important agricultural supply chains may also pose risks to the achievement of governmental objectives. For example, weather-induced shortfalls in the production of a major staple food could trigger sharp increases in domestic food prices, raising overall inflation levels, threats to the food security of segments of the population, and social unrest in urban and rural areas.

2.4 Risk and Vulnerability

2.4.1 Risk

Risky events can be characterized by their magnitude, scope or spread, frequency and duration, and their history, all of which affect vulnerability. Risks can be classified as

- *Idiosyncratic risks* that usually affect only individual farms or firms (e.g., plant and animal pests and diseases, illnesses of the owner or laborers);
- *Covariate risks* that affect many enterprises simultaneously (e.g., major droughts or floods, fluctuating market prices).

The high propensity of covariate risks in rural areas is a major reason that informal risk management arrangements break down and that formal locally based financial institutions are hesitant to provide commercial loans for agriculture (Skees, Hazell, and Miranda 1999; Skees and Barnett 1999).

Risk is the possibility that an event will occur with a potentially negative impact on the achievement of a farm or firm's performance objectives and/or on the successful functioning of the overall supply chain. (See Box 4.) The *exposure* of farms and firms (hereafter enterprises) to risk depends on various factors, notably their assets and their allocation via livelihood and/or business strategies.[12] An enterprise's assets and their allocation (crop and livestock mix, diversification of activities—farming, off-farm, and non-farm) influence exposure to risk, and these allocation decisions are in turn influenced by risks. In addition, the allocation of assets and exposure to risk determine the severity of risk-related

Box 4: Risk and Uncertainty: Similar but Different Concepts

The terms *risk* and *uncertainty* are both associated with exposure to events that can result in losses. Though the terms are often used interchangeably, *risk* can be defined as imperfect knowledge when the probabilities are known, and *uncertainty* exists when these probabilities are not known (Siegel 2005). Many of the expected losses from the risks facing modern agri-food systems are really related to uncertain events for which there are no known probabilities, although subjective probabilities can be conjectured by expert opinion. So, even if the terms *risk* and *uncertainty* are used interchangeably, the critical question is whether the subjective perceptions of probabilities of the events taking place are based on risky or uncertain events. For example, only under very restrictive conditions, when information is available on the probabilities of events and on expected losses are measurable, unwanted events might be insurable risks.

impacts. By combining the likelihood of risk, risk exposure, and the severity of risky events, one can estimate the expected losses from a risky event for different participants in the supply chain as well as the cumulative losses throughout the chain. Indeed, researchers and practitioners examining exposure to risk have identified a set of key factors:

- *Inherent commodity characteristics:* Product perishability complicates exposure to market and logistical risks. Commodity quality may have both observable and non-observable characteristics, with impacts on managerial and operational risks.
- *Inherent production characteristics:* Technically sophisticated production processes and greater specificity of production assets may exacerbate operational and market risks.
- *Geography and agro-ecology:* Logistically remote and/or otherwise difficult terrain increases risk exposure, as do agro-climatic conditions conducive for pests and diseases.
- *Political boundaries:* Border controls and crossing procedures add to risk exposure.
- *Transaction points:* The number of transport nodes and transaction points and the frequency of use influence risk exposure, as does the number of compliance points.
- *Infrastructure conditions:* The condition of transport, communications, energy water, and sanitation infrastructure, in addition to their availability, influences risk exposure.

Expected losses from a risky event include both tangible and intangible losses and short- and long-term losses. It is critical to consider losses in terms of how they affect short-term outcomes (e.g., a decline in producer prices after harvest) and in terms of how they affect livelihoods and outcomes in the long term (e.g., a decline in the water table that impacts planting decisions and yields in the future). Thus, in addition to examining whether risks are idiosyncratic or covariate, it is important to examine whether they impact performance flows (e.g., the movement of goods and services, incomes) and/or damage assets. For example, the nonpayment of a loan or the failure to achieve quality standards or timely delivery can result in the termination of future supply contracts, the compromise of business reputation, and the loss of access to credit and other supply services.

Expected losses are a function of the probability of a risky event actually occurring and the exposure to that risky event, that is, how performance outcomes might be influenced if the risk materializes. (See Box 5.) Expected losses are another way of considering the potential severity of negative impacts from a given risk, *without any (ex-ante* or *ex-post) risk management.* Some risky events have a low probability with low negative impacts and low expected losses; others have high probability with high negative impacts and high expected losses. Still others could entail more intermediate expected losses (high probability and low expected loss or low probability and high expected loss). See Table 4.

Box 5: Risks and Potential Risk Impacts

In the recent literature on supply chain risk, a distinction has been made about the relationship between risks and potential risk impacts. Gaonkar and Viswanadham (2004) classify three major scenarios of expected losses emanating from risks faced by supply chains (and by participants in supply chains) according to the severity of their potential negative impacts on the supply chain:

- *Deviations:* Fluctuations in key parameters (such as costs, demand, logistics) can lead to performance that differs from the expected value, but without changes to the underlying supply chain structure.
- *Disruptions:* These are changes in the structure of the supply chain due to the non-availability of certain production, processing, marketing, and distribution facilities, arising from risk events caused by natural or human factors. These events are unexpected, as is the risk management. Examples are disruptions in supply due to a fire, disruptions in supply due to a pest or disease outbreak or epidemic, or labor strikes at the farm or firm or at ports, all either internal or external to the enterprise.
- *Shutdowns:* These can be temporary and/or permanent shutdown of parts or all of the supply chain, external and internal to the enterprise).

Table 4: Expected Loss Scenarios (Probability × Severity)

		Potential Severity of Negative Impact	
		Low	***High***
Probability of Occurrence of Event	*High*	High probability Low impact	High probability High impact
	Low	Low probability Low impact	Low probability High impact

Source: Based on Smith (2005).

Table 5 provides an illustration of how different supply chain actors could be differentially impacted by a single risk event—in this case, a shortfall of rain during a key part of the maize growing cycle.

2.4.2 Vulnerability

The *vulnerability* of individual chain participants and the overall supply chain depends on the nature of the risks (correlation, frequency and timing, and severity) and on the effectiveness of the risk management instruments in use. Risk, combined with the enterprises' *modus operandi,* including their risk management responses, leads to performance *outcomes*. The magnitude, timing, and history of risks and the timing and effectiveness of responses determine the outcome. For the farm or firm and for the supply chain as a

Table 5: Illustration of the Differential Impacts of Insufficient Rainfall Affecting Maize

Supply Chain Participant	What Is Exposed to Risk?	Risky Event	Consequence	How Impact Is Manifested	Expected Magnitude of Loss
Small farmer	Rain-fed maize production	No rains in key month	30% decreased yield Lowered water table	Lower income Limited planting for next year	Medium income loss
Large farmer	Irrigated maize production	No rains in key month	Need to increase irrigation	Increased irrigation costs (electricity and labor)	Minimal income loss
Food processor	Maize purchases for milling	No rains in key month	10% less maize available for purchase	Higher costs for Maize	Minimal income if cost increases can be passed on
Urban poor consumer	Processed maize	Changing maize prices	15% higher maize cost Potential compromise of nutrition/ health	Less real income Less $$ for vegetables	Depends on availability of affordable substitutes

Adapted from Harland, Brenchley, and Walker (2003).

whole, the *outcome* of the risk and response process, in terms of performance loss relative to a given benchmark, is an indicator of major interest. To make the concept of vulnerability useful, an appropriate performance benchmark is needed for each participant in the supply chain.

However, risk-related performance losses for individual supply chain participants are neither necessary nor sufficient conditions for the existence of supply chain vulnerability. Supply chain vulnerability is associated only with losses that disrupt the flow of products in a manner that causes serious damage to the supply chain. To illustrate, yield declines, cost increases, and/or price declines resulting in income losses are not, in and of themselves, sufficient to determine enterprise disruptions or closure and supply chain vulnerability. However, sometimes the resultant income loss is so severe that it forces the enterprise below some minimum performance standard, perhaps resulting in production and delivery losses that can not be made up elsewhere in the chain. In such cases, an individual enterprise can substantially hinder the performance of the overall supply chain.

