



guidelines

A VALUE CHAIN APPROACH TO ANIMAL DISEASES RISK MANAGEMENT

Technical foundations and
practical framework for field application



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Acronyms and abbreviations

CSF	Classical Swine Fever
DEFRA	Department for Environment, Food and Rural Affairs (UK)
FAO	Food and Agriculture Organization of the United Nations
HPAI	Highly Pathogenic Avian Influenza
OIE	Office International des Epizooties (World Organisation for Animal Health)
TAD	Transboundary Animal Disease

Summary

PURPOSE OF THIS GUIDE

This guide is based on earlier practical field applications of approaches contained in a FAO working paper (Taylor *et al.*, 2010). The working paper's detailed technical section has served as a background resource document for the present guide. The practical approach described in Part Two of this guide has been developed largely during practical and training workshops carried out in Viet Nam with a focus on H5N1 HPAI (Highly Pathogenic Avian Influenza). Work carried out by the authors in Indonesia, Thailand, China, Egypt and other African countries has also contributed to the preparation of this guide.

Disease prevention and control, at the national or at local farm level, whether funded by the state or with private resources, must be planned and implemented in proportion to the level of risk associated with a particular animal disease. Planning for disease prevention and control should be risk-based, and prevention and control measures should be proportionate to the risk assessed. It is unrealistic to implement a very costly programme against a disease hazard that has low risk. Furthermore, it is recognized that in livestock production and marketing systems the different stakeholders (people, groups, organizations) may be affected by and react to disease hazards in different ways and may face and perceive and accept different levels of risk. The various stakeholders may also be affected in different ways by the prevention and control measures adopted. Ideally, prevention and control measures should be proportionate to the risk faced by each stakeholder; otherwise compensatory mechanisms may be needed to ensure compliance and equity.

Two technical issues should be addressed together in order to achieve this goal.

1. Understanding the livestock production systems and how the stakeholders operate and the decisions they make within the livestock production systems.
2. Evaluation of disease risks within the livestock production systems in question and of measures to reduce those risks.

The first issue involves what in economics is called "value chain analysis"; the second issue entails what in veterinary epidemiology is called "risk analysis".

The purpose of this guide is to show how elements of value chain analysis and risk analysis can be combined to form a practical and useful approach to planning for disease prevention and control measures. This approach should be risk-based and people-centred.

Some of the key questions answered using these analysis techniques are:

- Which processes within different production and marketing systems carry risk for disease spread, and what are their relative contributions to overall risk?
- Which production systems carry more overall risk and therefore require more regulation/intervention?

For example, with respect to H5N1 HPAI, should priority be given to backyard poultry, or do other commercial systems require urgent attention?

- Who has most to gain or lose through risk reduction interventions?

- Who are the people affected by risky processes/points, and to what extent?
- How can the state and/or the industry act to promote less risky operating environments for livestock production?
- Where in a country are the risk “hotspots”?
- When are the high risk times during the year?
- Where and when should surveillance be targeted?

The combination of value chain mapping and economic analysis with epidemiological risk analysis is useful in national animal health planning to:

1. assess the epidemiological and socio-economic justification for different disease control strategies;
2. inform the stakeholders involved in the different disease control strategies;
3. evaluate the socio-economic impact of contagious diseases and different control strategies on the different stakeholders affected;
4. plan adjustments to control strategies based on the results obtained from the epidemiological and socio-economic assessments.

This same approach is also valid for use at subnational levels of animal health planning, right down to the level of the farm or the village and it can be a useful tool in designing practical and sustainable biosecurity at any level. As such this guide may be used in conjunction with the FAO Animal Production and Health Paper 165 *Biosecurity for Highly Pathogenic Avian Influenza - Issues and options*, FAO, Rome, 2008).

A SUMMARY OF THE VALUE CHAIN APPROACH TO MANAGEMENT OF DISEASE RISK

Part One of this guide sets out the technical foundations of the value chain approach to management of disease risk. More detailed material on the key methods is presented as annexes.

Value chain mapping and analysis provides a systematic framework for determining how people manage domestic livestock populations and their products. Risk analysis provides a system for assessing disease risk within the livestock population. Together they provide a basis for studying disease risk and risk mitigation in livestock value chains.

Livestock sectors are constantly evolving in order to meet the changing needs of globalized society. This process can bring new and changing disease risks. Networks and linkages in value chains that link production systems, markets and consumers constitute a contact network, which provides opportunities for the transmission of contagious diseases within and between sectors. It follows that these chains (networks) must be understood and taken into account in planning risk management strategies for disease prevention and control.

Risk-based management of animal disease should be people-centred. This means identifying the people involved (stakeholders) in the livestock sector and examining how they operate, how they perceive risk and what determines their risk profiles. It also means determining their resource bases, the profitability of their business and their alternative opportunities, as well as their constraints in terms of regulations, investment in human capital and infrastructure.

The principles of risk analysis can be applied to disease management in value chains. Value chain risk analysis adopts the same principles and tools as those used in standard risk analysis and applies this approach in the context of the food chains.

Qualitative risk analysis provides a logical and uniform framework for decision-making. It can be used to support decisions that allow certain activities under certain conditions or, alternatively, that prohibit activities because no practical risk reduction measures are identified.

Part Two of the guide describes a practical approach for combining risk analysis with descriptive value chain mapping. The approach could be used successfully with expert consultations and/or working group input. The importance of value chain analysis in assessment of risk factors and potential socio-economic impacts of risk mitigation measures is also discussed.

Part Two also provides information on the key steps and components to be included in a complete analysis and planning process. It includes suggestions for field techniques, often based on experience of the authors and others. Further detailed field tools are presented as annexes.

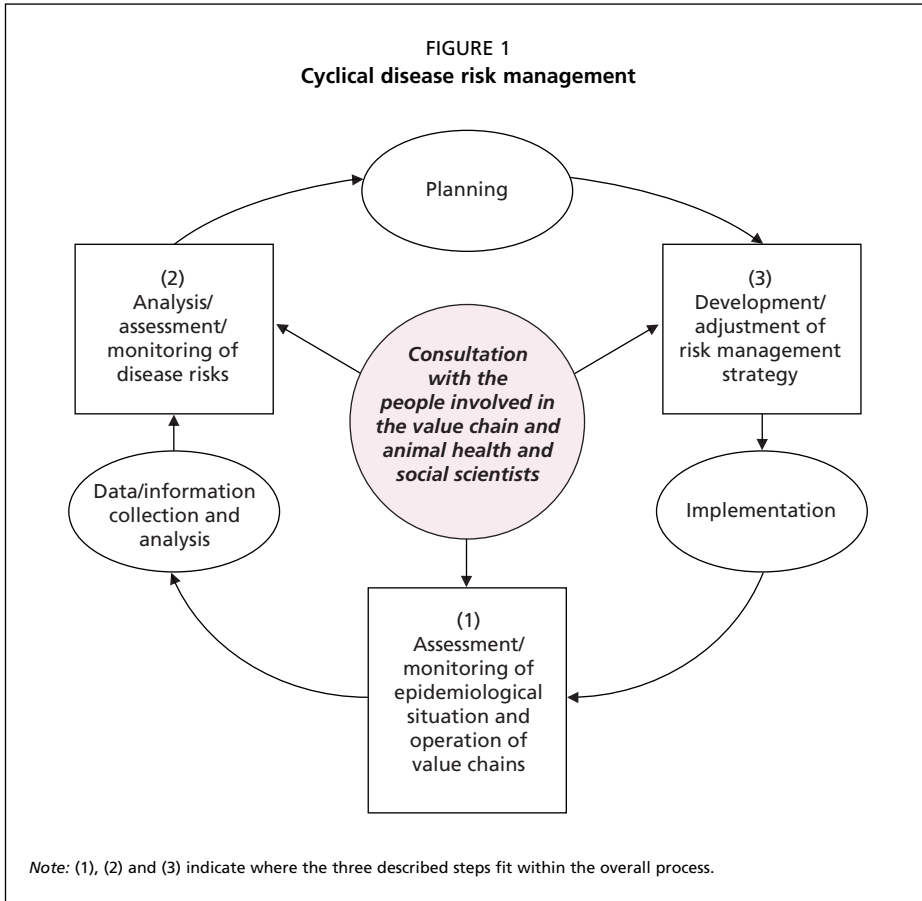
Three major steps are described, each in a separate chapter:

Step 1: Situation analysis and preliminary risk analysis

- Descriptive epidemiology of the situation regarding the disease(s) concerned.
- Description of livestock value chains and identification of people and organizations involved in those chains. Preparation of a value chain description, including lists of key stakeholders, important sites/infrastructure, location maps, process/product flow diagrams, descriptive text and key statistics, as well as values, prices and quantities.
 - Mapping of the main points of production, infrastructure, markets and processing points.
 - Collection of data on quantities of livestock product produced, marketed and consumed, as well as on prices of inputs and outputs.
 - The description should include the different people involved and the various types of livestock and livestock products.
 - Particular attention is paid to gathering information on the practices, rewards, cultural preferences, education and training of the people involved.
 - Initial indication of the governance of the chains, i.e. which people working in the chains have a strong influence on the setting of the rules and their enforcement.
- Identification and characterization of the risk issues and risk hotspots in value chains.
 - Organize information into tables to describe areas of risk (risk issues).
 - Make a preliminary assessment of areas within the chains that should be prioritized as risk hotspots.

Step 2: Detailed risk and value chain analysis leading to planning of risk management options

- Development of formal risk pathways and identification of potential risk mitigation measures.
- Development of options for inclusion in a risk management strategy.



Step 3: Option appraisal and decision-making

- Analysis of impact on the different stakeholders.

These three steps fit within a cyclical process of monitoring, analysis, planning and implementation of disease management as shown in Figure 1.

The first step is to carry out a value chain risk survey in order to describe livestock value chains and factors within these chains that contribute to risk of disease outbreaks and disease spread. During this process, disease risk and risky practices in the livestock value chains are described and characterized.

The objective of this preliminary analysis of the value chains is to identify the most important risk points (hotspots) where risk mitigation measures should be focused. Part of the preliminary analysis should focus on the cultural, socio-economic drivers that determine or influence the behaviour of people who run businesses and work in the value chain and how these affect the contributions of different stakeholders to risk. It is important to consider seasonal variation in any factors that may produce seasonal risk patterns. The value chains themselves may be subject to seasonal variation (e.g. special festival markets or higher demand for specific types of product).

The second step is to examine the risk hotspots to determine how control measures could be targeted at them. This step requires a combination of risk analysis and value chain analysis. A consultative/participatory approach, involving the people who run businesses and work in the value chain as well as the veterinary and livestock production authorities, is essential to maintain good risk communication. This is a continuing process during which increasingly detailed analyses are successively undertaken, each based on the results of the previous ones.

This second step requires detailed study of the processes (production, marketing, processing, etc.) throughout the risky parts of the value chains. This study should focus particularly on the behaviours and motivations of the people involved in the value chain, as it is usually particular types of behaviour that lead to increased or decreased disease risk. Based on this study, detailed risk pathways should then be traced in order to understand the factors affecting risk; a qualitative risk assessment must be carried out in order to identify potential risk reduction strategies. The risk factors associated with risk hotspots are examined with the aim of looking for the potential risk control points in the context of the value chain and identifying the risk reduction measures that may be applied. Thus, risk reduction may be achieved by a combination of several measures (as no one measure alone can be effective) at one or more points in a value chain.

Before risk mitigation measures can be firmly recommended consideration must be given to the potential impacts of intervention measures on the different stakeholders. This is important because if impacts are negative, compliance is jeopardized. The third step is therefore to appraise the likely impact of the proposed risk mitigation measures on disease risk (epidemiological assessment) and the possible impacts of mitigation measures on the value chains as a whole and the different people who work and run businesses in the value chain (stakeholders). Risk analysis can provide estimates of the effect of measures on overall disease risk. Value chain analysis can provide information about the potential impact of control measures on the value chain stakeholders and hence the feasibility of implementing the measures. It can also assess the performance of the value chain as a whole and, ultimately, the efficiency of the value chain in supplying markets and consumers. All together this provides an assessment of the feasibility of the proposed control measures.

Another important contribution of the use of value chain analysis in assessing the impact of control measures on value chains is that this strategy is people-centred as well as risk-based insofar as it takes into account the behaviour and reactions of the people involved in the value chains.

The chain should be considered as a mechanism that supplies food to consumers, employs people in production and processing and involves people in organizing and running businesses. All these people see the threat or presence of disease as a part of their daily lives and not necessarily their primary focus, particularly in endemic situations. Understanding how these people perceive and manage disease provides a basis for disease risk management that can be proportional to the disease impact.

Final recommendations for a risk mitigation strategy should take account of what measures are to be implemented, by whom, where, when and how. In particular, supporting measures may be required to encourage a change in the behaviour of the people working and running businesses in the value chain. These could be a mixture of incentives, compensation, penalties, sanctions, etc.

THE APPLICATION OF A VALUE CHAIN APPROACH TO DISEASE RISK MANAGEMENT

The purpose of applying the combination of value chain and risk analyses is to address the problem of disease risk and contribute to disease control planning. Therefore, the value chain analysis needs to focus specifically on elements that either increase disease risk or that are critical in disease risk management, thus avoiding the need for a complete value chain analysis; otherwise there is the danger that value chain mapping and analysis are carried out in unnecessary detail or with the wrong focus. The best way to achieve this is to ensure that veterinary epidemiologists and social scientists work together throughout the process at all levels.

The methodological approach presented here can be flexible and should not be seen as a rigid prescription. It is important to work at different levels of detail. A clear overview is needed to ensure that no important risks in the value chains are omitted, while attention to detail is needed in identifying and appraising risk reduction measures. The amount of detailed data and detailed analysis required depends on objectives of disease control decision-making. The iterative nature of data gathering is an ongoing process, and therefore it is not necessary or practical to get everything perfect before making decisions. The value chain/risk analysis process will identify areas that require more or less detailed data so that data collection efforts are focused and prioritized.

The processes described may be carried out by a few experts working together or with full involvement of all stakeholders through a series of workshops, discussions or personal interviews, depending on the availability of experts, time constraints and the budget available.

The analyses and monitoring of risk in value chains should be carried out in preparedness for disease and not only in response to outbreaks. An understanding of the “usual” patterns of movements of animals, products, materials, people, vehicles, etc., leads to a better understanding of how disease could spread if introduced into the system at different places. This in turn allows for planning of strategies to reduce risks.

It is important for veterinary services to monitor changes in value chains and assess how these chains may evolve in time and space (e.g. sudden reactions to market shocks, or long-term trends in consumer preferences and supply). Variations in short- or longer-term prices between areas within a country or across national boundaries may affect flows and alter the relative importance of different value chains, which in turn could affect disease risk. Risk factors can change seasonally and over the long term as livestock sectors develop. Veterinary services need to monitor the changes in the risk factor and respond to different risk levels.

At the regional level the principles of this approach can be applied to rapidly assess production systems, the epidemiological situation of disease and the socio-political situation within several countries to identify those areas where disease control interventions for specific diseases may be feasible or not in the short or medium term.

The processes of monitoring and evaluating the livestock value chains and assessing risks should never become an office-based and expert-orientated activity. The chains themselves are not run, managed or driven by the risk analyst, who is not part of these chains.

The livestock value chains are run by people who work and run businesses within the chains. They are managed by the people who determine how the chain functions and how stakeholders within the chains interact. Finally, the chains are driven by the consumers who demand food of a certain quality and in certain quantities.

If the risk analyst gets to know the people and interacts with them in a professional manner, offering his/her knowledge on animal disease and animal health, the chains will function better, then he/she will be considered an adviser. Such advisers will have a major impact on how these chains can avoid the introduction of disease and how they can manage and eliminate disease quickly, efficiently and cost-effectively.

PART 1

Technical Foundations

Why a value chain approach to management of disease risks?

Livestock sectors are constantly evolving worldwide in order to meet the changing needs of globalized society. This can bring new and changing disease risks for livestock.

Networks and linkages in value chains that link production systems, markets and consumers constitute a “contact network” for contagious diseases and provide opportunities for transmission of disease within and between sectors. It follows that these chains (networks) must be taken into account in planning risk management strategies for disease prevention and control.

Control of contagious diseases, including Transboundary Animal Diseases (TADs), demands strategic planning aimed at targeting disease control measures in those areas where they will have the most impact relative to the cost (cost effective). This should result in successful disease control strategies that are sustainable in the medium and long term.

Strategic planning must be based on knowledge in order to identify: the disease agent and the disease it causes; the risk factors of the diseases and the livestock populations in which it is active; possible interventions; and the people who manage and own these animals. This is epidemiology in its widest sense.