Table 6: Vulnerability: Expected Losses and Capacity to Manage Risk			
		Capacity to Manage Risk	
		High	***Low***
Expected Loss	*High*	Low vulnerability	High vulnerability
	Low	Very low vulnerability	Low vulnerability

The enterprise-specific performance standards (benchmark indicators) should thus be based on objectives relevant for *sustainable* participation in the supply chain.[13] *Resilience* is the enterprise's ability to resist and to recover from the potential negative impacts of risky events—especially when assets are degraded. An overall supply chain can also have greater or lesser capacities of resilience.[14] Given the varying portfolios of assets among and between enterprises, the same risky event can have different performance outcome effects. Similarly, enterprises with similar assets but different risk management responses might experience dissimilar outcomes.

Table 6 illustrates a continuum of vulnerability conditions. If the capacity to manage risks is low, enterprises facing high expected losses could, in fact, be vulnerable to profound disruptions that would curtail their ability to participate effectively in the supply chain. Yet, even when exposed to the same risky event, impacts vary depending on the farm or firm (or supply chain's) capacity to manage risk.

2.5 Risk Management Measures[15]

2.5.1 *Ex-Ante* Versus *Ex-Post* Measures

Approaches to risk management can be articulated as *ex-ante* or *ex-post* strategies. *Ex-ante* actions are taken before a risky event occurs, and *ex-post* management takes place after its realization. *Ex-ante risk* management includes:

- *Risk avoidance:* actions to side-step the risk entirely, perhaps through re-location, the withdrawal from certain business activities, etc.
- *Risk sharing or transfer* (to third parties) through insurance or other financial instruments
- *Risk retention,* yet properly budgeting against potential losses
- *Risk reduction:* actions taken to reduce the incidence of the risky event
- *Risk mitigation:* measures taken to reduce the negative effects of the risks

Ex-ante actions can reduce risk (e.g., the eradication of pests) or lower stakeholder exposure to risks (e.g., pest-resistant varieties or crop diversification). *Ex-ante* actions may transfer certain risks to other parties (i.e. insurance) or may entail a form of self-insurance against expected losses (e.g., precautionary savings) or reliance on social networks (e.g. access to community savings). In most cases, risk mitigation only partially offsets actual losses. In addition, *ex-ante* risk management actions are associated with real and/or opportunity costs, which may be a major constraint, especially for asset and income constrained entities.

Individual *ex-post* activities to cope with realized losses are, for example, selling assets, seeking temporary employment, and migration. Additionally, governments sometime forgive debts, provide other types of bailouts, or maintain formal safety nets, such as subsidies, rural works programs, and food aid to help enterprises (and their laborers) cope with negative impacts associated with risky events. Some short-term risk-coping strategies often have longer-term negative impacts on assets, on livelihood and enterprise strategies, and on achieving performance objectives. Thus, some coping activities result in the sale or degradation of assets and/or increased debt, which, in turn, results in a negative dynamic (that can even lead to an inability to participate in the supply chain).

Thus, *ex-ante* measures allow enterprises to eliminate or reduce risks, lower risk exposure, and/or mitigate against the losses associated with risky events. But they have real and/or opportunity costs *before* a risky event actually occurs. In contrast, *ex-post* risk management actions and instruments respond only to realized risk-related losses, but they can have very high real and opportunity costs after the event occurs.

Within any strategy taken to respond to anticipated risky events, a variety of instruments is available. All these instruments have different private and public costs and benefits, which might either increase or decrease the vulnerability of individual participants and the supply chain. When selecting a mix of risk responses, supply chain participants take account of the many inter-linkages among the different types of risk management strategies and instruments.

2.5.2 Location and Formality of Risk Management

The risks affecting agricultural supply chains can be managed at different points and by different players. For example, risks may be managed

- By individual enterprises, through enterprise strategies, with various management practices, and the like;
- In their interface with other supply chain participants by means of transactions, contractual arrangements, information flows, and other interactions, with some distribution or sharing of risk with those players;
- At a meso-level, such as through joint action with other farmers and firms (i.e., community networks, farmer groups or cooperatives, industry associations, and other groups);
- At a macro- or external level where players "outside" the specific supply chain—including banks, insurance companies, government agencies, donor agencies—share or absorb part or major elements of the risk through financial instruments, physical stockholding, and other means.

It is also useful to consider the formality of the risk management arrangements. *Private informal arrangements* reflect self-insurance by enterprises through personal arrangements or management measures. In developing countries, many types of informal risk-sharing measures are also adopted at the

Table 7: Informal Risk Management Strategies		
	Farm Household Level: Mitigating Risk	**Community Level: Sharing Risk**
Ex-ante	Savings Buffer stocks Enterprise diversification Low-risk, low-return cropping patterns Production techniques	Food crop sharing Common property resource management Social reciprocity Rotating savings/credit
Ex-post	Sale of assets Reallocation of labor Reduced consumption Borrowing from relatives	Sale of assets Transfers from mutual support networks

community level. Table 7 provides a few examples of informal risk management measures at farm and community levels.

Private formal arrangements involve various types of contracting and/or financial instruments.

Some formal risk management measures are *publicly mandated or implemented,* such as mandated (and sometimes subsidized) insurance, credit guarantees, transfers or public works, and the like. Public measures are taken when private informal or formal arrangements have broken down, are dysfunctional, are considered to be inappropriate, simply do not exist, or are not sufficient to meet policy specific objectives. Table 8 presents a range of formal risk management measures.

Table 8: Formal Risk Management Measures		
	Market Based: Sharing or Transferring Risk	**Publicly Provided: Transfer or Absorb Risk**
Ex-ante	Contract marketing Financial hedging tools (options) Traditional insurance Weather index insurance Contingent funds for disaster relief	Pest/disease management Physical crop or food stocks Price guarantees or stabilization funds Input subsidies Public insurance
Ex-post	Savings Credit	Disaster assistance Social funds Cash transfers Waiver (cancellation) of crop loans

2.5.3 Alternative Instruments for Managing Agricultural Supply Chain Risk

An array of approaches and instruments are available to help manage risks in an agricultural supply chain. These can be grouped into several broad categories:

- *Technology development and adoption:* Agricultural research and development of improved varieties and breeds, postharvest technology, software development, information and knowledge technology, basic and advanced applied education programs
- *Enterprise management practices:* Farm and firm diversification practices, farming systems approaches, just-in-time management, inventory control, improved forecasting capacity, food safety practices, certification of best practices, logistics planning, early warning systems, among other practices
- *Financial instruments:* Credit and savings (formal and informal), insurance (formal and informal), warehouse financing, price hedging instruments, and other vehicles
- *Investments in infrastructure:* Investments in transport and communication infrastructure (including air- and seaports), energy infrastructure, informatics and knowledge transfer infrastructure, storage and handling facilities, marketplaces, processing facilities, weather stations, and other structures
- *Policy and public programs:* Institutional arrangements, regulatory measures, government policies, property and human rights, labor laws, disaster management units, safety nets, and similar programs
- *Private collective action:* Commercial and no-commercial actions taken by farmer groups, cooperatives, industry associations, and other groups, in addition to various types of commercial contractual arrangements and partnerships

Multiple strategies are typically combined because no single approach or instrument can effectively reduce, mitigate, or transfer the broad range of risks normally encountered. As already noted, these strategies may need to be supplemented by *ex-post* measures following adverse events, perhaps through the sale of assets, the downscaling of enterprise operations, temporary migration, or other means. Table 9 provides a detailed listing of alternative measures, subdivided according to their broad objectives and where in or outside the supply chain they can be applied. When conducting a RapAgRisk assessment, in addition to categorizing the instruments—the levels and providers—it is important to fully understand and if possible, to scale or quantify the effectiveness of these instruments in relation to the underlying risks, risk exposure, and expected losses.[16]

Table 9: Possible Instruments for Risk Management for Agricultural Supply Chains

	Supply Chain Specific Production, Marketing, Processing			External to Supply Chain	
	Production	**Marketing, Processing**	**Support Service Providers**	**National**	**International**
Risk Reduction or Mitigation					
Investments in infrastructure	Farm machinery and equipment Irrigation and drainage systems Water and sanitation Storage and handling facilities Maintenance of physical assets Small transport, communication, and energy infrastructure	Machinery and equipment Water and sanitation Storage and handling facilities Maintenance of physical assets Enterprise-level transport, communication, and energy infrastructure	Storage and handling facilities and services Medium-scale transport, communication, energy infrastructure	Weather stations Early warning systems Large-scale transport, communication, energy infrastructure Back-up systems for critical infrastructure	Early warning systems Global communications Multi-country water resource infrastructure
Technology	New technology (improved varieties and breeds) Other improved inputs	New logistics or processing technology Information services to producers Extension services	Develop and promote new technology Information services Extension services	Investments in research and development Extension services Education system	Investments in research and development (e.g., CGIAR) Global centers of excellence for research and education

Table 9: Possible Instruments for Risk Management for Agricultural Supply Chains (*Continued*)

	Supply Chain Specific Production, Marketing, Processing			External to Supply Chain	
	Production	**Marketing, Processing**	**Support Service Providers**	**National**	**International**
Management practices	Food/livestock stocks Crop and livestock diversification Farming systems approach Disease and pest management practices Improve farm hygiene	Food and raw material inventories Enterprise and market diversification Seek alternative buyers and suppliers Adopt and promote best practices for food and occupational safety	Management consulting services Testing facilities for food safety, pests and diseases Develop and promote best practices	Macroeconomic management Trade and market policies Inspection and testing services for food safety Regulate best practices for human health and safety on farm Education and information for risk management	International best practices (e.g., ISO) International standards Testing facilities for food safety, diseases
Financial instruments	Precautionary savings Crop and livestock insurance Access informal and formal credit for risk-reducing inputs and investments	Insurance Price hedging Warehouse receipts Access and provide credit for risk-reducing inputs and investments	Provide flexible financial services	Regulatory and legal rules for financial system (credit, savings, insurance) Subsidize select financial instruments for risk management	Global financial markets Global insurance and reinsurance markets
Policy and public programs	Community projects and public insurance Extension services	Extension services	Facilitate group formation Legal services related to contracts	Guaranteed prices Regulatory and legal aspects of contracts National standards	International commodity agreements International development agencies
Private collective action	Contract farming mutual insurance	Contracting Cooperative Organizations	Microfinance institutions Credit arrangements	Support national enabling environment structures	Support enabling environment structures

Table 9: Possible Instruments for Risk Management for Agricultural Supply Chains (*Continued*)

	Supply Chain Specific Production, Marketing, Processing			External to Supply Chain	
	Production	**Marketing, Processing**	**Support Service Providers**	**National**	**International**
Risk Coping					
Investments in infrastructure	Repair and/or replace infrastructure	Repair and/or replace infrastructure	Repair and replace services	Fund repair and replacement of infrastructure Investments in new transport and communication infrastructure	Fund repair and replacement of infrastructure
Technology	Alter technology for future application	Adopt and promote new technology for future	Promote and adopt new technology for future	Develop and promote and adopt new technology for future	Develop and promote and adopt new technology for future
Management practices	Consume/don't sell products Seek alternative buyers Seek new products and markets Off-farm employment and nonagricultural enterprises Adjust to natural resource degradation	Seek alternative suppliers and buyers Restructure labor force Seek new products/ markets	Provide information on alternative suppliers and buyers Provide advice on new products and markets	Provide information on alternative suppliers and buyers Provide advice on new products and markets	

Table 9: Possible Instruments for Risk Management for Agricultural Supply Chains (*Continued*)

	Supply Chain Specific Production, Marketing, Processing			External to Supply Chain	
	Production	**Marketing, Processing**	**Support Service Providers**	**National**	**International**
Financial instruments	Sell off financial assets and stocks Sell off other productive assets Informal and formal credit Non-repayment of loans Seek charity and/or external assistance	Sell off financial assets and inventories Sell off other productive assets Non-repayment of loans	Provide emergency financing Purchase financial assets and stocks from supply chain actors Provide loan repayment plans	Loan forgiveness Financial bailouts Emergency disaster funds	Loan forgiveness Financial bailouts Emergency disaster funds
Policy and public programs	Safety net mechanisms	Safety net mechanisms	Safety net mechanisms	Charity or aid from national organizations and institutions	Charity or aid from international organizations and institutions
Private institutional and organizational	Collective action of farmer group to lobby for assistance Protests, petitions to general public and international community	Collective action of supply chain group to lobby for assistance		Assistance from national organizations	Assistance from international private entities

2.5.4 Support Service Providers: An Illustration of Agricultural Supply Chain Finance

Table 10 indicates that various types of service providers may play an important role in enabling producers and marketing entities to better manage risks either through investments, by adopting better management practices, or by transferring certain risks to others. Financial institutions may play especially important roles they adequately understand the prevailing risks that prospective clients face and tailor their credit, insurance or other products accordingly.

A number of unique characteristics of rural and agricultural markets constrain both the supply and demand for market-based finance (USAID 2005a):

- High transactions costs for both borrowers and lenders
- High risks faced by potential borrowers and depositors due to the variability of incomes
- Exogenous economic shocks
- Limited tools to manage risk
- A lack of reliable information about borrowers
- A lack of adequate collateral
- Inhospitable policy, legal, and regulatory frameworks

In all cases, lending for agriculture can expose (formal and informal) lenders to high levels of liquidity risk and covariant risk. Liquidity risk is greater because of the seasonality of crop production and the likelihood, in the event of expected or actual risk-related losses, that all farmers in the region will seek a loan or access to their savings at the same time. Lenders also have high exposure to covariant risks such as climatic risk and market (e.g., price) risks that are endemic to agriculture and that effect all enterprises in a given region who borrow for similar purposes (USAID 2005b). Financial institutions—such as commercial banks, credit unions, and microfinancial institutions (MFIs), as direct providers of financial services—tend to focus attention on the series of transactions to bring a product from inputs to the final market, rather than a on given stage in the chain. A supply chain perspective enables financial institutions to focus on the kinds of financial flows and the opportunities and risks associated with the provision of formal and informal financial services.

Supply chain finance operates according to the same logic as that of other financial transactions. Lenders face the risk that borrowers will not pay them back. Successful financial relationships must therefore include some form of client screening, client monitoring, and contract enforcement. Appropriate incentives must be in place to ensure that the costs to would-be defaulters are higher than the cost of repayment. In some cases, supply chain participants working in cooperation for production, processing, and marketing are better situated to enter, screen, monitor, and enforce contracts than are more formal providers of financial services (Meyer and Johnson 2007).

Table 10 provides an illustration of how financial institutions can consider various types of agricultural risk in the design of their lending products and policies. This case relates to the cotton supply chain in Uganda. There are thus opportunities for Ugandan banks to make sound lending decisions (managing their portfolio risks) and to tailor or customize their products while still assisting chain participants with finance for production and trading activities.

Table 10: An Illustration of Supply Chain Finance: Uganda Cotton Transaction Points, Risks, and Opportunities

Transaction Point	
Risks	**Opportunities**
Input supply: Retail price falls due to competition because margins are thin.	Short-term lending product of only one to two months to limit the exposure of the lender
Production: Inputs for production are late or incomplete.	Monthly phased disbursement lending product to limit the exposure of the lender
Farm gate price is below cost of production.	Monitor minimum prices announced by collateralized debt obligation Donor-financed credit guarantee facilities
Loan term is longer than production and marketing cycle.	Adjustment of the term of the loan product to match the seasonal production and marketing cycle
Yield is lower than expected.	Design the loan product to pre-finance only a portion of the total cost of production Opt for loans based on ginnery receipts so as to lend only postharvest
Operational acreage borrowed for is not realized.	Loan product designed to disburse in phases where financing is released only as the tasks in the production and marketing cycle are realized
Buying agents and traders: Transport is inadequate.	Financing and/or operating leases for trucks
Price is below cost of procurement.	Financing only against forward contracts provided in advance of borrowing from regional traders Price insurance products (not yet developed) compensating for low-price years from earnings of high-price years through a commercial insurer Opt for loans based on warehouse receipts so as to lend only post-delivery
Transaction Point: Ginneries	
Risks	**Opportunities**
Ginneries: Ginneries secure financing at low rates against international dollar denominated, forward contracts.	Few if any, financing opportunities exist

Source: USAID (2005c).

3. Guidelines for the Application of RapAgRisk Assessment

The objective of this section is to outline the steps and sequences required in planning and undertaking the RapAgRisk. The section is complemented by a methodological guideline document,[17] which presents supporting assessment materials and approaches in more detail.

3.1 Basic Assessment Principles

The RapAgRisk assessment is designed as a time-bound process to provide a first approximation of major risks, vulnerabilities, and areas requiring priority attention for investment and capacity building. The guidelines assume a rapid assessment process, involving a small study team and spanning a period of approximately three months.

The assessment combines analyses of secondary data with consultative processes based on interviews and field exercises involving a range of supply chain participants and service providers (from the private and public sectors), as well as policy makers. Though not all stakeholders share similar perspectives (nor is it expected that they should), the assessment should contribute to common understandings and agreed commitments to work toward mutually beneficial risk management outcomes. To ensure appropriate stakeholder participation in the assessment, the study team should include national experts when possible.