Sustained control of contagious disease can be achieved by reducing the risks of disease transmission in the livestock population, in addition to quick disease detection, containment and response. In order to reduce risks an understanding of the risks and the factors that determine them (risk analysis) is required. Detailed knowledge about the livestock populations and about the behaviour of the people involved in all stages of livestock production and marketing (value chain) is an essential component of risk analysis. This knowledge can be developed and enhanced through value chain analysis.

This guide offers methodologies developed explicitly to combine value chain analysis with risk analysis so that decisions can be made taking into account how the behaviours of different people involved in the value chain affect disease risk, as well as the effects of livestock disease and its control measures on those people. An inclusive analysis should aim at involving the people from the value chain in the process of risk assessment, mitigation strategies and communication.

RISK-BASED, PEOPLE-CENTRED CONTROL OF DISEASE RISKS IN LIVESTOCK VALUE CHAINS

The movement of infected animals or animal products and contaminated items is an important means of disease spread. Understanding that these movements take place within established chains, the question, then, is how to proceed with disease risk management.

Knowledge of the usual patterns of movement of animals, products, materials, people and vehicles can be combined with risk analysis to better understand how disease could

BOX 1

Compartmentalization

The principles underpinning zoning and compartmentalization are discussed in Chapter 4.3. of the OIE *Terrestrial Animal Health Code*. Zoning and compartmentalization are procedures implemented to define animal subpopulations of distinct health status within a territory. Zoning applies to an animal subpopulation defined on a geographical basis (using natural, artificial or legal boundaries) while compartmentalization applies to an animal subpopulation defined by management practices related to biosecurity. Establishing and maintaining a compartment requires a partnership between the veterinary services or other competent authorities of a state and the relevant enterprise/industry. Zoning and compartmentalization allow resources to be focused on activities that have the greatest chance of success in controlling or eradicating a disease or in gaining or maintaining market access for certain commodities. Compartmentalization may be applicable in situations where zoning cannot provide the required assurances, for example, in intensive industries where production systems are vertically integrated.

Compartment means an animal subpopulation contained in one or more establishments under a common biosecurity management system with a distinct health status with respect to a specific disease or specific diseases for which required surveillance, control and biosecurity measures have been applied for the purpose of international trade.

Biosecurity plan means a plan that identifies potential pathways for the introduction and spread of disease in a zone or compartment, and describes the measures which are being or will be applied to mitigate the disease risks, if applicable, in accordance with the recommendations in the *Terrestrial Code*.

http://www.oie.int/eng/normes/A_standardisation_activities.pdf

spread if introduced into the system at different places. This understanding allows for planning of strategies to reduce risks within the system (risk management). This implies an important shift in focus toward biosecurity in all its aspects. Maintaining biosecurity at farms (keeping disease agents from moving into and out of farms) is important but there is also a need to pay attention to biosecurity (risk reduction) in supply, production, transport and marketing chains¹.

One logical development from this approach is the concept of compartmentalization promoted by the World Organisation for Animal Health (OIE) (see Box 1).

This approach to disease prevention and risk reduction requires methods to analyse the functioning of the chains that link production systems, markets and consumers, with par-

¹ The reader is directed to the FAO Animal Production and Health Paper 165, *Biosecurity for Highly Pathogenic Avian Influenza - Issues and options*. FAO, Rome, 2008. In this paper biosecurity is defined as: "... the implementation of measures that reduce the risk of the introduction and spread of disease agents. Biosecurity requires the adoption of a set of attitudes and behaviours by people to reduce risk in all activities involving domestic, captive exotic and wild birds and their products ...".

ticular attention to the behaviour and motivations of the people involved. It also requires methods to assess risks for disease spread within the chains. In economics terminology, the study of the chains that link production systems, markets and consumers is called “value chain analysis”².

Value chain analysis should be used together with risk analysis in order to identify risk hotspots in the value chains. These risk hotspots should then be examined to determine what control measures could be targeted at them and how those measures could reduce risk. Value chain analysis can also provide information about the feasibility of the control measures and their potential impact on the people involved in the value chain³ (i.e. dynamics would change in the value chain after an intervention). Risk analysis can estimate the effects of measures on overall disease risk (i.e. the incremental level of control likely to be achieved).

The ultimate goal for disease managers to achieve is more efficient control of disease spread, through a better understanding of the movement and transmission of disease pathogens (viruses, bacteria, etc.) among domestic/wild animal populations throughout the value chains. This is often referred to as a risk-based strategy. An important additional result obtained by the use of value chain analysis is the understanding of the people, groups or organizations involved (stakeholders) in the livestock sector, how they operate, what their profitabilities and opportunities are and what their constraints are in terms of regulations, investment in human capital and infrastructure. This understanding allows the impact of control measures on stakeholders to be assessed so that the resultant strategy can take into consideration the knowledge, perceptions, behaviour and reactions of people. As such, the strategy is both risk-based and people-centred.

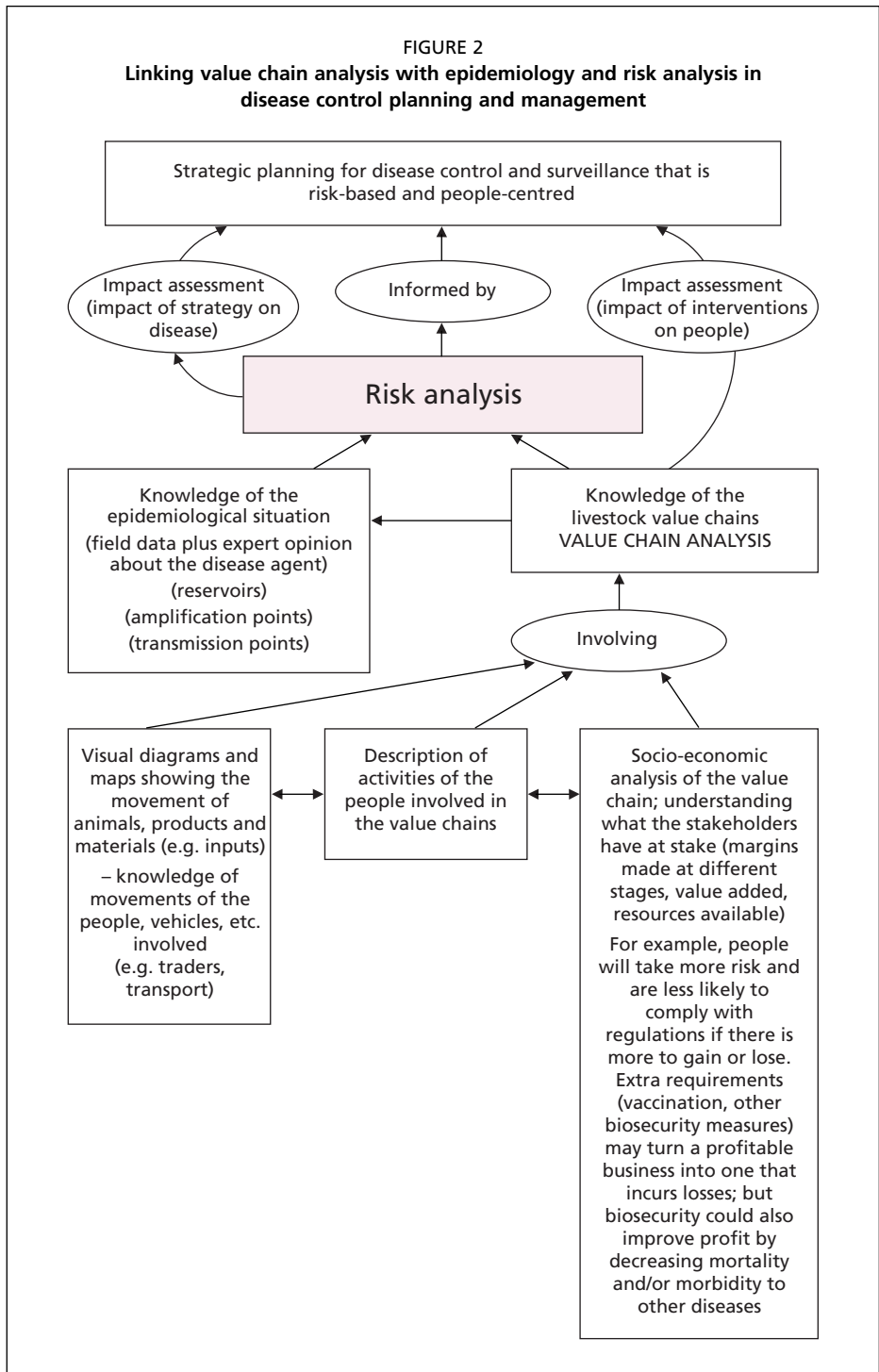
SYSTEMATIC THINKING – A BASIS FOR TRANSPARENT AND EVIDENCE-BASED PLANNING

An active strategy to reduce disease risk in value chains must necessarily involve changes in the behaviour of the people involved in the value chain (modification of risky practices, introduction of new behaviours). If such a strategy is to be effective, the different people involved will have to be convinced of its necessity and validity. To achieve “buy-in” it is necessary that the scientific basis (evidence) for the strategy is understandable (transparent) to all. An important basis for transparent and evidence-based planning and decision-making is “systematic thinking”, which requires formal methodological and analytical frameworks.

Figure 2 shows that there are two elements involved in the risk analysis leading to the desired risk-based and people-centred strategy:

² The FAO Animal Production and Health Paper 165 emphasizes that “... biosecurity recommendations should be developed for all component parts of the domestic poultry and captive bird sector, including intermediaries and service providers ...” and “... stresses the importance of situating biosecurity in appropriate economic and cultural settings

³ The FAO Animal Production and Health paper 165 notes that “...planning for biosecurity must incorporate socio-economic analysis to help identify the social and cultural acceptability of proposed measures, the level of cost that people can afford to pay, and the regulations, incentives and penalties that may be appropriate to induce the behaviour change that will be necessary in many situations...”. These issues are the focus of value chain analysis.



IN SUMMARY

- Animal diseases are spread by movements of inputs, animals and animal products and also by fomites, people, equipment and during transport.
- Movements of inputs, animals and products within the value chains are driven and controlled by people.
- Understanding the motivations for movements (value chain analysis) is essential to understand:
 - livestock sectors and their development;
 - animal disease spread;
 - animal disease risks (including seasonal variation);
 - animal health interventions to prevent and control animal disease;
 - additional policies that are required to support effective animal health policies.

Risk-based, people-centred control of disease risks in livestock value chains

- Planning for disease prevention and control should be risk-based and prevention and control measures should be proportionate to the risks.
- The aim is to identify the risky areas of the value chains and propose measures to make them safer.
- The ultimate goal is to achieve more efficient control of disease spread through a better understanding of the risk of disease spread in livestock value chains so that measures can be targeted.
- In livestock value chains there are many stakeholders who may affect and be affected by disease hazards in different ways; these people may face different levels of risk and may be affected by prevention and control measures in different ways.
- Ideally, prevention and control measures should be proportionate to the risk faced by each stakeholder; otherwise compensatory mechanisms may be needed to assure compliance and equity.
- Risk communication involving stakeholder consultation is an important process in establishing agreement on the contribution of different stakeholders to overall risk, the magnitude of risk and the distribution of risk among stakeholders.

Analysis of how production and marketing processes are managed can tell us important things for disease control

- Analysis of the economics at different points in the chains provides understanding of who and what factors govern these chains, economics at different stages, contractual arrangements, who sets regulations, who applies them and who enforces them.
- The interests that stakeholders have in the production process influence their willingness to comply with control measures and the amount of risk they are willing to take:
 - people will take more risk and are less likely to comply with regulations if there is more to gain or lose;
 - additional regulations may turn a profitable business into one that incurs losses.

Systematic thinking

- A basis for transparency, leading to strategies that are evidence based.
- Established analytical frameworks within which to address a problem, in this case:
 - formal risk analysis;
 - value chain analysis.

1. knowledge of the epidemiological situation (expert technical knowledge about the disease and the disease agent as well as local field data regarding disease occurrence in the place in question);
2. knowledge of the livestock value chains (this encompasses the physical and spatial aspects of the chains and also the involvement of people in the chains).

Value chain mapping and analysis provides a systematic framework for thinking about how people manage domestic livestock populations and their products, and risk analysis provides the systematic framework for thinking about disease risk within populations. These frameworks promote systematic thinking about disease risk, risk reduction interventions and risk management in livestock value chains.

Value chains and value chain analysis for the purposes of management of animal disease risks

WHAT ARE VALUE CHAINS?

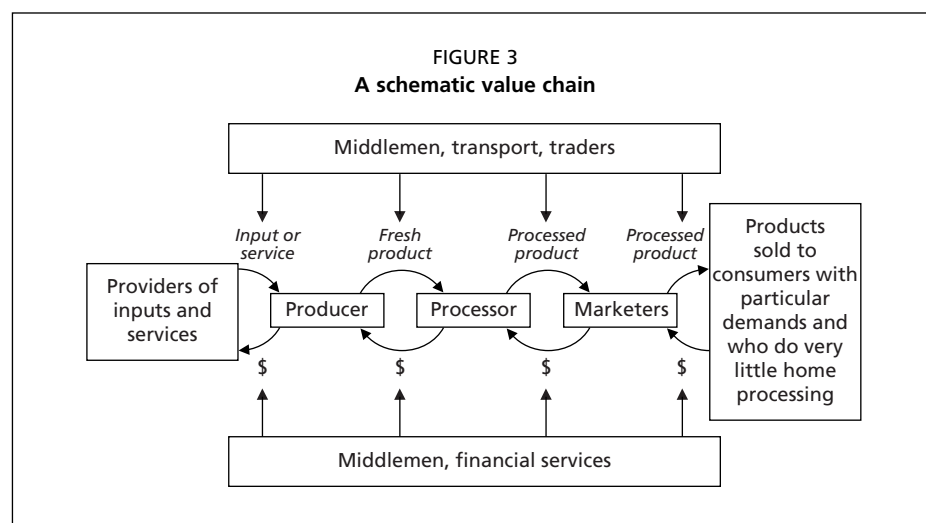
Value chains are groups of people linked by an activity to supply a specific commodity. These chains have inputs that are used to produce and transport a commodity towards a consumer; this is the supply chain. Money is sent from the consumer to the different people in the chains.

Value chains are:

- driven by consumer demand;
- run within the framework of national and local laws and local customs;
- managed by the people in the chain who set rules on how people interact, produce and transport a commodity.

Figure 3 shows a schematic view of a livestock value chain.

The guide provides the basic methods and background theory required for a thorough value chain analysis. For more detailed information on value chain analysis refer to Kaplin-sky and Morris (2000).



The position and role of animal health professionals in livestock value chains

People in public and private veterinary services are involved throughout the value chain as:

- suppliers of animal health inputs to producers – private suppliers and public service (e.g. public vaccination campaigns);
- employed advisers of large producers – company employees;
- regulators of marketing and transport – state animal health services;
- enforcers of food hygiene and quality regulations – veterinary public health services;
- advisers to government – animal health strategists.

Animal health professionals have many roles in value chains. They facilitate operation of the value chain by supplying advice and services aimed at improving livestock health and production; they also control the actions of people in the value chain by regulating livestock movements and marketing and by enforcing measures in response to disease outbreaks). The function of providing advice or instruction – particularly to producers and processors – is important in order to influence and/or change behaviour. Understanding of the motivations (economic and others) of people in value chains is an important prerequisite to effective communication.

Descriptive value chains

Processes, places, people

Value chains describe the processes through which livestock and other inputs pass during the production process. They can be a kind of flow chart or process map. Value chains also describe the places where each process occurs and the people involved.

Value chain descriptions provide a good starting point for risk analysis and can be used as part of a stakeholder consultation process to create useful discussions about risk issues and therefore promote good risk communication⁴.

The first output of a value chain study is usually one or several diagrammatic value chain “maps” consisting of boxes representing different people, groups or organizations and/or production/marketing sites in the chain with lines or arrows between these boxes indicating flows of livestock and animal products. Information on seasonal patterns and longer-term trends, product volumes and values, as well as numbers of enterprises or livelihoods supported at each point in the chain, can ideally be overlaid in the map.

Figure 4 shows a generic framework for livestock value chains. This provides a starting point for more detailed investigation and description. The key elements are listed below:

- Inputs and service suppliers (white)
 - All livestock systems require major inputs such as feed, pharmaceuticals, services (e.g. veterinary or breeding services).
- Livestock production units (light grey)
 - There may be many types of farms within this section of the value chain: parent flocks, hatchery or rearing farms, finishing farms; there is often movement and/

⁴ See Section – Risk communication, page 19

or trading of livestock between these farms; farms of different types may be integrated under one company's ownership or linked by contracts.