The RapAgRisk assessment facilitates supply chain sector and spatial mapping, risk and vulnerability analysis, and recommendations for improved risk management options. The assessment builds on existing methodologies to carry out supply chain analyses but expands on traditional applications. Given its multidimensional nature, RapAgRisk brings together a range of partial, complementary approaches to finally arrive at a representative bigger picture.

The assessment assumes that a certain level of baseline information is available for the selected agricultural commodity supply chain. This information enables quantitative analyses to complement the qualitative analyses based on stakeholder opinions. The assessment tool is designed to deal with crop-based (rather than animal product) supply chains, but it can be adjusted to deal with any agricultural supply chain.

Finally, the supporting methodological guideline materials are designed to facilitate transparent and objective analysis, an important aim in mapping and comparing risks throughout the supply chain. However, any proprietary supply chain information must be respected (e.g., information about contract relationships, certain financial information, environmental audit results, and

the like). Some stakeholders might be wary about providing information about their risks exposure, risk management practices, and vulnerabilities. Thus, considerable tact must be used to elicit information, in tandem with a coherent explanation of the exercise to stakeholders.

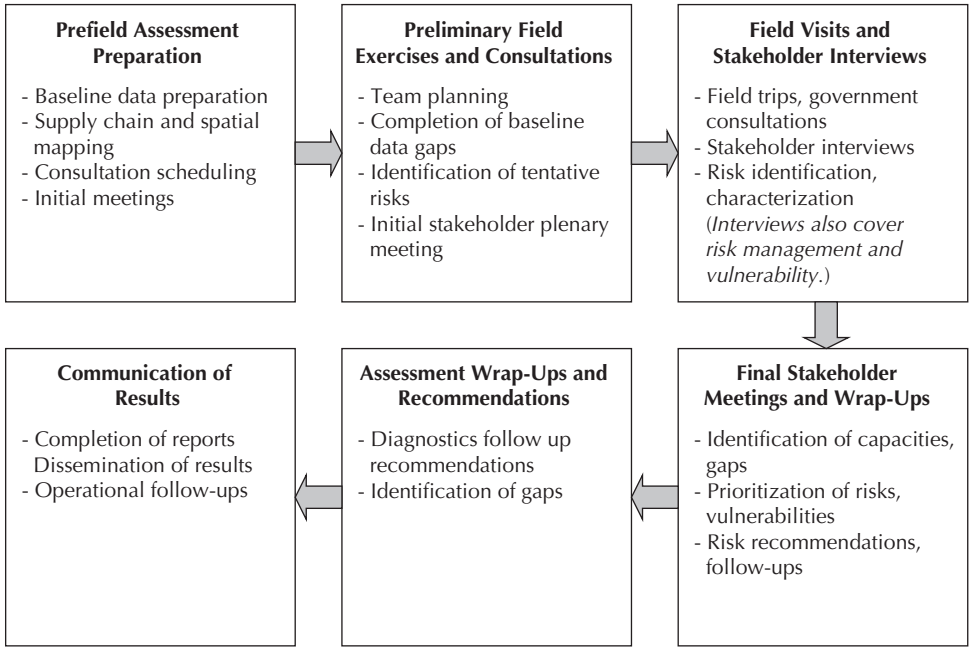
3.2 Assessment Process

The basic sequence for a RapAgRisk is outlined in Figure 2, with detailed steps set out in the assessment planning matrix in the complementary guidelines document.[18]

These steps can be sub-divided into four major components:

- *Component 1—Supply chain situation analysis:* Secondary data related to the supply chain structure, conduct, and performance are gathered and analyzed. During this situation analysis, so to speak, the assessment team gathers baseline and contextual information, maps the supply chain according to its sectoral and spatial dimensions, and, where possible, gathers cost structure information. The early stages of analysis may surface a number of priority (tentative) risks for further investigation.
- *Component 2—Risk analysis:* Various risk events related to weather, price, food safety, policy, labor, environment, logistics, and other factors

Figure 2: Overall Sequence of Analysis and Consultative Steps



are identified, characterized, and, where possible, quantified. The assessment team assesses the risk exposure of supply chain participants (examining the probability and potential severity of different risk events), thus estimating the expected losses arising from different risks for individual supply chain entities and for the supply chain as a whole.

- *Component 3—Risk management and vulnerability assessment:* Risk management capacities—existing risk management instruments and their evident effectiveness and sustainability—are assessed. Combining this assessment with information on expected losses, the assessment team is then able to identify areas of residual (high and low) vulnerability.
- *Component 4—Recommendations and suggested follow-up actions:* the team identifies recommendations and suggested actions for follow-up based on the conclusions of the RapAgRisk. This component includes suggestions in areas where additional information and analyses are needed and/or recommendations regarding priority areas for investment and capacity building.

3.3 Stakeholders

Guidelines for pursuing these steps are outlined in Sections 3.5–3.9. Before getting into the details, it is important to draw attention to the political economy dimensions of the RapAgRisk.

RapAgRisk assessments of specific supply chains need to combine objective analysis of available and gathered data with the perceptions of multiple stakeholders. These actors' underlying objectives and specific motivations for participating in the focal dialogue can vary, cutting across commercial, personal, political, economic development, and even humanitarian concerns and considerations. Some goals, perspectives, and expectations may be shared; others may not. Therefore, a commonality of goals cannot be an assumption at the start of the assessment process. Yet one of the objectives of the process is to build a heightened degree of common understanding and commitments toward common goals.

In managing the dialogue and other components of the risk assessment process, the team needs to take account of the divergent goals and motivations of affected stakeholders, address any perceptions or misperceptions that could be counter-effective, and, in so doing, advance the acceptance of the analysis, recommendations, and other outcomes irrespective of the individual stakeholders' motivations. In some circumstances, stakeholders might compete with one another to take ownership of the assessment process and the recommended agenda for action. Table 11 provides an illustration of the potentially varied perspectives of different stakeholders.

Table 11: Multi-level Stakeholder Matrix of Motivations and Perceived Impacts: An Illustration from a Staple Food Supply Chain

Stakeholder	Motivations	Perceived Positive Impacts
Government:		
Cabinet and security-related ministries	Political and social stability Security/law and order forces Loyalty	Lower party and personal political risk Lower internal security costs Assured food supplies for army and police
Ministry of Finance	Economic stability and growth Improved macro-level food security	Increased risk-amelioration budget expenses Lower emergency budget funding requirements Improved sustainability for rural sector Lower urban cost of living Improved and stabilized household incomes Less risk exposure to financial/banking system
Ministry of Agriculture/ Ministry of Irrigation/ Ministry of Food Supply	Improved macro-level food security Stable and market-responsive food production and delivery	Larger budgets and staff Increased rural activities Modernization of agriculture Increased integration of the rural economy into the market/urban economy Improved household incomes
Regional, district, and urban administrations	Improved food-market and related operations Improved local infrastructure	Increased political stature Increased administration budgets/staff Improved household food security Improved sustainability of local enterprises Less disruption in local services
Food-related and other enterprises:		
Farmers/ growers (non-contract suppliers)	Increased certainty for production and yield Improved certainty of input supplies, services and prices Improved certainty of market access and prices	Lower risk premium/discount in all pricing (inputs, outputs, and services) increased production margins Improved household sustainability increased household food security Increased ability/willingness to enter into grower/supplier contracts
Rural and urban food traders	Increased certainty/ stability of supplies Improved ability to forecast supplies	Improved predictability of supplies and prices lower contract default risk Increased ability/willingness to enter into supply and delivery contracts Lower risk premium/discount in all pricing (supplies and services)

(continued)

Table 11: Multi-level Stakeholder Matrix of Motivations and Perceived Impacts: An Illustration from a Staple Food Supply Chain (*Continued*)

Stakeholder	Motivations	Perceived Positive Impacts
Urban food stores and supermarket chains	Increased certainty/ stability of supplies Improved ability to forecast supplies/ prices	Lower cost of doing business Lower supplier contract default risk Less need for contingency alternative supply plans (reduced cost of business) Lower business premises security costs (food riots' first target is breaking into food stores and warehouses to steal supplies)
Urban agro-industries/ processors	Increased certainty/ stability of supplies Improved ability to forecast supplies Lower risk in execution of business expansion strategies	Improved processing margins Lessened supplier contract default Lower risk of delivery contract default Lower supply management efforts (coping mechanisms) Improved enterprise sustainability
Financial: banks and insurance	Lower financial risks Lower property damage loss claims	Improved margins Less risk management requirements Increased deal flexibility Widened client base

3.4 Data and Information

Multiple sources of data and information are required to undertake an agricultural supply chain risk assessment. Given the crosscutting nature of RapAgRisk, a diverse set of literature should be reviewed in preparing for an assessment. The complementary guidelines document[19] outlines a key set of themes and lines of inquiry to be considered when first reviewing the background literature. This step involves an in-depth analysis of the supply chain, covering performance trends and variability in recent years; the supply chain's structure, dynamics, and level of integration; and the position of the focal commodity sector in the overall economy. The initial literature review also elicits the key drivers of change in the supply chain and broad agri-food system in recent years. At this stage the literature should also be reviewed to pull out information on risk management and vulnerabilities, as well as particular poverty dimensions that may be relevant.

Baseline data should also be collected at this point, covering commodity market characteristics, macroeconomic conditions, supply chain structure, and selected enabling environment and risk factors. Sources of information and data for the agricultural supply chain risk and vulnerability assessment can include

- Existing household surveys, subsector studies; firm-level surveys; policy analyses;
- Meteorological department data or studies on weather-related risks;
- Data on production, costs, profitability, and quality parameters;

- Project background documents examining the structure and performance of input/output markets or financial system status;
- Interviews with banks/micro-finance institutions (MFI)s, input suppliers, exporters, processors, representatives of farm and industry organizations, research and extension personnel, and local and regional government officials.

In reviewing the literature and available information sources, the team should anticipate a couple of specific challenges. First, information and data may be context specific, and so a mix of information is often required to balance different aspects (e.g., spatial or seasonal dimensions). Second, in some instances certain strands of information may be of a propriety nature to supply chain participants.

3.5 Supply Chain Situation Analysis

The purpose of the situation analysis is to identify major participants in the supply chain and to fully decompose the system and its current status (subsystems, cost structures, spatial and seasonal dimensions) in order to better identify events that can lead to major losses and/or breakdowns in the chain. This step is a crucial building block. It is important to understand the broad, general context in which the supply chain is operating in order to better appreciate the causes of and potential solutions for risk and uncertainty. In most instances, a substantial amount of pertinent information will already have been collected and analyzed for other purposes; so the supply chain situation analysis should draw on this analysis.

The situation analysis involves

- A contextual overview of the supply chain;
- A mapping of the supply chain to reflect different spatial and sectoral dimensions;
- An analysis of the supply chain cost structure.

3.5.1 Contextual Analysis

The supply chain contextual analysis covers a number of key elements, including

- Role and significance of focal commodity in economy and rural sector;
- Demand and market context;
- Structural patterns, relationships, and spatial distributions;
- Government, policies, and institutions.
- Recent performance and cost structures.

The analysis takes into account factors related to the broad enabling environment, including

- The importance of the supply chain in the national economy, regional, and local economies, in the agri-food sector, to enterprises, and to rural-urban households;

- The influencing policy, regulatory and institutional, and political economy issues;
- The overall reliability and dependability of transport, communication, and utility (e.g., energy, water and sanitation) infrastructure and services;
- The salient features of the prevailing arrangements for finance and insurance in agriculture generally and in the focal commodity subsector;
- The salient features of public and private sector service providers of technical assistance, capacity-building, and general education services;
- The broad patterns in the geography of agricultural production and supply chain organization;
- The country's prominent agro-ecological zones and weather patterns and the pertinent conditions in relation to the focal commodity subsector.

The analysis also zeroes in on issues directly relevant to the specific agricultural supply chain. Conventional concepts and analytical tools are used to describe the structure and performance of the focal supply chain and to determine

- The salient techno-economic characteristics of production and marketing for the supply chain;
- The final markets for the primary and secondary products;
- The key participants in the supply chain and where are they located (direct and dedicated participants, versus indirect and partial participants, private and public sector);
- The key product, finance, and information flows, as well as when and where they take place and by whom;
- The key transaction points in terms of flows and potential bottlenecks;
- Supply chain performance, also relative to the national economy and the agri-food sector;
- The underlying structure of costs, prices, and margins through the supply chain in a representative normal year;
- Performance effectiveness in a representative normal year;
- The levels of farm, processor, other player productivity in a representative normal year;
- The entry/exit conditions in the agri-food supply chain (competitiveness and maturity of the supply chain and of individual participants);
- The poverty dimension of the supply chain story (e.g., small farmers, SMEs, hired farm labor, non-farm rural labor, urban labor, producers, consumers).

3.5.2 Mapping the Supply Chain

To facilitate the subsequent risk analysis, the team must then conduct a series of mapping exercises depicting different activities, actors, and relationships among segments of the chain, as well as the interactions among producers and intermediaries. Information gathered in this step provides an understanding of the sourcing, production, and delivery segments within the commodity

sector, as well as the different dimensions through which a supply chain can be viewed. The complementary guidelines document[20] outlines a number of graphical examples that depict the supply chain according to its structural and spatial dimensions.

3.5.3 Cost Structure

Supply chain cost structures can be determined and later used to simulate the effects of various types of risk. Where relatively good cost, financial, and productivity data are available, simulations can be done assessing differential impacts of adverse (price, weather, other) events and critical points where stakeholders incur financial losses or severe disruptions in their operations. A representative supply chain cost structure can help to capture the difference between some normal situations and some diversions from the norm, in addition to identifying the magnitude of changes in certain variables that would mean a financial loss for supply chain participants (most notably farmers in this instance).

Sources of information for the supply chain situation analysis include existing supply chain or industry analyses, countrywide agricultural development or trade studies, investment climate studies, agricultural strategy documents, national and international databases, national poverty assessments, and general country economic development studies.

3.6 Risk Analysis

Once the supply chain situation analysis is completed, the team can focus on the risks and uncertainties affecting the agri-food supply chain. Although numerous reports may identify selected risks, there is a need for a more systematic assessment highlighting patterns of risk exposure and the associated expected losses from various risky events for different supply chain participants. In addition, the team should map out different patterns of risk transmission throughout the supply chain.

With particular regard to the risk analysis and risk management dimensions, the sequence of analytical and consultative steps involves

- Characterizing and charting key players in the supply chain and identifying critical flows and transactions of product, information, finance, and logistics;
- Identifying and characterizing the range of risks faced by players along the supply chain, with a focus on critical flows and transactions;
- Ranking risks in terms of probability and potential severity—identifying the key risks and their expected losses;
- Identifying the existing *ex-ante* and *ex-post* risk management strategies taken by players in the supply chain and/or external parties;
- Assessing the apparent effectiveness, costs, and benefits of the risk management strategies taken by players, as well as options to improve risk management effectiveness.

This stage of the assessment results in a number of key outputs, such as a presentation of the risk profile of individual supply chain entities and the supply chain as a whole, as well as the documentation and summary of key informant interviews[21]. This step involves interviews with representative entities throughout the supply chain (farmers, input suppliers, market intermediaries, transporters, processors, and others), as well as additional service providers (farm extension advisors, financial institution representatives, and the like). For supply chain participants, perceptions about the risks they face should be sought in relation to their

- Sourcing of inputs (goods, services, raw materials);
- Own production and processing of goods or services;
- Marketing of the product (whether it is a finished or intermediary good or service).

Chain participants should provide perspectives on their differing exposures to their relevant risks, to the risks of their suppliers and buyers, and to the risks of the overall supply chain. Survey instruments and/or stakeholder meeting dialogues should be structured to obtain both perceptions and data so that the probability and severity of different risks can be quantified and ranked with some degree of confidence. Additional information can be obtained from published price and weather data. Service providers (e.g., financial institutions, freight and transport operators, technical advisors) are also interviewed to assess the risks that they face in their business relations with the supply chain and to gauge their perceptions about the risks borne by those chain participants. Once constructed, the preliminary mapping and rating of different risks should be reviewed in a meeting with multiple stakeholders.

The methodological guidelines set out supporting materials to categorize different risk impacts and to guide stakeholder interviews. For a given commodity context, the assessment team may wish to prioritize a number of risks that emerge from the initial situation analysis. The methodological guidelines for the analysis of key risk categories, including

- The definition and scope of different risks;
- An illustration of direct risk impacts according to supply chain entities and wider spillover impacts;
- Defining indicators to measure the risk;
- Analytical steps to determine expected losses;
- Dimensions to consider in the assessment of risk management capacity.