- Animal marketing and processing (dark grey)
 - There may be many types of farms or holdings within this section of the value chain: parent flocks, hatchery or rearing farms, finishing farms; there is often movement and/or trading of livestock between these farms; farms of different types may be integrated under one company's ownership or linked by contracts.
- Product marketing (dark red)
 - The product may be marketed to consumers with more or less intermediate processing (e.g. live poultry are sold direct from a farm to the final consumer).
- Waste and by-product (light red)
 - All livestock systems produce by-products and waste, which can serve as vehicles for disease transmission or environmental contamination.

Figure 4 shows only the key components of livestock production value chains. Enabling business environment factors, such as supply of finance/credit, regulation/inspection and quality control are not illustrated on the diagram, nor are the specific people shown in detail; however, these are elements that must also be described in a value chain mapping exercise. This may be achieved entirely within a text commentary or with a combination of text and additional coding on diagrams (e.g. colour coding of arrows to indicate contractual relationships). In different value chains middlemen and markets may be involved to a lesser or greater extent at all the stages shown in Figure 4. These people and organizations are often very important in controlling the flow through chains and in fixing prices. They can also be important in terms of disease risk because their business puts them in contact with many people in different chains and at different parts of chains.

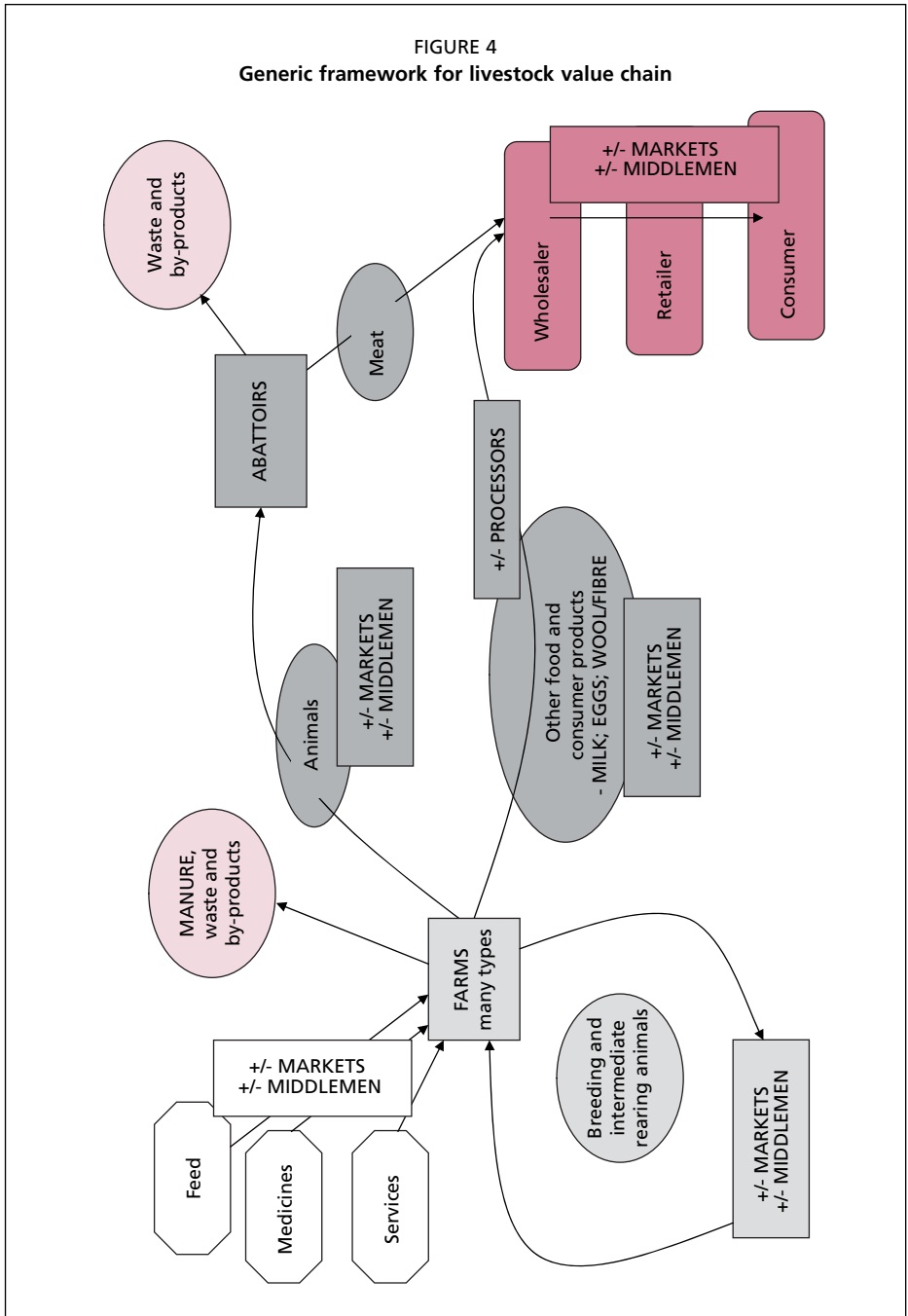
Figure 4 is a very simple starting point serving as an *aide memoire* for the key elements that should be described in a value chain map and analysed in value chain analysis. It is very important to note that even within the same livestock species there will be many different chains, each for different products; for example, with regard to chicken there are very different value chains for eggs, broilers, native chickens, etc. In order to analyse risk associated with a poultry disease such as H5N1 HPAI all of these chains must be described. Even within a single product, such as meat chicken, there may be several distinct, yet interconnected chains. This is illustrated in Figure 5, which shows a more developed framework map of a meat chicken value chain.

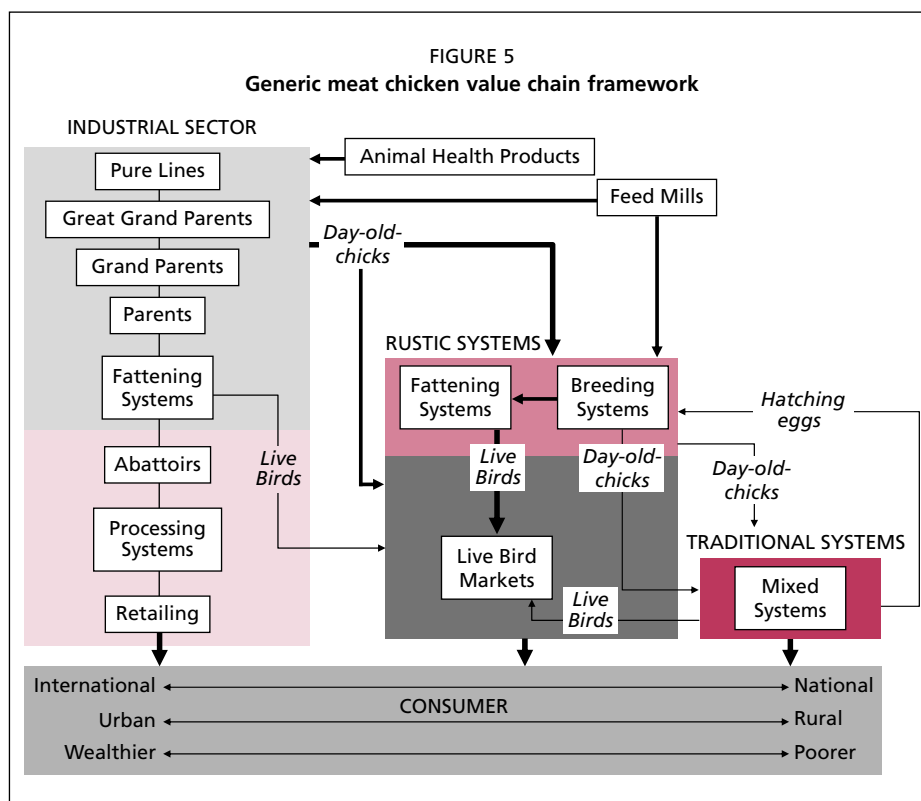
VALUE CHAIN ANALYSIS

The main objectives of value chain analysis as used for risk assessment are the following (Rushton, 2009):

- Identify the main people, groups and organizations in the livestock value chain from the input supplier to the producer, trader, processor, retailer and through to the final consumer.
- Identify and map the different routes to market the livestock and livestock products, which could be what currently exists and what potentially is available or could be developed.
- Assess how well the marketing chain is working.

FIGURE 4
Generic framework for livestock value chain





Value chain analysis should describe the internal and external environment of the identified chain or chains. They should contain information on the following:

- physical location of activities and of the people in the chain;
- who is involved in the value chain;
- economic profitability⁵ for different people at different points, including transaction costs between people and points;
- who sets regulations or conditions (pressures) for participation in the chain, who applies the rules and ensures compliance with them and/or provides assistance in meeting the conditions, i.e. who governs these chains;
 - public legislation that impacts on the functioning of the chain; this could include regulations not directly related to animal health, such as tax regulations favouring different scales of operation;
 - contractual arrangements;
 - in the poultry and swine sectors there exists a well organized commercial category, and it is well known that this private sector is very important in setting the regulations along the chain while working within a legal and institutional framework set by the state;
- who and what factors are driving developments or changes in a value chain; this implies a temporal factor for the analysis;

- a complete value chain analysis will allow an assessment of the equity across the chain and its efficiency to convert inputs into products demanded by consumers;
 - equity can be skewed by governance and poor distribution of information across chains; for example, traders may have and retain better knowledge of consumer demands than producers so that traders can take advantage of premium markets without passing on benefits to producers;
 - presence of disease in the chains will reduce efficiency of the chain.

For the purposes of animal disease management and health planning it is important to identify how people influence risk and react to it in the chain. It is particularly important to describe how chains actually work, not how they ideally work; for example, it is common to find abuse of procedures both by people directly involved in market chains and by those in authority, and this leads to enterprises operating outside regulations. These defects in market chains can often cause serious animal and public health risks. In such cases it is useful to ask: “Where is the leverage to deliver compliance with measures necessary to reduce risk?”

Given that value chains exist to supply food to consumers and to provide livelihoods for people working in the chains, it could be expected that the value chain itself will adapt so that somehow supply can be maintained. Understanding how a value chain functions in absence of disease will help animal health advisers to anticipate how chains may react in the presence of disease. When working with value chains where disease is present or those at risk of disease we need to think like veterinarians treating sick animals and ask how the chains can be kept disease free and healthy.

It would be illogical and a fundamental error to treat the value chains and the people within them as inert and extraneous during an animal disease risk analysis. A value chain should be considered as an organism made up of interacting components. If disease is introduced into a value chain the people concerned will modify their behaviour based on their risk perception; their reactions, in turn, will affect how the chain functions and operates.

Resilient chains will manage disease risks and internalize (“absorb”) them in order to remain functioning but other chains may become inefficient when affected by diseases, or they may collapse completely. In either case some value chains may be more prone than others to disseminating disease if it is introduced. This would be the case when a buyer and a seller in a chain do not have the same information about the health status of the livestock being traded: the seller knows the animals are affected by disease but does not tell the buyer; the buyer assumes the animals are healthy, but may place a lower value on them because he/she cannot be certain. This problem of asymmetry of information is known in new institutional economics as “moral hazard”. It is an area where the state has a role to ensure buyers of the quality of the products being traded and to lay down clear guidelines to sellers on what is expected of them in a transaction. It is well known that Newcastle disease is spread by such transactions with a high level of moral hazard.

From a biological perspective there are diseases that do not show clinical signs, so that neither the buyer nor the seller have sufficient information on disease presence during a

⁵ i.e. gross margin analysis or enterprise budget (see Annex 2: Developing and analysing enterprise budgets, page 75)

transaction. If a disease occurs it may be difficult to trace where it came from. Some traditional mechanisms manage this lack of information; for example, in some countries of South America pig carcasses are returned to the farmer if cysticercosis is detected. Other situations such as movement of sheep subclinically infected with foot-and-mouth disease (FMD) in the United Kingdom (2001 epidemic), or movement of ducks or vaccinated chickens subclinically infected with H5N1 HPAI in Southeast Asia are cases where existing mechanisms have not been successfully managing risk, thus leading to the spread of disease.

The rapid healing of a chain is vital to ensure that people who depend on the chain for income and food are affected as little as possible. Understanding and anticipating how the value chains modify and manage disease risks allows planners to identify interventions that can help a value chain to reduce the overall risk and risk of dissemination.

SUMMARY

Value chain analysis provides a practical framework for disease risk assessment and animal disease management. It is a tool that can be used to identify key constraints and opportunities within a livestock value chain, including possible risk for disease transmission within a livestock sector and the people involved at these points. In turn where the risks are deemed to be high enough and the reduction of these risks is thought to create large impacts on society in general (externalities) public interventions may be appropriate. Such initial “look and see” analyses help to direct where further cost-benefit analyses are required. If these more in-depth and complex assessment methods indicate that a positive return to society could be generated by state intervention then implementation planning can begin.

Value chain analysis can also be a useful tool in such planning insofar as it directs and identifies people and organizations who need to be involved in order for an intervention to succeed. Used in a participatory way, for example, as part of a stakeholder consultation, value chain mapping acts as a focus for communicating knowledge, and can play a very important role in risk communication, thus leading to more transparent decision-making on animal disease management.

However, in adapting this tool it must be remembered that, whereas the original focus of the tool is on improving market efficiency, the focus should be on risks of disease transmission in the production and market chain. Therefore a value chain analysis focused on disease risk will contain information on:

- opportunities for disease transmission (implying knowledge at the outset of the basic epidemiology of the disease in question);
- practices (regulated or not) aimed at risk reduction/biosecurity and compliance with these;
- resources and the capability of people in the chains to react to disease challenges.

This is the interface where the value chain analysis begins to merge and overlap with risk analysis.

Risk Analysis

RISK ANALYSIS – KEY CONCEPTS AND PRINCIPLES

Risk analysis is a formal method of dealing with hazards and risks.

This guide focuses on how the principles of formal risk analysis can be applied to disease management in value chains. Value chain risk analysis uses the same principles and tools as standard risk analysis. This section provides an overview of the principles of risk analysis (see Annex 1: Risk pathway analysis and risk control, for a more detailed description of the important methodology).

A formal framework for risk analysis in veterinary science was developed specifically to provide an objective method for making decisions on intercountry trade (OIE 2004a & b), but it is also applicable to other areas of animal disease control and, more widely, to other risky decision contexts. The risk analysis process recommended in the OIE International Animal Health Code consists of four components (see Box 2 and Figure 6)

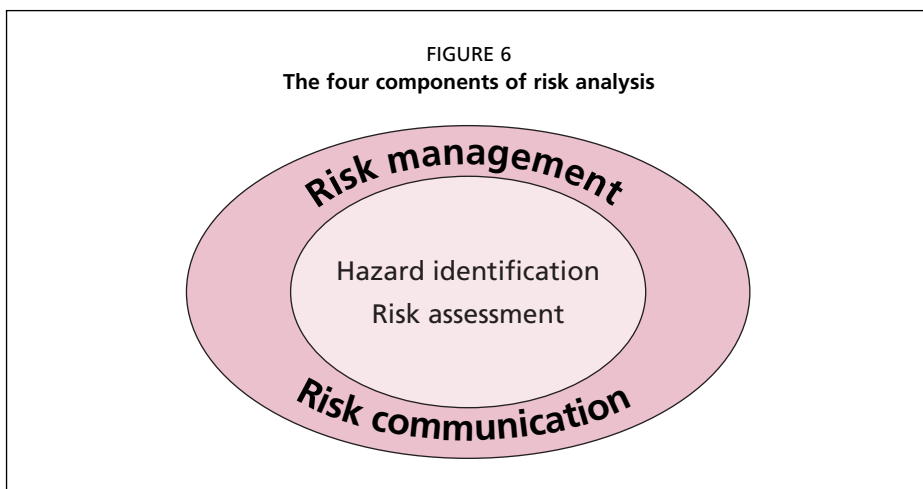
BOX 2

The four components of risk analysis

1. **Hazard identification** is a necessary first step, a hazard being something that is potentially harmful to animals, humans, plants or the environment. To proceed to risk assessment from hazard identification requires the framing of a “risk question” about the hazard and the potential harm (unwanted/harmful outcome) it may cause.
2. **Risk assessment** requires assessment of the likelihood of an unwanted outcome (or outcomes) and the impact or costs associated with the unwanted outcome. The assessment may be qualitative or quantitative.
3. **Risk management** is the identification and implementation of risk reduction measures, involving:
 - a. risk appraisal;
 - b. option appraisal (including impact assessment);
 - c. implementation of chosen risk reduction measures, and;
 - d. monitoring and evaluation.
4. **Risk communication** is essential where two or more stakeholders are involved; will also include communication about risk reduction measures, and any regulations that are used to enforce these.

http://www.oie.int/eng/normes/mcode/en_chapitre_1.2.1.htm

Source: OIE, 2008



As suggested by Figure 6, it is useful to consider risk management as the encompassing component bringing together all the elements of risk analysis. Risk communication is an important activity that should be carried on throughout the whole process.