The methodological guidelines set out semistructured interview guidelines to assess the risk perceptions of supply chain entities and to examine how these risks and possible negative impacts could be managed more effectively. For supply chain entities, the interviews are structured to determine their respective roles and the relative importance of their commodities to business enterprises, to prioritize risks and estimate expected losses, to overview supply chain linkages, and to elicit risk management options and capacities.

Interview guidelines for supply chain service providers are designed to assess supply chain risk perceptions and spillover risk effects that the providers face in both the public and private sectors.

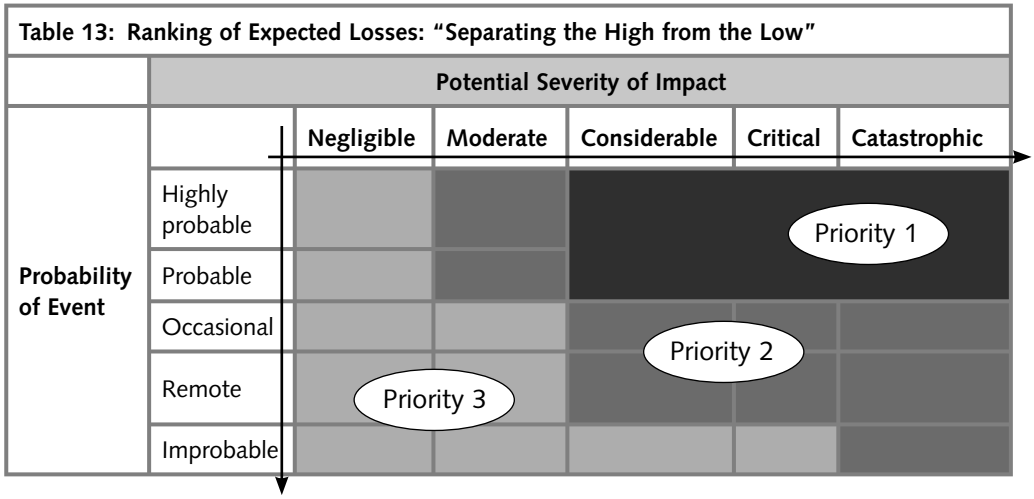
The risk analysis should address a number of issues, including

- The risk and uncertainty factors that can disrupt the supply chain (differentiating among risk-related deviations, disruptions, disasters);
- The extent to which risks and uncertainties are idiosyncratic (affecting individual chain participants), covariate within the chain (affecting multiple chain participants), and/or covariate outside the chain (impacting chain participants and the overall economy);
- Changes in costs, prices, and productivity levels that result in financial loss for supply chain participants;
- The transmission of risks through the supply chain—where and when risk and uncertainty unfold and they spread throughout the chain (via individual participants and among chain participants);
- Whether there are perceptions of equitably or inequitably shared risks in the chain;
- Which supply chain participants are most exposed to risk and uncertainty;
- What is exposed in terms of assets and/or livelihoods and enterprise strategies (e.g., reduction of income or consumption and/or the destruction of assets);
- How risks are manifested, how they impact enterprises (e.g., the destruction of assets and/or lowering of income and consumption);
- The key transaction points and types of transactions associated with risk and uncertainty;
- The what, who, how, where, and when of the greatest expected losses;
- Which losses or impacts tend to be short-term rather than long-term;
- How important the expected losses are internally for different participants in the chain, relative to their assets, livelihood/enterprise strategies, and performance outcomes.

Table 12: Expected Loss Ranking Matrix (Probability × Severity)

		Potential Severity of Impact				
		Negligible	**Moderate**	**Considerable**	**Critical**	**Catastrophic**
Probability of Event	Highly probable					
	Probable					
	Occasional					
	Remote					
	Improbable					

Table 13: Ranking of Expected Losses: "Separating the High from the Low"



Priority 1 = High expected loss
Priority 2 = Medium expected loss
Priority 3 = Low expected loss

Even when only qualitative information or perceptions can be obtained, the team can make efforts to organize such feedback in a systematic way, enabling comparisons and rankings, then prioritizing them according to expected losses. For example, Table 12 sets out a matrix to organize information on risks, risk exposure, and expected losses. The potential severity of a risk is mapped against the probability of the event occurring. Depending on the point of intersection, a prioritization on expected losses (low, medium, high) can be determined, as outlined in Table 13.

3.7 Risk Management and Vulnerability Assessment

3.7.1 Risk Management Assessment

Based on the information gathered, the assessment team identifies and characterizes existing risk management strategies and measures undertaken by supply chain participants and third parties, such as insurance companies, the government, donor agencies, and others. Why certain risk management measures have been adopted would also be probed. Risk management strategies and approaches are characterized in relation to their locus, their timing (e.g. *ex-ante, ex-post*), whether they are formal or informal, their type (technology, infrastructure, financial, management practice, organizational/ institutional arrangement), and their breadth of application.

In examining current practices for risk management and their evident efficacy, the following questions can be posed:

- Who are the formal and informal and the public and private sector providers of risk management services?
- How accessible, available, and affordable are risk management instruments to participants in the chain?

- For each participant, what are the present *ex-ante* risk reduction and prevention practices? What real and/or opportunity costs are associated with these? Is this strategy perceived to be effective? What constrains its effectiveness? What might be a preferred strategy?
- For each chain participant, what *ex-ante* risk mitigation is practiced? For each chain participant, what *ex-post* action is taken? What real and/or opportunity costs are associated with these? Is this strategy perceived to be effective? What constrains its effectiveness? What might be a preferred strategy?
- What are examples of risks transferred to third parties or shared among supply chain participants? What is the perceived effectiveness of these measures? What constrains their further use? Is the risk sharing equitable?
- What is the evidence regarding the resiliency of the supply chain and of individual participants? What transpired during the last significant shock? What adjustments were made? How quick was the recovery? Were the players able to cope/respond on their own, or did they require external support (e.g., from government)?
- What are the actual and potential synergies for risk management between participants in the chain, with support service providers, with others not directly in supply chain?
- How do chain participants view their capacity for risk management?
- Are there major differences in capacity to manage *ex-ante* risk deduction and risk mitigation and/or *ex-post* risk coping?
- What are the perceived constraints to improved supply chain risk management? Are these perceptions consistent with the real constraints? If not, why not?

The assessment team should review the effectiveness and current capacity for managing pertinent risks and rate it utilizing the 1–5 scale outlined in Table 14. In determining the most appropriate ranking, the team should consider a range of factors, including access, affordability, effectiveness, and sustainability. Table 15 elaborates on these key parameters.

Table 14: Capacity to Manage Risk Scale

	Rank	Definition
1	1	Partially effective yet approaches are likely to be costly, unsustainable
↓	2	Between 1 and 3
↓	3	Effective yet mixed pattern of affordability/sustainability
↓	4	Between 3 and 5
5	5	Very effective with a high likelihood of sustainability

Table 15: Assessing Capacity to Manage Risk		
Capacity	**Key Dimensions of Capacity**	
Low ↓ *High*	Availability	Risk management instruments (e.g., functioning insurance, financial markets) are available
	Access	Risk management instruments can be accessed by key players at risk
	Timing	*Ex-ante* risk management instruments are in place (for prevention, mitigation, preparedness); *ex-post* instruments can be quickly deployed (transfers, assistance)
	Affordability	Risk management instruments do not impose unreasonable cost constraints (e.g., interest rates, insurance premiums)
	Responsibility	Responsibility for risk management arrangements lie within private (formal and informal) and public sectors
	Knowledge	Adequate knowledge and information dissemination about the value of specific risk management instruments
	Effectiveness	Demonstrated positive impact of risk management instruments
	Sustainability	Risk management instruments meet present needs, as well as those in the indefinite future

3.7.2 Vulnerability Assessment

The steps in the previous section focus on the risks, the expected losses, and risk management practices and capacity. In essence, these steps examine to what extent there is a problem that can be defined as a "vulnerability" to fall below some performance benchmark as a result of the occurrence of some risky event (e.g., the lack of risk management capacity to compensate for the expected losses). Clearly, the identification of appropriate performance indicators as benchmarks for vulnerability is critical, and the indicators can vary by farm and firm. Although past experience sheds considerable insight on the topic, vulnerability is actually a forward-looking concept. The assessment team is seeking to understand the sequence of risk → risk exposure → expected losses → risk management capacity → outcome—and to do so *before* a risky event takes place. Understanding this sequence could facilitate the adoption of a risk management strategy that negates the vulnerability. At this stage, the analysis seeks to pinpoint clear gaps between the prevailing approaches to risk management and/or the set of circumstances in which prevailing practices are unlikely to be sufficient, given the potential severity of loss.