Each of the four parts of the OIE risk analysis framework is described below in more detail.

Hazard identification – framing the risk question – risk of what?

A hazard is something that is potentially harmful to humans, animals, plants or the environment. A pollutant that may contaminate the environment is a hazard. A pathogenic organism that may be present in a piece of meat or infected animal is a hazard.

The existence of a hazard is a prerequisite for the issue of risk to arise. Furthermore, for risk to be an issue there must be several possible outcomes associated with the hazard, of which at least one is unwanted/harmful. An unwanted/harmful outcome is defined as an outcome that brings damaging consequences. Importing live animals from another country may lead to the introduction of an animal that is infected with a certain pathogen (the hazard). Such importation may lead to a variety of outcomes: no onward spread of infection; onward spread of infection to local livestock resulting in an epidemic; a self-limiting outbreak; or cross-border spread.

Of key importance is that there is uncertainty about which particular outcome will occur – there is an element of chance (or risk). This is where the risk question arises. Risk assessment (next section) involves an evaluation of the probability and impact of an unwanted outcome occurring. To carry out this evaluation in a systematic manner it is necessary to have a clearly framed risk question. A clear risk question should specify the outcome of interest, the population/location and time period for which the risk is to be assessed. The general form of a risk question is therefore:

**“What is the risk of [outcome] associated with [hazard]
in [location/population] during [time period]?”**

Risk assessment

Risk assessment is the systematic evaluation process of assessing or evaluating the magnitude of the risk of an unwanted outcome resulting from a hazard. In risk analysis, risk is defined as being composed of two contributing components: (i) the likelihood (probability) of the hazard causing the unwanted outcome, and (ii) a measure of the impact (consequences) of the unwanted outcome. There are three major steps in carrying out a risk assessment, as follows:

1. Elucidate the steps necessary to get from hazard to unwanted outcome; this usually makes use of a tool called risk pathway analysis⁶.
2. Identify and collect the information necessary to:
 - a. estimate the probability of each event in the pathway; and,
 - b. describe or estimate the impact of the unwanted outcome.
3. And finally, make an overall assessment of the risk.

Some unwanted outcomes may be assessed as very unlikely to happen; however, they may have very severe impacts if they do occur, and therefore the risk may still be assessed as “unacceptably high”. The converse is also true, i.e. the overall impact of an event that is assessed as quite likely to occur may not be particularly serious. For example, the probability of bacterial infection from eating street vendor food is relatively high, but the consequence (short bout of diarrhoea) is relatively mild, and therefore most people would assess the risk as acceptably low and enjoy eating street food from time to time and occasionally suffer the consequences. In contrast, the probability of contracting rabies from a dog bite may be numerically extremely low, but the consequence (death) is severe, therefore the risk is assessed as unacceptably high and most people would seek post-exposure prophylactic treatment.

Risk assessments are usually divided into quantitative and qualitative risk assessments. However, this division represents two extremes of what in reality may be a more continuous range (e.g. semi-quantitative assessments are also common).

At the quantitative extreme, the probability of a hazard occurring is calculated using probability calculations. In order to do this we would need to estimate probabilities at each step of each and every risk pathway. This is the recommended method for use in quantitative import risk assessments (OIE, 2004b). The methodology described in this document focuses on a qualitative and semi-quantitative approach.

Risk management

Box 3 summarizes the fundamental principles underlying control of contagious diseases. Of these, the second (reducing the contact rate) is the main focus of risk reduction in value chains.

The objective of carrying out risk analysis is to search for ways to prevent disease transmission throughout production and market chains – i.e. to find ways to manage (reduce) the risk. Risk reduction creates an awareness of and takes into account all the ways in which disease can spread and takes every practical measure to minimize the risk of disease spreading. This includes spread both into and out of farms and at every step of the value chain, wherever disease agents may be found.

⁶ See Annex 1: Risk pathway analysis and risk control, page 63

BOX 3

The three fundamental principles of contagious disease control

1. *Reduce/restrict production of disease agent:*
 - cull the infected animals quickly (stamping out); this requires good surveillance and reporting;
 - vaccination: for some diseases vaccination does not fully protect from infection but will reduce production of disease agent in infected animals.
2. *Reduce contact rate within the population (this requires understanding of the contact networks within value chains and application of biosecurity), for example:*
 - barriers – routine and temporary (contribute to segregation)⁷;
 - streamline value chains (contributes to segregation)⁷;
 - remove disease agent from environment so that contacts are no longer potentially dangerous (cleaning & disinfection)⁷.
3. *Reduce the number of susceptible animals:*
 - vaccination;
 - area culling (so-called pre-emptive slaughter of animals around outbreaks).

Risk management should be undertaken as a structured and systematic process encompassing all aspects of risk analysis. Risk management entails identification and implementation of risk reduction/control measures. The entire process can be broken down into the series of activities shown below.

- **Risk appraisal (using the output from risk assessment)**
 - Becoming aware that a risk issue exists (i.e. danger of unwanted outcomes associated with a hazard).
 - Putting the identified risk issue into context (scoping the problem). This should involve a rapid overview of the relevant livestock value chain(s), including communication with stakeholders and a preliminary risk assessment.
 - Gathering further information to be used in the detailed risk assessment; analysis of risk pathways and risk factors; obtaining information on costs, benefits, etc., (possibly as formal cost-benefit or risk-benefit analyses); obtaining information on stakeholder perceptions of the risk issue.
- **Option appraisal (including impact assessment)**
 - Identifying the possible options for management; obtaining information on stakeholder perceptions about risk reduction or risk mitigation measures.
 - Assessing how different options may change the way value chains operate (analysis of impacts on different stakeholders in the value chain).
 - Making decisions on which safeguards (risk reduction or risk mitigation measures), if any, to put in place.

⁷ See: 'Fundamental principles' of biosecurity in the FAO Animal Production and Health Paper 165 *Biosecurity for Highly Pathogenic Avian Influenza - Issues and options*, Rome, 2008.)

- Implementation of chosen risk reduction measures
 - Ensuring that the decisions taken are translated into actions, and monitoring the outcome of those actions.
- Monitoring and evaluation
 - Evaluating the outcome of the decisions and actions.
 - Re-evaluating the problem and its context in the light of the outcome of the actions taken.

Risk management utilizes the results of risk assessment to evaluate potential benefits against assessed risks, to reach decisions on acceptable risk and to formulate risk management policy on that basis.

Different groups may have very different perceptions of a particular risk and very different ideas of the assessed risk. Both of these issues require good risk communication to achieve an effective risk management policy.

Cost-benefit and/or risk-benefit analyses should be included in the decision-making process. In this respect, it becomes important to fully comprehend the roles and motivations of the different people involved in the value chain⁸.

Risk management is an iterative process. New information obtained during the above process may give rise to a need for further hazard identification, risk assessment, etc., which may in turn lead to further management options, and so on. Risk communication is essential at each step of the risk management process. This means ensuring that all relevant stakeholders are consulted and given an opportunity to contribute to the risk management process.

Acceptable risk

The general objective when managing risk is usually expressed as attaining “acceptable risk”. But what is an acceptable risk and according to whom is it acceptable?

This is a very difficult question because what is considered an acceptable risk to one person, group of people or country may not be considered acceptable to others. Many factors affect agreement regarding the acceptability of any given level of risk, particularly because “those who bear the risk are often not those who receive the major benefits”. However, negotiating about whether a risk is acceptable requires common recognition of the magnitude of the risk on the part of all those involved in the negotiations. This requires an assessment of that risk by means of a methodology that is agreeable to all parties. It is in order to ascertain what is acceptable in the situation under analysis that risk communication, the fourth element of risk analysis, must begin at an early stage of the risk analysis process. The acceptability of a risk then depends on different stakeholders’ perceptions of the balance between the assessed risk and the potential benefits of taking the risk and/or the cost of risk mitigation measures.

Risk communication

Risk communication means an open information exchange among all those affected by the risk in question and/or the decisions taken with regard to risk reduction strategy.

⁸ See – Analysis of impacts on different stakeholders, page 52

BOX 4

Summary of principles of risk analysis

Risk analysis is a formal method of dealing with hazards and risks. It comprises hazard identification, risk assessment, risk management and risk communication.

Hazard identification

Hazard identification is the process of identifying all the potential hazards in a given situation.

- A **hazard** is an agent that can cause harm or damage to people, animals, plants or the environment (e.g. a virus, heavy rainfall).

Risk assessment

For a risk to exist a hazard must be present and there must be more than one possible outcome deriving from that hazard. In addition, there is uncertainty about which outcome(s) will occur and at least one of these outcomes must be unwanted. A risk assessment is the formal systematic process of evaluating the risk (or risks, for there may be more than one) resulting from a hazard. A risk assessment describes the risk in terms of both the likelihood (probability) and the impact (consequences) of an unwanted outcome.

- The unwanted outcome is the harmful or damaging event that may (or may not) be caused by the hazard (e.g. flooding, an epidemic).
- Risk assessment addresses a risk question that must be precisely worded: "What is the risk of *[outcome]* associated with *[hazard]* in *[location/population]* during *[time period]*?"
- The risk we assess is a combination of the likelihood of the unwanted outcome happening and its impact if it should happen.

Risk management

Risk management utilizes risk assessment results in a judgement process to balance potential benefits against assessed risks, to reach decisions on acceptable risk and to formulate policy (risk reduction/control strategy) on that basis. Cost-benefit and/or risk-benefit analyses may be included in the decision-making process.

Risk communication

Risk communication means an open information exchange between all those affected by both the risk in question and the decisions taken (the stakeholders), before the final policy decisions are taken. It should be started as early in the risk analysis process as possible, and should continue throughout the risk management process.

Communication should begin as early in the risk analysis process as possible before the final policy decisions are taken, and should continue throughout the risk management process.

Risk communication fulfils several functions:

- exchanging scientific or factual information between all people involved with or interested in the risk issue;
- providing information about the risk perceptions and the level of risk acceptable to the different stakeholders;
- disseminating information about the acceptability and feasibility of various possible risk mitigation measures;
- disseminating information about the effects of proposed decisions and measures to allow for evaluation;
- encouraging and establishing trust between all those people and organizations affected by or interested in the risk issue.

This last function represents one of the most important advantages of ensuring risk communication at an early stage. Establishing trust is particularly important because very often the people who benefit from a successful risky endeavour are a different group from those who suffer if the endeavour should fail. For example, a farmer wishing to import a new, more fertile livestock strain will reap most of the benefit if no infectious disease is imported; however, if infection is imported and it spreads through the region or country, many other farmers (and their animals) will suffer.

Box 4 contains a useful summary of the principles of risk analysis.

THE VALUE OF QUALITATIVE RISK ANALYSIS

Qualitative risk analysis provides a logical and uniform framework for decision-making. Qualitative risk analysis can be used to support decisions to allow certain activities under certain conditions or, alternatively, to prohibit activities because no practical risk reduction measures are identified.

Qualitative risk analyses usually have the following common features:

- Risk assessment, which entails the following:
 - formulating the risk question: hazard identification, context and theoretical transmission pathways;
 - specific risk pathways;
 - description of the main factors affecting the risk probability at each step of the risk pathway(s); this is often in the form of a table detailing the factors, comments on the factors and a qualitative risk estimate where appropriate;
 - summary of risk reduction factors.
- Risk management options: measures that could be taken to reduce risk.
- Recommended immediate actions, bearing in mind that these risk assessments were being carried out at a time of emergency when quick but transparent decision-making was needed.

An example of a qualitative risk analysis is presented in Box 5.

BOX 5

Example of qualitative risk analysis for HPAI

A qualitative risk assessment of introduction and dissemination of the H5N1 HPAI virus in Ethiopia by migratory birds, by Goutard *et al.* (2007).

Steps:**1. Background information:**

- a. Characterize the poultry population. This was a very basic value chain overview. (Detailed value chain analysis was not needed because the question here was about the introduction of the virus by wild birds, and not the spread of virus within domestic poultry.)
- b. Characterize wild waterfowl migration across Ethiopia.

2. Define the risk question: What is the risk of introduction of H5N1 HPAI virus into domestic poultry in Ethiopia by migrating waterfowl?**3. Develop the risk pathway(s):** a representation of the chain of events leading from wild birds to infection of domestic poultry.**4. Collection of information pertinent to the risk pathway(s):** There were two key questions from the risk pathways:

- a. What is the likelihood of migrating wild waterfowl releasing the virus in Ethiopia?
- b. What is likelihood of an interface between wild waterfowl and domestic poultry?

5. Assessment of the factors that affect the level of risk (risk factors): In this analysis, factors were identified such as gregariousness of wild waterfowl, and these factors were given a score based on expert opinion.**6. Risk rating:** risks along different pathways were rated using descriptors (null, negligible, low, moderate, high, and very high).**7. Communication of results:** an overall risk evaluation, including a discussion of the level and sources of uncertainty in the evaluation and recommendations for further action.

PART 2

Practical Framework

SUMMARY OF STEP-BY-STEP APPROACH

Step 1: Situation analysis and preliminary risk analysis:

- descriptive epidemiology of the situation regarding the disease(s) of concern
- description of livestock value chains and identification of people and organizations involved in those chains
- identification and characterization of the risk issues and risk hotspots in value chains
 - organize information into tables to describe areas of risk (risk issues)
 - make a preliminary assessment of areas within the chains that should be prioritized as risk hotspots

Step 2: Detailed risk and value chain analysis leading to planning of risk management options

- development of risk pathways and identification of potential risk mitigation measures
- development of options for inclusion in a risk management strategy

Step 3: Option appraisal and decision-making

- analysis of impacts on different stakeholders

Step 1: Situation analysis and preliminary risk analysis

This first step is to carry out a value chain risk survey. This involves the participation of stakeholders in the preparation of descriptive summaries of the livestock value chains. These preliminary summaries can be prepared during stakeholder workshops and interviews with focus groups and key informants. The preliminary documents can then be supplemented by additional data and circulated back to the workshop participants for their comments and approval. During this process the epidemiological situation of the target disease(s) is described, and the factors in the value chains that contribute to risk of outbreak and spread of disease are identified and discussed.

It is important to work at different levels of detail. It is best to start with a broad overview and a quick evaluation of value chains and risk. Once this has been done, risk points and data gaps can be identified and focused on when preparing the more detailed risk and value chain analyses.

DESCRIPTIVE EPIDEMIOLOGY OF THE SITUATION REGARDING THE DISEASE(S) OF CONCERN

This will mainly involve gathering all available information regarding:

- **fundamental knowledge of the disease;**
 - the basic epidemiology, life-cycle of disease;
 - characteristics of the disease agent;
- **local and regional patterns of disease occurrence;**
 - information derived from passive and active surveillance;
 - incidence/prevalence of disease;
 - temporal and spatial patterns of outbreaks;
 - production systems and species affected;
 - morbidity and mortality rates and other effects on livestock.

CARRYING OUT VALUE CHAIN ANALYSIS⁹

To fulfil the needs of the risk analysis for which it is needed, the value chain analysis should provide specific information, as follows:

- how and where livestock and products are produced, processed and traded;
- amounts of livestock/product produced, processed and traded through each part of the chain;

⁹ Much of the following material is taken and adapted from Rushton, 2009.

- the people involved in transactions along the chain and an understanding of how and why they are involved;
- the economic factors along the chain (volume, value added, transaction costs, etc.);
- the risk behaviour of the people involved in transactions along the chain, and the factors that influence that behaviour, i.e. how do people operate and what governs their decisions and motivates them?

It can be seen that the value chain studies are necessary to deliver qualitative and quantitative information about processes, behaviour and economics. In this process it is important to include information about temporal aspects (seasonality) as well as spatial (locations), because value chains may operate differently at different times of the year (e.g. in response to cultural festivals, seasonal consumer demand trends, links with other agricultural activities). This may lead to local and seasonal risks that would warrant targeted control measures.

A value chain analysis can be split into three basic steps:

1. description of the value chain (value chain mapping);
2. identifying the important routes, people, groups and organizations involved in the chain;
3. assessing the profitability, power and institutional environment of the key people, groups and organizations involved in the chain.

A value chain analysis should pay particular attention to gathering information on the people involved, their practices, rewards, cultural preferences, education and training.

Description of the value chain (value chain mapping)

A graphical representation of the livestock value chain can be prepared through primary and secondary data collection.

Initially, a rapid overview of the relevant livestock sector should be obtained by starting with simple livestock value chain maps for all the main livestock products in the area of concern, and then by studying available literature and secondary data (e.g. market data, census data) as well as by consulting experts.

Once the available knowledge has been organized, participatory approaches involving consultation with key informants and stakeholders (e.g. workshops, individual and group interviews, focus group discussions) can be used to map out the value chains. An advantage of using a consultative approach is that a basis is established for good risk communication. The value chain maps themselves are a powerful communication tool, providing a focus for discussions about disease risk and risk mitigation/management).