Here are some key questions in examining vulnerability:

- Are underlying (weather, market, other) conditions in the (near) future expected to be better, worse, or the same?
- How have recent changes or events enhanced or degraded the capacity of supply chain participants (and/or third parties) to manage risks? (For example, have contingency funds been used up? Have assets been enhanced or degraded?)
- Have perceived vulnerabilities been reduced because risk management capacity has been enhanced or because the likelihood or extent of expected losses has been appropriately or inappropriately downgraded?
- What has recent experience illustrated about the resilience of individual supply chain participants in the face of major shocks? Minor disruptions?
- To what extent have changes in production practices and institutional arrangements for marketing rendered participants more or less vulnerable to shocks?
- What currently perceived vulnerabilities might be readily addressed? Which would require very substantial resources, capacity-building measures, and so on?
- To what extent is it possible to quantify the vulnerabilities of the supply chain and/or of particular types of its participants?

Table 16: Vulnerability to Risky Event Based on Expected Loss and Capacity to Manage Risk

	Capacity to Manage Risk →				
Expected losses	1	2	3	4	5
High					
Medium					
Low					

AU: Spackled variation is OK in this table. Pl check & suggest.

Table 17: Vulnerability Scale

Vulnerability Scale	Code	Key Characteristics
Extremely vulnerable		High expected loss, low capacity
Highly vulnerable		Medium-high expected loss, low-medium capacity
Moderate vulnerability		Medium expected loss, low-medium capacity
Low vulnerability		Low-medium expected loss, medium-high capacity
Limited vulnerability		Low expected loss, high capacity

Even when the analysis is more qualitative than quantitative, the assessment team should make an attempt to cluster or rank-order different types of vulnerabilities. Tables 16 and 17 provide a suggested method for doing so.

3.8 Recommendations and Suggested Follow-Ups

Based on the preceding analysis, the assessment should conclude with a set of recommendations to improve existing risk management measures and to facilitate the adoption of additional measures, either by individual supply chain participants, by sets of participants in collaboration, or by third parties. In coming to final conclusions, the assessment team should consider the following guidelines:

- Give primary attention to possible *ex-ante* measures to reduce, mitigate or share risks, although in some circumstances assessments are conducted during and after adverse shocks and attention is certainly needed on workable coping strategies.
- Give attention to both formal and informal risk management options available to the different parties, although in practice, most analytical attention is likely to focus on the scope for improving or supplementing formal mechanisms, including institutional and financial arrangements, technological changes, the adoption of improved management practices, and/or investments in infrastructure. To the extent that the overall assessment is focused on the position and welfare of poorer farmers, greater attention has to be given to alternative informal mechanisms and improving their efficacy.
- Devote primary attention to addressing areas categorized as having high vulnerability, either for individual chain participants or for the chain as a whole. High vulnerability may be evident from past experience, or it may be expected due to unfolding changes in market conditions, regulations, or other circumstances. Depending on the purposes for which the assessment is done, primary attention might be given to addressing areas of high vulnerability for specific entities (e.g., smallholder farmers, ginners, the government treasury).
- In addition to improving existing approaches and instruments, be aware of the need for laying the basis for new approaches and instruments. Such a need would vary according to the prevailing circumstances. In some circumstances, the range of existing arrangements might seem adequate, but their effectiveness might actually be below optimum due to data or capacity shortcomings and/or the adverse effects of government policies or regulations. In such cases, providing options and recommendations for strengthening existing arrangements is essential.
- In the consideration of alternative (and especially new) approaches and instruments, include at least preliminary coverage of expected costs and benefits, potential technical or regulatory constraints, possible distributional consequences, and realistic scenarios for the adoption and impact on underlying vulnerabilities.

- Undertake specific analysis of the needs and options for policy and regulatory reforms that affect farmer and agro-enterprise risk management, as well as the possible revision or reform of governmental risk management instruments.

This step is likely to involve an iterative process of consultations with supply chain participants, providers of risk management services, and pertinent government entities. Ideally, the output takes the form of some type of action plan, highlighting areas for near-term investment, capacity building, and facilitation, and indicating other areas where more in-depth (and likely quantitative feasibility) assessment is needed. The terms of reference for such follow-up assessments should be prepared.

3.9 Feedback, Monitoring, and Evaluation

This step is not part of the immediate supply chain risk and risk management assessment. However, feedback, monitoring, and evaluation are critical because risk management is a long-term challenge. Strategies need to be refined over time in light of experience and unfolding market, climatic, regulatory, and other circumstances. Therefore, provision has to be made for short-term feedback and long-term monitoring and evaluation of adopted supply chain risk management strategies.

This exercise need not be complicated or costly. A suitable baseline—covering prevailing risks, risk management efforts, and outcomes—has to be established, and changes from the baseline have to be monitored over time. When interventions are being designed to strengthen existing risk management measures or to introduce new instruments, efforts are needed to monitor and evaluate the implementation experience and to draw lessons for broader discussion and dissemination.

Monitoring and evaluation efforts should consider the interface between risk management and the broader (changing) patterns of competitiveness, participation, and the distribution of rewards and risks in the supply chain. It is certainly of interest to understand the pattern by which this or that institutional or financial arrangement has been taken up or how effectively a government program has been better targeted or implemented. However, that experience should also be related to the broader performance of the supply chain.

Conclusions

The purpose of the paper has been to present the conceptual basis and methodological approach underpinning a Rapid Agricultural Supply Chain Risk Assessment (RapAgRisk). The paper focused on the application of this assessment for crop-based supply chains in developing countries. In the introduction, the paper detailed the motivating context for this type of assessment, taking into account the changing risk landscape, current structural changes in major food systems, and the reorganization of the risk management approaches of public and private entities.

The paper has been framed around a conceptual framework highlighting the roles of and linkages between direct supply chain participants, service providers (e.g., financial intermediaries, transporters) and third-party stakeholders (e.g., government). A detailed typology of risk categories illustrated the main areas of focus for the assessment (i.e., weather, price, food safety, logistics, environment, labor, and policy). Based on this typology, the paper examined risk transmission mechanisms across the supply chain and in particular subsystems. The conceptual framework also dealt with the analysis of risk management practices and vulnerability. The final section of the paper set out the steps and sequences required to undertake the RapAgRisk. The section also reflected on basic assessment principles to guide future work highlighting the time-bound, consultative, and evidenced-based nature of the analysis.

The assessment should result in an identification of priority areas for investment and/or capacity-building interventions. The target audience for final assessment products includes World Bank staff, country-level stakeholders, policy makers, and other practitioners. Given this audience, final assessment materials need to include a range of messages tailored for

- Policy makers;
- Supply chain participants;
- Donors, technical agencies, and nongovernmental organizations.

To support the implementation of RapAgRisk, the concept paper is accompanied by a detailed set of methodological guidelines.[22] The guidelines are based on the conceptual approach and are designed to lead teams throughout all stages of assessment planning, implementation, and follow-up. The guidelines include information on

- Baseline information analysis;
- Supply chain situation analysis;
- Risk identification and characterization guides;

- Semi-structured interview templates;
- Report templates and sample illustrations;
- Final report template;
- Assessment planning matrix.

References

Benson, C. 2008. Economic perspective on the impact of climate extremes on the rice supply chain and implications for macroeconomic planning. Prepared for World Bank/ProVention Activity on Philippines: Agriculture Climate Risk Assessment in support of Philippines Climate Change Adaptation Project (P101076), The World Bank, Washington, D.C.

Croom, S., P. Romano, and M. Giannakis. 2000. Supply chain management: An analytical framework for critical literature review. *European Journal of Purchasing and Supply Management* 6 (1):67–86.

Gaonkar, R., and N. Viswanadham. 2004. A conceptual and analytical framework for the management of risk in supply chains. Paper in *Robotics and Automation, 2004*. Proceedings. ICRA 2004. 2004 IEEE International Conference. 3: 2699–2704. http://ieeexplore.ieee.org/xpl/freeabs_all.jsp?arnumber=1307468

Harland, C., R. Brenchley, and H. Walker. 2003. Risk in supply networks. *Journal of Purchasing and Supply Management* 9:51–62.

Heitzmann, K., R. S. Canagarajah, and P. B. Siegel. 2002. Guidelines for assessing risk and vulnerability. SP Discussion Paper 0218. Social Protection Unit, Human Development Network, the World Bank, Washington, D.C.