The major suppliers, traders and markets of livestock and livestock products can be identified by working closely with livestock producers.

Working closely with the traders of livestock and livestock products and markets identified with the producers will help to determine what happens to the livestock and livestock products and the intermediaries involved. (If the consumer level is not reached at this stage it is recommended that the work continues down the chain until the consumer is reached.)

Once an understanding of a chain has been developed from input supplier to producer and on to the consumers, any data gaps should be identified and filled by using either primary or secondary data. Secondary data involves contacting people and organizations that have previously collected and documented important data and information in the past.

Results should be shared with people who have knowledge of the particular livestock subsector that the work is focused on to ensure that the routes for livestock marketing are accurate and well described. The preliminary value chain analysis should be presented to and discussed with the producers and traders to gain further refinement, to make necessary modifications and to identify possible weaknesses. The consultations should aim at gathering detailed and locally specific information from people directly involved in the value chains.

Key informant workshops, individual and group interviews and focus group discussions should involve key informants who represent:

- livestock producers;
- animal slaughterers and product processors;
- government departments of livestock health and production;
- private veterinarians;
- traders and marketing organizations;
- any others relevant to a particular livestock chain.

The value chain maps should contain the following minimum information:

- input infrastructure (feed mills, pharmaceutical companies, etc.);
- processing infrastructure (slaughterhouses, processing plants, cold storage);
- production infrastructure;
 - livestock population by species, product focus, scale (flock and herd size categories), production systems and husbandry type;
 - geographical distribution of livestock production systems, production clusters;
- movement and marketing infrastructure;
 - major movement corridors of inputs, livestock and products (road, rail, air, river);
 - geographical distribution of major livestock consumption areas for different products (e.g. cities);
 - marketing inside the country, livestock markets and product markets;
 - transport routes and transporters, movement of livestock from production areas to consumers;
 - exports and imports.

The maps should be accompanied by commentaries describing:

- the different people involved in production and marketing of livestock and livestock products;
- the practices, rewards, cultural preferences, education and training of people involved.

Such an analysis will identify the key routes of trade for the livestock and livestock products, the main people, groups and organizations involved in livestock production, processing and trading, as well as who the main consumers are and where they are found.

Some attention to detail is required at this stage because livestock production chains are diverse and complex. For example chicken meat is produced in many forms for different consumer demands:

- 42-day broilers
- 120-day broilers
- native/village chickens
- spent hens as a product of the laying sector

These different chains make use of different genetics and farming systems and supply different consumers through different markets involving different traders who are governed in different ways and have different entry points for disease risk and risk management.

Identifying the important routes, people and organizations involved in the value chain

To identify the most important routes, people, groups and organizations in the livestock value chain it is recommended, where possible, to determine the:

- number of livestock producers using the different routes within a chain;
- volume of product that moves through the different routes of the chain;
- monetary value that moves through the different routes of the chain.

Figure 7 presents different ways of expressing the importance of the different branches of a livestock value chain. Each of the diagrams tells a different but important part of the whole story. Diagram (2) shows that there are over twice as many national traders as local traders. Diagram (3) shows that one-half of the producers sell direct to consumers; however, diagram (4) shows that this only accounts for 17 percent of the volume of product. Diagrams (4) and (5) show that the majority of product (51 percent by volume and 59 percent by value) is handled by national traders, who sell 77 percent (by value) of the product on to retailers.

It is important to realize that there is further detail in the value chains that is not captured in the diagrams. The producers and consumers that deal direct are almost certainly different from those involved in the national trader-retailer chain. Direct producer-consumer chains are most likely smaller scale and locally focused (e.g. within village).

All of these different pieces of information have relevance from the point of view of risk assessment and management. The magnitude of risk is influenced by the numbers of producers and others who interact at different points, by the volume of product flow and by the geographic “reach” of the chains. The monetary value of products handled through different points directly indicates what is at stake for stakeholders in different chains and is therefore an important consideration when designing risk mitigation measures that may impose regulation or otherwise modify the chains.

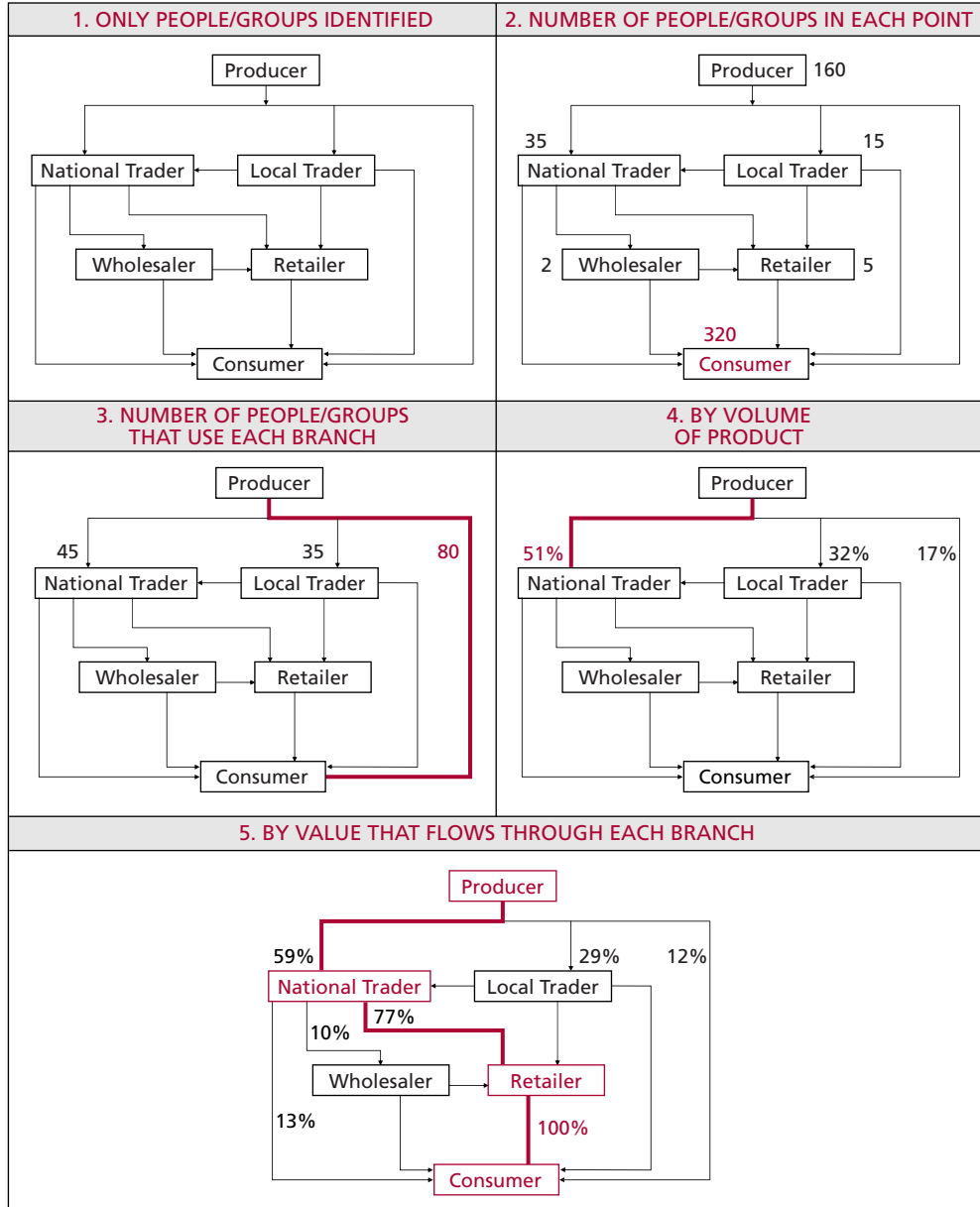
Some of this information may be sensitive, and it will not always be possible to carry out a quantitative analysis of each route in the value chain.

Assessing the profitability, power and institutional environment of the key people and organizations involved

The first step is to identify the key people, groups and organizations in the chain who could benefit from developing enterprise budgets for their livestock activities¹⁰. These people should be interviewed with regard to the input and output markets for their livestock activity including the opportunities and constraints they perceive in terms of supply, demand and regulation of the activity. Where possible information should be generated on how important each person, group or organization is in terms of power to determine price, to set quantity and quality standards and to search for and gain entry into new markets.

¹⁰ See Annex 2: Developing and analysing enterprise budgets, page 75, for more detailed coverage of this topic.

FIGURE 7
Different ways of assessing the importance of different branches of a livestock value chain or a system



Source: Rushton (2009)

The data collected and analysed for use in developing enterprise budgets for the different people along the chain can be used as follows:

- To examine the profitability of each group of people, their important inputs and outputs.
- To examine the share of the profits across the chain to see whether there are some people who have more power (stake) than others.
 - Many analysts examine marketing margins across chains that only consider prices paid and received and do not take into account the costs of doing business. It is recommended that a value chain analysis should treat with caution such margins and should attempt to collect more detail on cost structures at each part of the chain.
- To check the general efficiency of the chain in terms of:
 - taking inputs and making outputs;
 - transmitting information on what consumers want to the production and processing parts of the chain.

Governance of the chain

Understanding how value chains are governed is important when choosing risk reduction strategies because governance of a livestock value chain determines how the chain develops by upgrading the product, process and functioning of that chain, or by changing to a completely new chain. Private regulation across livestock value chains is playing an increasingly important role in dictating the development of livestock production and processing standards. The enforcement mechanisms through the private sector are strong as they can be transmitted by price. This is particularly important when considering demands on the livestock sector for safer food and also for animals that have been produced in a welfare friendly manner. The role of the private sector for animal health improvement needs to be taken into account when planning state level interventions (Henson, 2006). Therefore, a good understanding of the governance of livestock sector chains will allow public organizations to identify the key people and organizations in the chains and to develop strategies that involve them in the changes in animal health practices and standards.

Assessment of profitability and governance will provide information on the likelihood of acceptance of interventions and reactions to the disease. This is important in ensuring the effectiveness and social acceptability of any risk reduction strategies.

Checklists for value chain analysis

Some useful checklists of items to consider in value chain description and analysis are provided in Box 6.

IDENTIFYING RISK ISSUES AND RISK HOTSPOTS IN VALUE CHAINS

This step is to identify and characterize disease risk and risky practices in the livestock value chains. This requires the input of expertise both in epidemiological risk analysis and in the economic and institutional environment in which the value chains operate. A preliminary qualitative assessment of risks can thus be made based on the descriptions of processes in the value chains and on knowledge about how people involved in the value chain operate.

BOX 6

Checklists of items to consider in value chain description and analysis

This list starts from consumers/products and work backwards; however, the reverse process works equally well.

- All different livestock products produced in the area of interest
- Products imported into the area of interest
- Main markets (focus on big wholesale markets)
- Processing infrastructure
- Production infrastructure (production types, areas)
- Input supply infrastructure (breeding flocks, hatcheries, feed mills, input supply chain)

Produce diagrams showing linkages between different elements and people or organizations in the value chains and maps showing locations of different parts of the networks.

- Consumer centres (big towns, cities) – which products are demanded by urban, peri-urban and rural consumers?
- Marketing and processing centres (including places handling import/export to/from the area of interest)
- Production areas (locations of big farms, hatcheries, etc.)
- Input sources (within and outside the area of interest)

Different categories of information are needed in the preliminary value chain description.

Production process

- Inputs
 - source:
 - where (geographical location in terms of access by producers)
 - who (whether producer-supplier contract requires informal or formal contracts (transaction costs and compliance))
 - how (cash, credit, credit on what terms)
 - prices
 - seasonality
 - time/changes
- Production
 - products (with regard to demand, prices, quantities and seasonality, quality and preferences)
 - cost structure
 - productivity
 - subsidies/support (government policy)
 - veterinary inputs and services

./...

BOX 6 (contd.)

Checklists of items to consider in value chain description and analysis

- Marketing routes
 - mapping of markets
 - data on traders and trader networks
 - prices
- Processing
 - mapping of slaughter places
- Consumption
 - mapping of retail outlets
 - prices
 - destination (final market) for produce (may be outside province)

Governance, regulation, routine

- Behaviours/routines (Who sets the rules? Who enforces them? What are the incentives/disincentives for doing them? Who governs?)
 - For example, how are things done? Particularly here we will be looking for “risky” behaviours and “biosecure” behaviours. Do visitors to farms come into direct or indirect contact with the livestock? Are animals from different sources mixed at markets? Do traders clean and disinfect their vehicles? Do feed suppliers visit farms in different production sectors?

Local field conditions

- What washing facilities are available at markets? Is the temperature suitable for virus survival (at different times of year)?

This type of assessment is often done by people who are outside the value chains that pose and create a disease risk to society. Given that most contagious diseases generate significant negative externalities and that the control of diseases generates many positive externalities, the state needs to address the issue of market failures in disease control because it is recognized that the state often has to underwrite losses resulting from disease. Therefore the state has to play a role in minimizing how disease is maintained and spread. To achieve success the “outsiders” who assess the risk need to be aware that they themselves are not the experts of the system, the value chain that generates risk, nor will they be the ones who implement or bear the costs of proposed changes to reduce disease risks. Therefore, to improve chances of success the assessment must be consultative and must involve and inform the people in the value chains, and at all costs avoid any mechanisms that alienate them from the process.

The approach entails examining the value chains to identify opportunities for disease transmission within them and identifying the factors that are likely to affect the probability and amount of disease transmission (risk factors, including the risky behaviour of people involved in the value chains).

Identifying the opportunities for transmission of a disease agent and estimating the risk

At each point in the value chain ask the following questions:

- Can a disease agent enter here? (source, route)
- Can a disease agent survive here? (conditions, treatments)
- Would a disease agent be noticed here? (surveillance)
- Can a disease agent be carried out from here? (destination, route)

Along with these questions it will be necessary to make an estimation of the likelihood of transmission of a disease agent and the impact/consequences of the disease agent arriving at any point in the chain.

The likelihood of disease agent transmission will depend on various factors related to the operating conditions of the value chain. These conditions may be called “risky practices” or “risky behaviour” of people involved in the value chain. People who work or run businesses in a value chain would not, of course, intentionally set out to spread disease as this would jeopardize the very existence of the chain in which they generate their livelihoods. Risky practices are usually the result of economic drivers, and are not the result of intentional disease agent transmission.

Some common methods of disease transmission, risk factors and risky practices are shown in Box 7.

The volume of flow through parts of the value chain is also very important in determining overall likelihood and, ultimately, the risk of transmission of a disease agent. For example, the likelihood of exposure of poultry to H5N1 virus through delivery of feed may be quite low per delivery, but the likelihood will increase as the number of deliveries increases (more chances per unit time to get exposed). Commercial units may have in place more risk mitigating biosecurity measures; but they also have higher volumes of traffic with potential exposure because they use more commercial feed, employ external labour, etc. Therefore the net likelihood of exposure to virus over any period of time can be high and the consequences of exposure/infection in these units can also be high.

The potential impact of the disease agent reaching any point in the value chain will be broadly related to consideration of the following:

- likely amount of disease agent involved (viral/bacterial load);
- likely exposure and subsequent infection of livestock (or people in the case of zoonoses);
- likely amplification of infection (size of any resulting outbreak);
- likely spatial spread, especially spread to new geographic areas;
- potential to spread across species (e.g. ducks to chickens, poultry to humans);
- potential economic losses;
- potential “humanitarian” losses.

Identifying the risk hotspots

The objective of this preliminary analysis is to identify the most important concentrations of risk (hotspots) in the value chains. Risk mitigation measures should be focused on those areas

BOX 7

Disease spread, risky practices and risk hotspots in value chains**Common methods by which disease can be spread in value chains**

- infected livestock:
 - themselves carried over distances;
 - mixing with other stock at markets spreading infection;
- people in contact with livestock:
 - input suppliers visiting multiple farms and villages;
 - traders visiting multiple farms, villages and markets;
 - market personnel;
- vehicles in contact with livestock:
 - visiting multiple farms, villages and markets;
- contaminated equipment:
 - cages, etc.;
 - egg trays;
- animal by-products:
 - manure;
 - skins, feathers;
 - guts and other slaughter waste;
 - hatchery waste (spoiled and reject eggs);
 - eggshells.

Examples of risky practices in value chains

- multiple pick-ups by traders;
- inadequate cleaning and disinfection of vehicles and equipment;
- long distance movement of livestock without health assurance or traceability;
- large live-animal markets that may be constantly stocked with a rapidly turning changing population;
- market trade in "intermediate" livestock (i.e. stock marketed for further rearing);
- mixing of stock from different sources;
- mixing of species,

Examples of risk hotspots for prioritization (using risk associated with H5N1 HPAI in poultry value chains in this case)

- poorly managed hatcheries and day-old chick/duck supply;
- marketing of live birds: important aspects are the volumes handled in any one place; the mixture of species or types of birds handled (this provides opportunity for disease to spread between the population involved in the different product chains; such mixing and cross-over may be subject to seasonal factors);
- marketing of by-products, such as manure, bedding, offal, feathers, etc., can carry high risk of virus contamination and are often not controlled;
- poorly managed commercial production units;
- poorly managed transport: especially poor hygiene of personnel, vehicles (bicycles, motorbikes, trucks, etc.), egg flats, crates and cages, etc.;
- free-range waterfowl production.

During the process of a rapid assessment of likely risk hotspots in the value chains it is important to take into account the complexity of the chains and most importantly to look for areas where several chains converge or diverge as these are potential infection amplification and spread points. It is also useful to take account of the number of individuals or groups and locations at different points in the value chain. Greater numbers probably imply greater risk and make disease surveillance and regulation more difficult. When considering both disease risk and risk mitigation interventions it is important to examine how the people and locations are organized and how the groups govern and regulate themselves.

It is also important to consider seasonal variation in any factor that may produce seasonal risk patterns. The value chains themselves may be subject to seasonal variation, e.g. special festival markets, higher demand for specific types of product, etc.

Organization of key information in a tabular framework

The key information for describing main risk factors can be organized using a tabular framework. This tabular framework brings free text descriptive information that may be derived from interviews and workshops into line with more formal risk pathway analysis. Separate tables can be used for each main value chain.

A template for such a table is shown below (Table 1). An example of a completed table is provided in Annex 5: Example of a preliminary risk analysis table for risk of foot-and-mouth disease in northern Viet Nam

The risk factors are subdivided within the table into those that have their main effects on:

- disease agent introduction to area;
- exposure of local livestock to disease agent;
- spread of disease agent within area;
- spread of disease agent to another area.

If specific production and marketing chains are to be treated as “contained compartments”, as would be the case, for example, if trade is undertaken on the basis of compartmentalization, attention should focus on disease risk and biosecurity within these compartments. In such a case, the subdivision of risk factors could be those affecting: the introduction of disease agent to a chain; the exposure of local livestock in the chain to the disease agent; the spread of disease within the chain; and, the spread of disease to other chains.

The factors are further subdivided according to the main ways those factors affect transmission of disease, as follows:

- Live animals
 - Consider movements of live animals (volume, type, seasonality, destination and use), supply of breeding stock and young stock, as well as slaughter stock movements, handling by intermediaries and markets, regulations, checks and enforcement, border and internal inspection posts, drivers of movements, ability to police borders, exposure of susceptible livestock and biosecurity precautions regarding live animal contacts.
- Animal products
 - Consider movements as above but of products, exposure of susceptible livestock and biosecurity precautions regarding animal product contacts.

TABLE 1
Template for a preliminary risk analysis tab

Area of concern	Type of carrier involved in transmission	Factors affecting risk	Evidence-based qualitative partial risk estimate	Questions remaining
(1)	(2)	(3) <i>Relevant descriptive information about the value chain; especially describe risky practices that affect the risk of disease</i>	(4) <i>A preliminary qualitative assessment of risk that is based on the evidence presented in column (3), e.g. high, medium, low; give justification</i>	(5) <i>Identify any data/information that is critical to the risk estimate – particularly items that should be further researched and/or carefully monitored</i>
Disease introduction to country/area	Live animals Animal products Fomites Other?			
Exposure of local livestock to disease	Live animals Animal products Fomites Other?			
Spread of disease within the area	Live animals Animal products Fomites Other?			
Spread of disease to another country/area	Live animals Animal products Fomites Other?			

- Fomites
 - Consider all people and vehicles that have direct or indirect contact with livestock, journey structures, cleaning and disinfection (C&D) regulations, application and enforcement of regulations, exposure of susceptible livestock, and biosecurity precautions against contacts with fomites.
- Other routes (e.g. possible airborne transmission in the case of FMD).

These subdivisions are sometimes a bit artificial. In particular, the factors associated with exposure of local livestock would overlap with both introduction and local spread because exposure and infection are the necessary end point of both these risk pathways. However, these subdivisions are useful to make the qualitative risk assessments more transparent (e.g. as a general rule the movement of live animals is a higher risk than the movement of animal products).

Column (3) in Table 1 should contain any relevant information about processes and practices in the value chain that generate disease risk. This information should be presented

as brief descriptive text highlighting the key factors that influence risk. Any other information that enables an estimation of the risk level should also be included.

Column (4) in Table 1 can contain comments relating to each risk factor described, and, where appropriate a qualitative estimate of risk (e.g. risk described as “low”, “medium”, “high”, etc.).

Further information required can be noted in column (5) of the table. The advantage of including this aspect as a column in the tables is that information needs can be prioritized on the basis of the probable/possible importance of any particular factor.

The result should be identification of factors in the value chain that are likely to be important in affecting the probability and the amount of disease occurring. From this it should be possible to summarize the preliminary risk analysis by describing risk hotspots including:

- identification of the most important risks from the preliminary analysis;
- description of the location(s) of the risks:
 - location(s) within the value chain;
 - geographic location(s) within the country;
 - location(s) in time, i.e. any seasonal variations in risk;

The next step will be to identify potential risk management options.

Step 2: Detailed risk and value chain analysis leading to planning of risk management options

This step again involves a combination of risk analysis and value chain analysis. The risk hotspots are examined in order to determine how control measures could be targeted at them. A consultative/participatory approach involving veterinary authorities and value chain stakeholders is essential in order to maintain continuity of good risk communication. The process is iterative in that increasingly detailed analyses are successively undertaken, each analysis being based on the previous one.

DETAILED RISK ANALYSIS FOCUSED ON RISK HOTSPOTS

This requires a detailed study of the processes (production, marketing, processing, etc.) throughout the risky parts of the value chains. This study should focus particularly on the behaviours and motivations of the people involved in the value chain as it is usually particular types of behaviour that lead to increased or decreased disease risk. This study entails (i) developing detailed risk pathways in order to fully understand the factors affecting risk; (ii) carrying out a qualitative (at least) risk assessment; and, (iii) identifying potential risk reduction strategies. If time and opportunity are available, it is useful to carry out the risk pathway analysis together with stakeholders in a workshop setting in order to ensure that the risk pathways are realistic in terms of the ways that the people involved in the value chain behave.

This step can be summarized as follows:

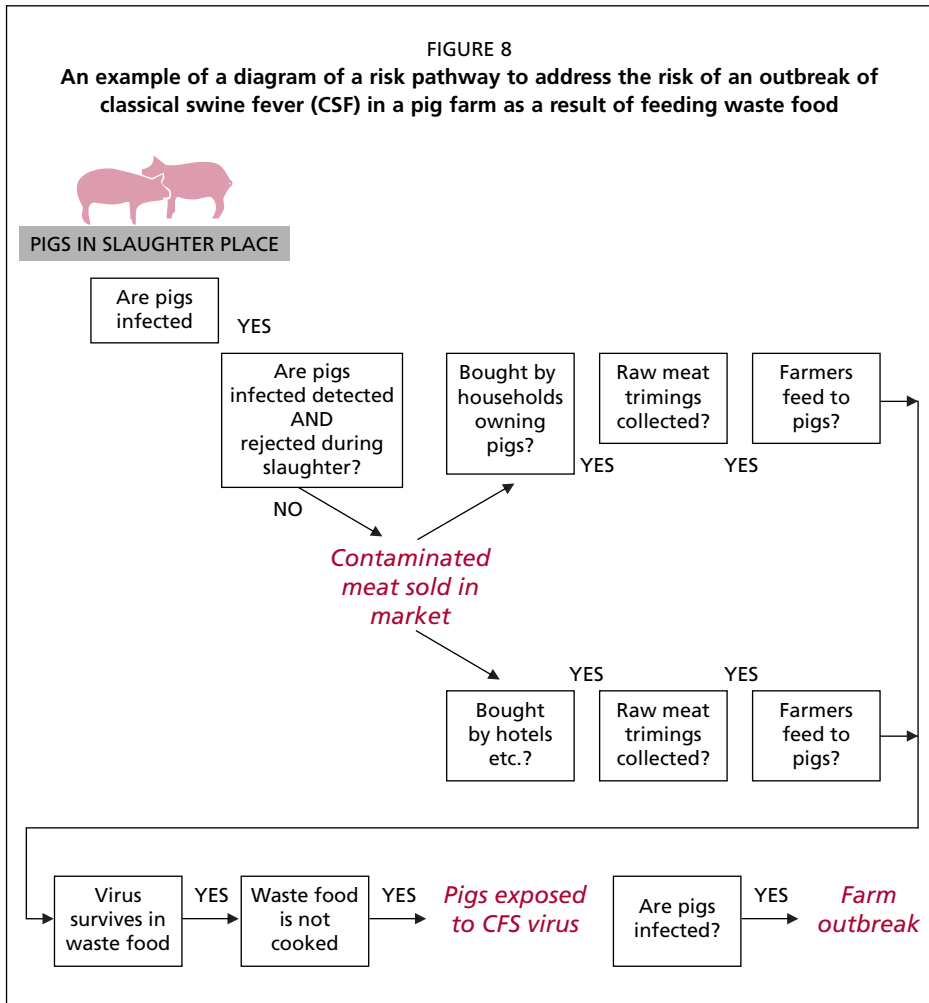
- Focus on the most important risk areas (risk hotspots) identified in the preliminary analysis.
- Develop risk pathways and qualitative risk assessment around risk hotspots.
- Identify and describe the most important factors that affect the level of risk at hotspots (risk factors). It may be useful to divide all factors according to whether they tend to increase or decrease risk.
 - Because intrinsic components of many risk factors in the value chain are risky practices and risky behaviour of stakeholders, consultation with people involved in the value chain should be an essential part of this activity.
- Identify possible risk mitigation measures and risk control points (i.e. points in the value chains where measures will be applied); in particular, try to identify the most potentially critical control points to be targeted by disease control interventions.
 - This is based on the qualitative/semi-quantitative risk assessment (maybe using a risk scoring system) and on appraisal of possible risk reduction interventions (i.e. impact of interventions on the level of risk at each point in the chain and overall).

- If a risk scoring system is developed, this requires description of the specific data to be used to quantify (score) risk for both assessment and future monitoring of control measures.

Risk pathways and value chains

Risk pathways should be developed around each risk hotspot. Risk pathway analysis is the main tool used in risk assessments and is fully described in Annex 1: Risk pathway analysis and risk control. Risk pathways describe each stage in the disease transmission process as it occurs within the value chain.

Figure 8 shows an example of a risk pathway for assessing the risk of an outbreak of classical swine fever (CSF) in a pig farm as a result of feeding waste food to the animals. This pathway uses a process that begins where potentially infected pigs are slaughtered for human consumption and ends where a farmer fed infected meat scraps to his pigs and they become infected.



In developing a risk pathway, all the conditions necessary for the disease outbreak to occur are identified and information about the likelihood of each of these conditions to occur is needed in order to make an assessment of risk. In the above example, the information required includes the following:

- Information about the pigs being slaughtered:
 - Sources of pigs in slaughter places
 - Types of slaughter places (e.g. rustic/home slaughter or controlled abattoir)
 - Application of pre-marketing/movement health checks
 - Application of vaccine and vaccination coverage where pigs originate
 - Visibility of infection (clinical signs, virus carriers)
- Information about the slaughtering process itself:
 - Thoroughness of meat inspection
 - Safe disposal of rejected carcasses
 - Handling of waste from slaughter place
- Information about the marketing of pig meat:
 - Types of retail places for sale of pork?
 - Do pig farmers buy pork from off-farm places?
- Information about the handling of pork:
 - Do households and hotels discard raw meat trimmings?
 - Do hotels supply kitchen waste to farmers?
- Information about local pig farming practices:
 - What proportion of pig farmers feed their animals waste food?
 - Do particular types of farms follow this practice (e.g. smallholders)?
 - Proportion of farmers that cook or treat waste food and efficacy of treatment?
- Information about the CSF virus:
 - Survival characteristics of virus
 - Dose of virus required to infect pigs by oral route

Much of the information required relates to how the value chains operate and the behaviour of the people involved in the value chain. Therefore, a full understanding of the risk issue requires understanding of the socio-economic drivers for behaviours that influence risk. For example, it is necessary to understand the economic factors that may induce waste feeding rather than use of commercially milled feed to pigs, especially when considering control or banning of waste feeding as a risk control measure.

The above list of required information is in effect a list of factors that influence risk (risk factors). Gathering the information into a tabular risk assessment framework, as shown in Table 5 of Annex 1: Risk pathway analysis and risk control, allows important risk factors to be characterized.

Risk scoring

After carefully describing and characterizing the risk factors at hotspots a risk scoring system can be developed. Scoring would increase the transparency of the evidence base for use in risk management planning and would also form the basis for active monitoring of the changes in risk brought about by a risk management strategy.

In order to develop a risk scoring system it is necessary to understand the criteria that can be used to quantify the risk¹¹. By studying the risk pathways we can identify (semi-) quantitative data items that can form the basis for a risk scoring system, as follows.

- Factors that tend to increase risk will be measured by criteria giving a positive score.
- Factors that tend to decrease risk will be measured by criteria giving a negative score.

For example, scoring criteria for the likelihood of animals without health certification being traded in a market could be based on an estimate of the proportion of animals passing through the market that have valid certificates in order:

- 0-30 percent of animals have certificates in order, e.g. score -2;
- 31-50 percent of animals have certificates in order, e.g. score -1;
- 50-70 percent of animals have certificates in order, e.g. score +1;
- more than 70 percent of animals have certificates in order, e.g. score +2

The score would be specific for particular markets in a specific value chain. Different markets could score differently if they have different levels of enforcement of veterinary supervision and checking, as well as different enforcement of sanctions.

It is sometimes difficult to decide if a factor is positive or negative as it might depend on wording, for example, "animals marketed without certificates" is negative; "animals marketed with certificates" is positive. The important thing is not to double count by including both positive and negative wordings of a single factor.

Establishing a scoring system requires care and discussion and is usually developed by panels of experts. This may require organization of further workshops or working groups that can work over prolonged periods.

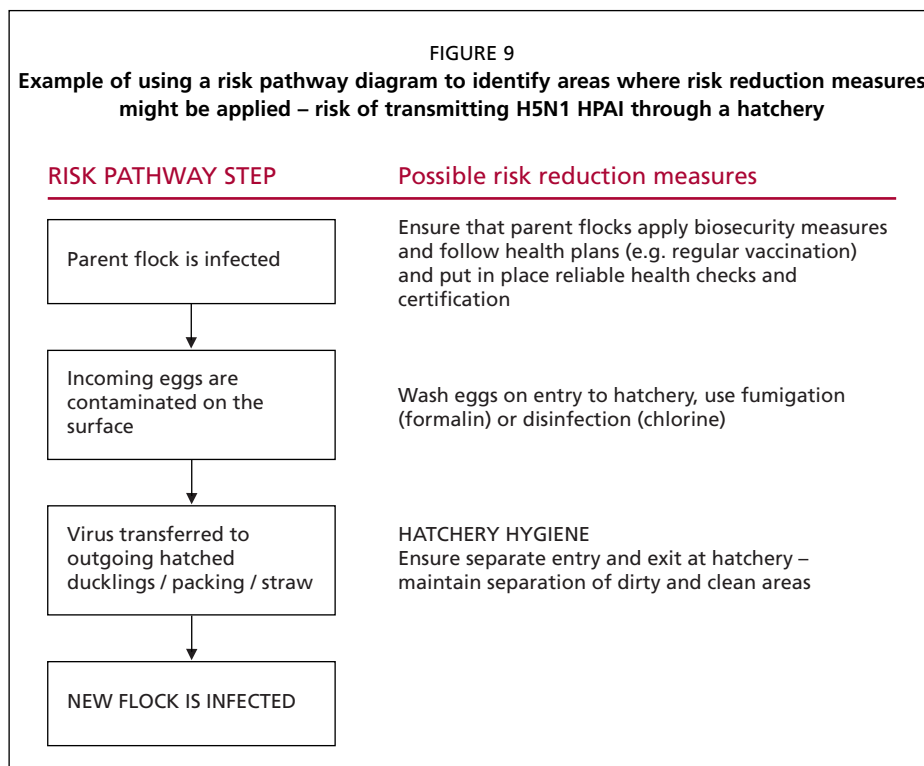
Developing a risk scoring system will help to identify key data that it would be worthwhile spending money on to collect; therefore it is logical to carry out this risk assessment process, with the development of the scoring system prior to more detailed (expensive) data collection.

A scoring system also provides a direct connection to risk mitigation. Risk mitigation measures are measures that counteract risk factors. Risk mitigation will aim at lowering the score for positively scored risk items and raising the score for negatively scored risk items.