Holzmann, R., and S. Jorgensen. 2000. A new conceptual framework for social risk management and beyond. Social Protection Discussion Paper 9926. The World Bank: Washington, DC. See www.worldbank.org/sp

Jaffee, S. 1995. "Transaction Costs, Risk and the Organization of Private Sector Food Commodity Systems." Chap. 2 in *Marketing Africa's High-Value Foods: Comparative Experiences of an Emergent Private Sector,* eds. S. Jaffee and J. Morton, 21–64. Dubuque, IA: Kendall/Hunt Publishing.

Jaffee, S., T. Debb, T. O'Brien, and Y. Strachan. 2006. Uganda, standards and trade: experience, capacities, and priorities. Trade Diagnostics Study. The World Bank.

King, R. P., and L. Venturini. 2005. "Demand for Quality Drives Changes in Food Supply Chains." In *New Directions in Global Food Markets,* eds. A. Regmi and M. Gehlhar. Agriculture Information Bulletin Number 794. Washington, DC: United States Department of Agriculture. See www.ers.usda.gov

Meyer, R. L., and C. Johnson. 2007. Value chain governance and access to finance: Maize, sugar cane and sunflower oil in Uganda. Paper prepared for U.S. Agency for International Development, Washington, D.C.

Siegel, P. B. 2000. Towards an integrated framework to manage risk in rural areas. Paper presented at the Conference of International Association of Agricultural Economists. August 13–16, Berlin.

Siegel, P. B. 2005. Looking at rural risk management using an asset-based approach. Background paper prepared for the report *Managing Agricultural Production Risk: Innovations in Developing Countries*. Commodity Risk Management Group,

Agricultural and Rural Development Department. Report No. 32727. The World Bank, Washington, D.C.

Siegel, P. B, J. Alwang, and S. Jorgensen. 2003. Rediscovering vulnerability through a risk chain: Views from different disciplines. *Quarterly Journal of International Agriculture* 42:351–370.

Skees, J. P, and B. J. Barnett. 1999. Conceptual and practical considerations for sharing catastrophic/systemic risks." *Review of Agricultural Economics* 21:424–441.

Skees, J. R., P. Hazell, and M. Miranda. 1999. New approaches to pubic/private crop yield insurance. EPTD Discussion Paper No. 55. International Food Policy Research Institute, Washington, D.C. See http://www.ifpri.org/publication/new-approaches-crop-yield-insurance-developing-countries

Smith, S. 2005. "Applying risk management to the supply chain." PowerPoint presentation presented on April 5 at WESTEC Advanced Productivity Exposition, Society of Manufacturing Engineers, Los Angeles Convention Center, Los Angeles.

U.S. Agency for International Development (USAID). http://www.microlinks.org/ev_en.php?ID=9652_201&ID2=DO_TOPIC#vc

———. 2005a. A fresh look at rural and agricultural finance. RAFI Notes, Issue 1. See http://www.microlinks.org/ev.php?ID=8222_201&ID2=DO_TOPIC

———. 2005b. The role of financial institutions. RAFI Notes, Issue 3. See http://www.microlinks.org/ev_en.php?ID=9753_201&ID2=DO_TOPIC

———. 2005c. Uganda value chain analysis: Mapping maize, sunflower and cotton costs, final report. USAID Rural SPEED Project, Uganda.

———. 2006. Uganda commodity value chains mapping for tea, final report. USAID Rural SPEED Project, Uganda.

Wharton School. 2006. Creating the optimal supply chain: Special report. University of Pennsylvania. See http://www.bcg.com/expertise_impact/Capabilities/Operations/Supply_Chain_Management/PublicationDetails.aspx?id=tcm:12-14865

World Bank. 2005. *Managing Agricultural Production Risk: Innovations in Developing Countries.* Washington, D.C.: Agriculture and Rural Development Department.

World Bank. 2008. *World Development Report: Agriculture for Development.* Washington, D.C.: World Bank.

Endnotes

[1] We use the term "agricultural supply chains" in this report. In the literature, similar terms and concepts are "subsector," "commodity chain," and "value chain." These terms and concepts are all very similar (see Box 3).

[2] Agricultural Risk Management, "Supply Chain Risk Assessment," http://tiny.cc/RapAgRiskAssessGuidelines

[3] We must acknowledge Richard Burcroff (consultant, World Bank) for contributions to this paper and Brian Berman, Marc Sadler, Julie Dana, Joanna Syroka, and other colleagues from the Agricultural Risk Management Team for their helpful comments.

[4] We refer to agriculture and agricultural risk in terms of the entire so-called farm-to-fork continuum.

[5] Agricultural Risk Management, "Supply Chain Risk Assessment." http://tiny.cc/RapAgRiskAssessGuidelines

[6] Agricultural Risk Management, "Supply Chain Risk Assessment," http://tiny.cc/RapAgRiskAssessGuidelines

[7] Most traditional value chain analyses do not address the vulnerability of the chain or of individual actors to various shocks or bottlenecks; nor do they address the effects on underlying cost structures, productivity patterns, and so on. The adaptability and resilience of the chain and of individual actors are core variables in their sustainability and long-term competitiveness, yet these capacities are not typically analyzed.

[8] See, for example, Benson (2008) for an analysis of climate-related risks affecting the rice supply chain of the Philippines. See Jaffee et al. (2006) for an analysis of the food safety and agricultural health risks associated with several of Uganda's food and agricultural export supply chains.

[9] For general information on supply chain analyses and template and case studies, see http://www.microlinks.org/ev_en.php?ID=9652_201&ID2=DO_TOPIC#vc

[10] Smallholder farmers typically face a systemic market risk in that their most accessible (localized) markets may be characterized by a lack of access to information, poor transport and storage facilities, and low numbers of regularly active buyers.

[11] For example, the ratings pertaining to the risk of adverse weather incorporate assumptions about the typical agricultural technologies used, especially irrigation. Sugar and cut flowers are thus rated lower because sugarcane is almost always grown with irrigation, whereas cut flowers are predominantly grown under controlled conditions (e.g., greenhouses).

[12] This relates to the aggregate (or whole enterprise) exposure to risk rather than risk in a single commodity chain.

[13] For example, a farmer who suffers a 20 percent yield shortfall might not be able to satisfy the supply contract and/or may not be able to repay a loan. This shortfall could, in turn, mean that the farmer not only loses income in the current production cycle, but is excluded from future supply contracts and inputs on credit.

[14] Resilience is a capacity to adjust on an inter-seasonal or inter-annual basis. One can also consider supply chain agility, which is the capacity to make immediate adjustments to cope with unfolding events. This might involve changes in the flow of products, the use of substitute products and suppliers, and other accommodations.

[15] This section draws on concepts presented in Heitzmann, Canagarajah, and Siegel (2002) and Siegel (2005).

[16] Taking this step enables analysts and stakeholders to distinguish among circumstances where (a) there is high-risk exposure yet adequate mechanisms in place (e.g., low vulnerability), (b) there is high-risk exposure yet weak or highly unsatisfactory risk management (e.g., high vulnerability), and (c) there is low-risk exposure or severity and adequate risk management measures (e.g., low vulnerability). Circumstances determined to involve high vulnerability are then focal points for in-depth examination and subsequent remedial actions.

[17] Agricultural Risk Management, "Supply Chain Risk Assessment," http://tiny.cc/RapAgRiskAssessGuidelines

[18] Agricultural Risk Management, "Supply Chain Risk Assessment," http://tiny.cc/RapAgRiskAssessGuidelines

[19] Agricultural Risk Management, "Supply Chain Risk Assessment," http://tiny.cc/RapAgRiskAssessGuidelines

[20] Agricultural Risk Management, "Supply Chain Risk Assessment," http://tiny.cc/RapAgRiskAssessGuidelines

[21] Agricultural Risk Management, "Supply Chain Risk Assessment," http://tiny.cc/RapAgRiskAssessGuidelines

[22] Agricultural Risk Management, "Supply Chain Risk Assessment," http://tiny.cc/RapAgRiskAssessGuidelines

ARD

AGRICULTURE
AND RURAL
DEVELOPMENT

Agriculture & Rural Development Department
World Bank
1818 H Street, NW
Washington, DC 20433
http://www.worldbank.org/rural

This report was generously funded by:

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Swiss Confederation

Federal Department of Economic Affairs FDEA
State Secretariat for Economic Affairs SECO

Ministry of Foreign Affairs