Risk reduction

The risk factors associated with risk hotspots are examined with the aim of looking for the potential risk control points in the context of the value chain and identifying the candidate risk reduction measures that may be applied. A detailed methodological approach is presented in Annex 1, section 8.2 (Risk control – using risk pathways to identify risk control patterns). Risk reduction throughout a value chain may be achieved by a combination of several measures (none of them necessarily 100 percent effective) at a number of points in a chain. The aim is to identify where risk factors are expressed in the value chains and then to either identify measures that would reduce risk in those areas or, if risk cannot be reduced to an acceptable level, to identify parts of a value chain that must be closed off altogether. Figure 9 shows an example of using risk pathway analysis to identify areas where risk reduction measures might be applied.

¹¹ Risk includes the impact/consequences of the unwanted outcome at that point.



Some common areas in value chains where risk reduction measures may be focused are summarized below.

Movements across the boundaries of a country or zone

Unofficial trade (smuggling) is often a risky behaviour that can be difficult to combat. When there are strong economic incentives for unofficial trade it is difficult to prevent it from occurring by application of border controls; borders can be extremely porous to the determined trader. It is, therefore, important for veterinary authorities to monitor the social behaviour and economic drivers for such activity (e.g. monitoring the price differentials).

Robust disease intelligence is also important for disease assessment of the potential risk of any cross-border movements. This requires information about the surveillance activities of national veterinary services in neighbouring and other countries. For this purpose it may be possible to set up regional initiatives whereby the national veterinary services of several countries cooperate in the gathering and sharing of information. The factors affecting the behaviour of officials at border control posts should also be examined; for example, do they have the required facilities to perform their duties?

The behaviour of exporters and importers of animals and animal products should be closely examined so that opportunities can be explored for modifying that behaviour to make it less risky. For example, the provision and communication of information about risks of importing animal products and about regulations and penalties should be targeted.

It may be possible to modify and improve enforcement of regulations pertaining to trading in products further along the chain (within the country or zone) in order to make smuggled animals/products less easy to market.

In the final analysis it may be concluded that unofficial cross-border trade cannot be avoided and that the best risk management option may be to seek ways to make such trade official. This would result in trade that could be more easily regulated. The objective would not be to obstruct trade, but rather to facilitate safe trade.

Exposure of livestock to risk material and spread of disease within value chains

In line with the second fundamental principle of disease control (Box 3), risk control depends on reducing the contact rate in the value chain. Box 8 provides some suggestions for this.

Risk reduction in value chains depends ultimately on modification of the behaviour of farmers, traders and any other people who handle animals, products and/or any material (fomites) that may carry risk of disease transmission.

Farmers need to take measures to prevent possible exposure of their own livestock to potentially contaminated material and thus should quarantine animals that are imported to their farms. Other people involved in the value chain need to take measures to ensure that they do not transfer the disease agent during movement from one place to another. These measures are all part of good biosecurity¹².

Box 9 presents the broad categories of measures that contribute to biosecurity on farms and throughout value chains.

In addition, rendering parts of the livestock population immune to disease in particular places and at particular times, through targeted vaccination, may be an efficient tool for reducing disease risk in value chains.

Importance of surveillance

Disease surveillance, which should involve all people, groups and organizations in the livestock sector, remains a critical control issue. Good surveillance and a rapid controlling response to infection can reduce the impact of disease outbreaks. Lower impact means the assessed risk is less; therefore disease surveillance linked with a rapid controlling response is a general risk reduction measure. Where no reliable risk control measures can be identified along a risk pathway (e.g. measures to control risk of infection of domestic poultry through contact with wild migrating birds) targeted surveillance is a legitimate risk management response.

It may therefore be important to strengthen surveillance in those parts of the value chain where risk cannot be reduced by control measures.

¹² See FAO Animal Production and Health paper 165 *Biosecurity for Highly Pathogenic Avian Influenza - Issues and options*, FAO, Rome, 2008.

BOX 8

Reducing the contact rate in value chains [suggestions]

- Branching chains are more risky; therefore risk management should aim to streamline the chains, if possible, by reducing cross-links, branches and steps within market chains. This results in fewer opportunities for the disease agent to be carried between sectors and to be dispersed widely. In regulating these chains, it is also important to understand what the impact might be on livelihoods and on stakeholders along the chain.
- Take steps to prevent carriage of disease agent between steps of the value chain:
 - application of cleaning and disinfection.
- Maintain disease transmission gaps in the market chain, e.g. empty cleaning days at market sites, separation of poultry from different sources/species.
- Completely separate market chains for different poultry sectors; establish strict protocols for personnel moving between them (integration/compartmentalization).
- Focus control measures upstream in the value chains because if material entering the chain is lower risk then the whole chain is lower risk:
 - reducing poultry disease risk in hatcheries to ensure the health and hygiene of day-old-chick supply could be an important component of reducing risk of disease in household flocks;
 - ensure that animals destined for market are from safe health sources; restrict access to markets depending on the biosecurity status of source farms.

Layout of the detailed descriptive risk assessment

As in the preliminary analysis, these analytical steps are organized into a tabular framework. An example can be found in Annex 6: Example of a detailed risk assessment and risk mitigation analysis – Viet Nam.

As a preface to the table it is useful to state the broad risk issue(s) being addressed. In Annex 6, the risk issues are identified as:

1. Entry of foot-and-mouth disease virus (FMDV) into Viet Nam carried by infected live animals, products from infected animals, fomites (or even airborne).
2. Exposure of local livestock to FMDV, carried by infected live animals, products from infected animals, fomites (or airborne).

Next, it is useful to provide a descriptive background that gives the key facts about the value chain that are relevant to disease transmission risk. The text in the example provided in Annex 6 illustrates the characteristics of information obtained from workshops; for example:

- Viet Nam is endemic to FMD and surrounded by countries where also FMD outbreaks regularly occurs (Cambodia, Laos and Southern China). Neighbouring countries do

BOX 9

Broad categorization of biosecurity measures applicable in livestock value chains

- Measures that focus on the livestock population and management (control and/or knowledge about origin and health status of the population):
 - maintenance of closed herds;
 - integration of production (input supply, production, marketing all through linked and traceable channels) – compartmentalization;
 - purchase livestock from known sources;
 - health checking of purchased stock (pre-movement health check/test);
 - regulation of animal and product movement with certification and enforcement of checks en route;
 - measures to ensure traceability of livestock: identification and registration (I&R).
- Measures that act as a checking point or “trap” to discover diseased animals and break the transmission cycle:
 - standstill on movements off-farm within ‘x’ days of movements onto farm;
 - veterinary inspection/health checks at markets, holding points and abattoirs;
 - quarantine of incoming stock.
- Measures focused on blocking direct or indirect disease transmission:
 - Prevent direct contact with possible infected source animals (e.g. fences, measures to keep wildlife out of contact with herds).
 - Prevent indirect contact (e.g. control of fomites; barriers to deny access; cleaning and disinfection). Indirect contact usually involves other people than the farmers themselves, middlemen, market personnel, etc.; the involvement of these people in the value chains is particularly important here.
 - Prevent within farm the spread and buildup of infection (“all in, all out”, separation of age groups, etc.).
 - Prevent spread and buildup of infection within other sites, e.g. markets (empty days, cleaning and disinfection, separation of stock, etc.).

Note that measures can be aimed at preventing disease coming on (bio-exclusion) and also going off (bio-containment). The measures are basically the same but farmers and others have more of an interest in preventing disease entry; for example, culling and disinfection should be carried out upon entry to farm and on exit, but it is the culling and disinfection on entry that protects the farmer directly concerned with the task. Notably, the ‘x’ day standstill mentioned above aims solely at preventing disease moving off the farm.

not vaccinate regularly or do not vaccinate at all, or only vaccinate a small percentage of animals (Laos, Cambodia).

TABLE 2
Template for detailed descriptive risk assessment

Risk location		Risk factors ^[1]		Possible criteria for risk scoring and monitoring ^[2]	Describe potential risk mitigation measures	Possible impacts of risk mitigation on stakeholders
In value chain	Geographic and temporal	Factors that increase risk	Factors that decrease risk			
<i>Refer to value chain description</i>		<i>Refer to risk pathways</i>			<i>Refer to value chain analysis</i>	
(1)	(2)	(3)	(4)	(5)	(6)	(7)

^[1] Factors that affect the level of risk at this point.

^[2] Criteria should in principle be quantifiable. Even if actual measurement is difficult, expert consultation should make it possible to assign a score, so that criteria here should be in the form: "amount of", "proportion of", "level of", etc.

A table (see Table 2) is used to gather together relevant information on risk factors associated with described risk hotspots (columns 3 & 4). Potential risk mitigation measures (column 6) are added alongside possible risk scoring criteria (column 5). The information in these columns should be derived from careful risk pathway analysis.

Before risk mitigation measures can be firmly recommended consideration must be given to the potential impacts of intervention measures on different stakeholders. This is important because if impacts are negative, compliance is jeopardized. The final column (7) of the table provides a space to briefly comment on possible impacts of risk mitigation on stakeholders. This aspect will require further analysis as part of designing the risk management strategy and can require expertise from outside; this is dealt with in the next chapter.

The identification of possible critical control points (CCPs) can be dealt with in paragraphs below the table. Value chain and risk analysis can identify risk hotspots in the value chains, but not all risk hotspots will necessarily be critical risk control points. For designation as a critical control point the most important criteria are the following:

1. Is there a significant risk of the hazard at this step?
 - Use the risk score criteria listed in the table to support conclusion.
 - Points where the impact/consequences component of the risk assessment are high will be viewed as more critical (e.g. points where disease could be widely dispersed); knowledge of the value chain is important here.
2. Do control measures exist at this step?
 - Is the risk at this point amenable to risk mitigation?
 - Knowledge of the risk pathway is important here as well as questions of feasibility (these are dealt with in the next chapter).
3. Would the measures eliminate or reduce risk to an acceptable level (impact of the measure on risk)?
 - Could control at this step alone make the whole hotspot safe? If so, it is fitting to call this a critical control point.

TABLE 3
An example of a part of a detailed descriptive risk assessment addressing risk of spreading FMD within a country

Risk hotspot identified as movement of live calves through markets		Risk factors ⁽¹⁾		Possible criteria for risk scoring and monitoring ⁽²⁾	Describe potential risk mitigation measures	Possible impacts of risk mitigation on stakeholders comments
Risk location		Factors that increase risk	Factors that decrease risk	<i>Refer to risk pathways</i>		
In value chain	Geographic and temporal	<i>Refer to value chain description</i>				
Describe the levels of markets (risk may be differently quantified at different levels), e.g. local market for calves	Every district centre has a weekly livestock market	Origin of calves at markets is not known; Markets are high frequency (weekly); Calves are sold for further rearing; Calves are dispersed over a wide area	Some markets have very low throughput; Some calves are sold for slaughter (veal)	Calves come from x km radius – the wider the radius the bigger the score Percentage of calves traded that have papers inspected and in order Percentage of calves going for further farm rearing – high percentage = high risk score Calves moved onwards over x km radius - the wider the radius the bigger the score	Improve certification and checking of calves into market – restrict intake to calves from “certified” source Quarantine calves in market for several days before sale Quarantine calves in farms for several days after sale	Increased requirement for certification and checking increases work of veterinary services; perhaps increases cost of marketing for the producer and/or trader; requires enforcement backed by penalties Farm quarantine would require facilities at farm, and possibly education for farmers on how to maintain on-farm quarantine.

IS THE CALF MARKET A CCP? This could well be a CCP. There may be significant risk of FMD spread at this part of the value chain resulting from a combination of factors such as: calves are entering market from a wide area; many calves are without certification; and many are going for further rearing in distant places. The most feasible and, therefore, most likely to be effective measure in this case might be to apply improved certification of calves traded through markets; this will require traceability with an identification and registration system to be in place.

Note: Whenever movement of live animals (especially) is identified as a risk there should also be an assessment of the risk of associated fomites spread by traders and transporters, and measures to combat this. Cleaning and disinfection would be the key measure here, but consideration of the details of how and where this could be applied is needed.

4. If answer to questions 2 and/or 3 is “no”, will a subsequent step eliminate or reduce risk to an acceptable level?

- If sufficient risk reduction is not achievable at this step then we need to think of applying control measures elsewhere in the chain.

Brief preliminary recommendations for risk reduction measures can be described under the table.

Table 3 shows how this tabular framework could be filled with information using a hypothetical example.

Step 3: Option appraisal and design of strategy

The ultimate purpose of the value chain and risk analyses is to support decision-making on disease prevention and control measures in the context of developing a risk management strategy. Having identified potential and critical risk control points, the next step is to appraise the likely impact of the risk mitigation measures on disease risk (epidemiological assessment) and to estimate the possible impacts of those measures on the value chains as a whole and on the different people and organizations involved in the value chain (value chain analysis).

Risk analysis can provide estimates of the impact of measures on overall disease risk. Value chain analysis can provide information about the potential impact of control measures on the people involved in the value chain, on the performance of the value chain as a whole and, ultimately, on the efficiency of the value chain in supplying products to the consumers. All together, this provides an assessment of the feasibility of control measures.

The decision-making process can be summarized as follows:

- Assess the potential impact of risk reduction interventions on overall risk of disease using risk analysis.
- Assess the potential impact of risk reduction interventions on different stakeholders using value chain analysis.
- Assess the potential impact of risk reduction interventions on the value chain as a whole.

The third of these assessments is made by fully understanding the behaviour of the people involved in different parts of the value chain in order to anticipate their reaction to interventions and in order to comprehend how these reactions together might change the operation of the whole chain.

Designing the risk management strategy will take account of all the following issues:

- potential epidemiological impact of interventions on disease risk;
- potential economic impact of interventions on the value chain;
- technical feasibility of interventions;
- costs of interventions (and how the costs are divided among different stakeholders);
- likelihood of compliance of stakeholders with interventions:
 - consultation with all the people involved in the value chain who would be affected by the interventions, with a commitment to consider the likely positive and negative impacts on each stakeholder;
 - with reference to compliance issues, there may be a need for:
 - incentives to comply (value-added in the value chain);
 - research and extension;
 - education;

- subsidies;
- compensation;
- sanctions;
- legislation and enforcement.

ANALYSIS OF IMPACTS ON DIFFERENT STAKEHOLDERS

The use of value chain analysis as a strategy for assessing the impact of disease control measures takes into account the behaviour and reactions of people involved in the sector, and is thus people-centred as well as risk-based.

An important element in the decision-making is therefore the human behaviour in value chains, particularly the behaviours that could either moderate or exacerbate risk. This includes an understating of:

- people's perception of risks;
- people's motivation for being engaged in the activities;
- the drivers for people's behaviour (economics, knowledge and understanding, peer pressure, morality);
- how to influence behaviour (e.g. incentive, regulation, ban compliance).

A risk control point may be identified from a risk point of view; however, if mitigation measures have negative stakeholder impacts that cannot be resolved, mitigation may be compromised or impossible. For example, informal movement of live animals across borders is a common risk point for introduction of disease, but such informal trade is usually so strongly driven by economic factors that control by banning imports or channelling all imports through tightly controlled border posts is often impossible.

In order to understand and anticipate the behaviour of people involved in the value chain – and therefore to anticipate the ways in which value chains as a whole will change as a result of disease introduction and/or control measures – detailed analyses are needed:

- Economic assessment of the impact of unwanted outcomes (disease outbreaks and disease spread) is an intrinsic part of risk assessment (risk = probability and impact/consequences).
 - This combines epidemiological analysis and value chain analysis in order to quantify the economic impacts of outbreaks on parts of the value chains.
- Economic assessment of the impact of risk mitigation measures; this is particularly linked to economic analysis of value chains.
 - The scale of the impact associated with risk, i.e. the disease, must be used to justify any negative impact of risk reduction, i.e. disease control measures.

As is the case throughout all previous steps of this process, understanding the different people involved in the value chain is important at this step. This analysis identifies and focuses on the different effects perceived by the different value chain stakeholders. The key questions are:

- Which people, groups and/or organizations are affected?
- What are the effects (real and perceived) of the risk on these people, groups and/or organizations?
- How do these people, groups and/or organizations influence risk (how are they involved in the risk pathway/risk factors)?

- What are the effects (real and perceived) of the risk reduction measures on these people, groups and/or organizations?
- Is compliance with risk mitigation likely to be compromised by negative effects?
- How can compliance be promoted using incentives and/or penalties?

These questions would be best addressed through further stakeholder workshops.

Practical analysis of impacts on different stakeholders

A mainly descriptive approach can be taken. The aim should be to draw on all the gathered information from analysis and assessment of risks and description and analysis of value chains.

Table 4 shows a suggested tabular framework in which to organize information for a stakeholder impact analysis. The example is filled in with some brief text regarding a possible risk reduction measure (restriction of live-bird marketing). More detailed text may be included and it may also be necessary to cross-reference to other analyses presented in other tables.

It is important to identify people along the livestock chains who affect and are affected by risk and risk reduction (prevention and control) measures. There are then several important questions to address:

- Is their participation critical to successful disease control? Participation should be proportional to their contribution to disease risks.
- Can we understand their attitude regarding the likelihood of their active participation in control measures?
- What measures are available, necessary and justified to ensure their participation?
 - education (knowledge)
 - incentives (the 'carrot')
 - enforcement (the 'stick')

The table is used to identify groups that are most affected by the risk issues, and further, to highlight those areas where there may be a mismatch between the impact of a particular stakeholder group on the risk level and the impact of disease and/or disease control measures on the same stakeholder group.

For example, of the stakeholders shown in Table 4 it is only the smallholder producers who would suffer high impact of the risk (therefore only this group is likely to perceive the risk as a priority and willing to take actions to reduce risk). At the same time the wholesale traders have a high impact on the level of risk and are therefore an important target group for control measures; however, as the wholesalers are likely to suffer only low impact from the risk there is little incentive for them to act to reduce risk and it may therefore be necessary and justified to enforce sanctions to ensure their compliance.

The market traders are in a different situation. Their usual behaviour only has "low/medium" impact on the risk level, and they stand to suffer only "low/medium" impact from the risk. On the other hand, they stand to suffer "high" impact from the proposed control measure; therefore an argument based on equity would suggest that this group should be compensated in some way for complying with the measure.

TABLE 4
Tabular framework for analysis of impacts on different stakeholders

Proposed risk reduction measure	Impact of the risk reduction measure on risk	Stakeholders involved	Impact of the risk (e.g. HPAI outbreak) on stakeholder	Impact of the stakeholder on risk (+ or -)	Impact of the risk reduction measure on stakeholder (+ or -)
No live birds allowed at district (urban) markets	Reduced risk of human exposure Reduced circulation of live birds through traders leading to reduced risk of outbreaks caused by fomite transmission	District town consumers	Low (perception of human health risk is very low; there may be interruptions in supply but substitutes, e.g. pork, are available)	Low (contribute to risk of disease transmission if they take live birds home and mix with other birds before eating)	Medium/high (consumers have strong preference to buy live birds; current hygiene standards in markets are poor regarding "dead meat")
		Market traders	Low/medium (perception of human health risk is very low; there may be interruptions in supply and traders cannot trade other products)	Low/medium (the market traders are mainly sedentary therefore do not contribute too much to fomite transmission)	High (they are set to trade live birds and would require much adjustment to trade otherwise)
		Wholesalers (suppliers to market traders)	Low (may be positive for some traders who benefit from panic selling because price they pay producers drops)	High (the activity of traders moving from farm to farm contributes greatly to the risk of disease spread; also traders who deal in birds from quarantined areas bring high risk)	Medium (traders could still supply into a differently structured market; with some adjustment)
		Smallholder producers	High (outbreaks trigger severe control reaction from veterinary authorities and product sale price drops)	Medium (farmers may contribute to risk if they sell birds of uncertain health status; farmers could influence trader-associated risk by insisting on biosecurity precautions at their farm boundary)	Medium (producers could still supply into a differently structured market; with some adjustment)
		etc.	etc.	etc.	etc.

CHOICE OF INTERVENTIONS – DECISION-MAKING CRITERIA

In making final choices about interventions it would be very useful if a "balance sheet" could be developed for each potential intervention. The balance sheet would compare costs with benefits as illustrated below:

Costs of risk reduction measures

The costs should be fairly well quantifiable if a good value chain analysis is available.

Calculation should include financial and non-financial costs (see below).

Benefits in terms of risk reduction leading to lower disease incidence

These benefits are difficult to quantify precisely. Semi-quantitative estimates only are likely to be available, e.g. risk reduced from "high" to "medium".

Note that many interventions could have positive benefits in terms of reduced incidence of many diseases, including endemic (rather than exotic) diseases.

There may also be benefits in terms of quality and access to premium markets.

In filling out this balance sheet it is important to consider costs and benefits for each of the different stakeholders. It is frequently the case that those who pay for risk mitigation are not the same as those who stand to gain from it, and this has important implications for implementation and the likelihood of adoption and compliance. The framework shown as Table 4 is a tool that can be used to address this.

Value chain analysis can provide information about the impact of control measures on the different people involved in the value chain (things will be changed in the value chain or in the linkages between people); the risk analysis can provide estimates of the effect of measures on overall disease risk (the incremental level of control likely to be achieved).

While the costs may be quantifiable, the benefits are more difficult to quantify. Therefore, the final choice of a risk mitigation measure will be somewhat subjective. It is usually necessary to proceed with a risk management strategy based on only qualitative – and sometimes incomplete – information. However, if a consultative, participatory approach is used from outset and throughout the risk and value chain analysis (following the principles of risk communication) the final choices will most likely be accepted and adopted by the key stakeholders involved.

Considering human behaviour

To achieve disease control and/or reduction of disease risk, it is important to consider the motivational drivers behind human behaviour when looking for points in a value chain that may be most easily and effectively influenced or controlled.

One of the advantages of value chain analysis is that, if properly done, it lays a foundation for understanding the relationships and the behavioural drivers of the people in the chains.

Among the variety of behaviour patterns that impact on the risk of disease there may be behaviours that positively reduce risk or, on the other hand, behaviours that could increase risk or that are risk-neutral. When designing a risk management strategy the important criteria are as follows.

1. Epidemiological: What is the importance of the behaviour with respect to disease risk?
 - This is basically a technical issue that can be addressed by studying the risk pathway and assessing risk, i.e. the risk assessment. One difficulty here is that it is often

BOX 10

Checklist of factors to consider when trying to assess the likelihood that a risk reduction measure will be complied with by farmers/traders/food handlers

- Does the measure require a significant increase in workload?
- Does the measure require a significant change in management?
- Does the measure require significant investments?
- Are the means available for the implementation of the measure (e.g. vaccines, protective clothing)?
- Are people sufficiently committed?
 - education
 - understanding of risk, consequences and importance of measures
 - visibility of the risk (diagnostics/ testing)
 - severity of the risk (real and perceived)
 - incentives
- Are consumers demanding safe and quality assured products?
- As part of the risk management strategy, is the compliance with the measure properly monitored, and is the assurance given that measures are being effectively implemented?

Adapted from: Schoonman (2007).

difficult to quantify the effects of a particular behaviour (e.g. application of a biosecurity measure) on disease risk. Expert opinion and judgement become essential in estimating disease risks along the risk pathways or in estimating the level of risks associated with behaviour of people along the value chain.

2. Economics: What are the costs and benefits associated with the behaviour?

- There are likely to be benefits from more biosecure behaviour other than that specifically targeted. Also there are costs and benefits other than purely financial (e.g. increased complexity of workload is a cost; increased pride in one's farm and a feeling of security are benefits).

3. Behavioural drivers with regard to willingness and ability to comply: What are the factors that influence choice of behaviour?

- practical feasibility of the behaviour: practical workload issues (there is some evidence in the literature regarding practical issues such as requirements for attention to detail, requirements for skilled application of measures rather than simply box ticking, etc.);
- "proportionality" refers particularly to the way the key stakeholders perceive both the risk and the costs associated with the behaviour (their understanding of the epidemiological and economic aspects, perceptions about the size of the risks being mitigated, perceived costs and benefits);

- socio-economic incentives;
- contractual arrangements;
- governance; private vs public regulation; potential for market enforcement.

Box 10 presents a checklist of factors to consider when trying to assess the likelihood that a disease prevention/control measure will be complied with.

Concluding remarks

All of the information gathering and analysis thus far should allow the analysts to build up a conceptual model of how the value chains operate and respond to challenges and change brought about by disease and disease control interventions.

In practice we could be faced with two main scenarios:

- A disease-free chain. Here the key questions are:
 - How vulnerable is the chain to incursion of disease (risk assessment)?
 - What routine adjustments could make the chain less vulnerable (prevention)?
 - How would the chain as a whole react if disease is introduced (response)?
 - What measures should contingency plans contain to alleviate damage if disease is introduced (risk mitigation)?
- A chain that already operates with disease present. Here the key questions are:
 - How is disease affecting chain efficiency (risk consequences)?
 - What could be done to improve the efficiency of the chain (this may or may not involve eradicating disease from the chain)?

These questions should be answered using the conceptual model of how the value chains operate. In general terms, a model is defined as an understanding of the ways in which component parts of a system interact together to bring about a final outcome. In this case, the component parts are the people involved in the value chain and their actions, and the final outcomes of interest are the impacts of disease and disease control measures in terms of: food and other livestock product supply, livestock disease spread, productivity, profitability, food security and food safety.

The critical aspect is to approach the chain as a mechanism that supplies food to consumers, employs people in production and processing and involves people in organizing and running businesses. All these people will see diseases, their threats and/or presence, as a part of their everyday lives – and not necessarily their primary focus. Understanding how these people perceive and manage disease provides a basis for risk management that can be proportional to the disease impact.

The approaches described in this guide emphasize the importance of understanding human behaviour in value chains focusing on behaviours that can either moderate or exacerbate risk. They take into account people's perception of risks, drivers of behaviour (economics, knowledge and understanding, peer pressure, morality), in an effort to ascertain how to influence behaviour (incentive, regulation, ban).

Final recommendations for a risk mitigation strategy should take account of what measures are to be implemented and by whom, where, when and how. In particular, supporting measures that may be required to encourage stakeholder compliance should be included (incentives, compensation, penalties, sanctions, etc.).

ANNEXES

Annex 1

Risk pathway analysis and risk control

RISK PATHWAY ANALYSIS

Risk pathway analysis is the main tool used in risk assessments.

The risk pathway describes all the stages in the biological process that lead to the unwanted outcome. A risk pathway is a series of conditions that must be met, or events that have to occur, in order for the unwanted outcome to occur.

It is easiest to begin by sketching a risk pathway on paper, as a diagram showing all the steps on the pathway. Figure 10 illustrates the pathway corresponding to a simple import risk assessment.

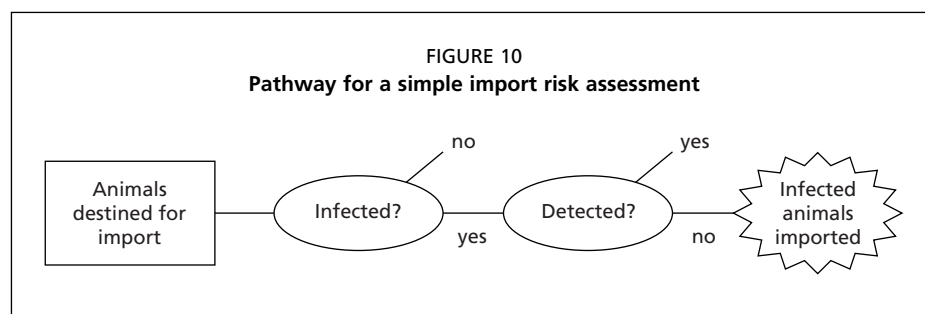
The diagram shows that the first step to consider is whether or not animals destined for import are infected. Secondly, if animals are infected, they may or may not be detected by a pre-export test (if not detected then the unwanted outcome has occurred).

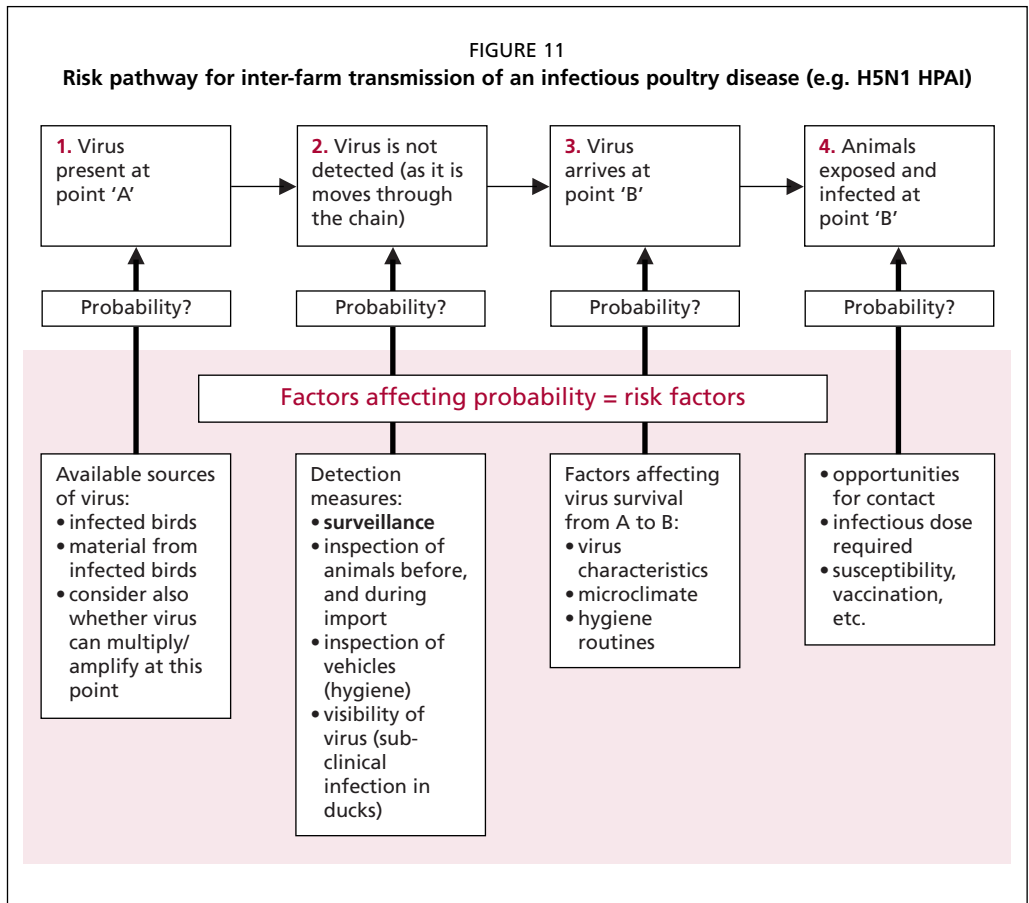
Constructing the risk pathways can be a valuable participatory and discursive process in risk communication.

Developing and using risk pathways in risk assessment

Risk pathways explicitly show the chain of events that must occur for the final unwanted outcome to happen. Each event in a risk pathway has a non-zero and uncertain probability of happening. Risk assessment involves assessing the probability or likelihood of passing each step, and then to combine these into an overall likelihood.

Figure 11 shows a simplified generic risk pathway concerned with inter-farm transmission of an infectious poultry disease (e.g. H5N1 HPAI). This figure illustrates the basic risk assessment principle of breaking down the process of disease transmission into a series of steps. For disease to transmit, every step must be passed. Note that there may be many more steps in the sequence of events between point A and point B. There are also likely to be several different process pathways that can carry virus from point A to point B





associated with different carriers (see Box 11). These different processes will be identified from the value chains. As you consider the value chain processes in detail you may find that you need to break down the risk pathway into a number of smaller sections. You can approach this systematically by creating a series of pathway diagrams that show how processes in the value chain (e.g. transport of live animals) are related to each other and can carry disease risk in different ways (e.g. infected live animals and fomites – vehicles and people).

When constructing risk pathways we need to consider all the ways in which virus could spread and then identify the opportunities for virus spread within the processes described by the value chains. The most common ways that HPAI virus can be spread are briefly summarized in Box 11.

Data and information required for estimation of probability along risk pathways

In order to make any estimation of probability it is necessary to understand and assess the factors that influence the probability of an event happening – the risk factors. Steps along the pathway will normally have many risk factors associated with them and the final estimate of risk (as defined by the risk question) will be formed by considering how all these

BOX 11

H5N1 HPAI virus spread mechanisms

1. Infected birds:
 - themselves carried over distances;
 - mixing with other poultry at markets spreading infection.
2. Meat and other products from infected poultry.
3. People in contact with poultry or their products:
 - input suppliers visiting multiple farms and villages;
 - traders visiting multiple farms, villages and markets;
 - market personnel;
 - veterinarians and animal health workers visiting farms.
4. Vehicles in contact with poultry:
 - visiting multiple farms, villages and markets.
5. Contaminated equipment:
 - cages;
 - egg trays.
6. By-products (these can be traded and handled through the value chains):
 - poultry manure;
 - feathers;
 - guts and other slaughter waste;
 - hatchery waste (spoiled and reject eggs);
 - eggshells.

factors combine and act together. Some factors affecting the likelihood of disease transmission are listed in Box 12. It is usual for each of the crucial steps along a risk pathway to be dependent on a number of different factors (that may be linked). Descriptive information and/or quantitative data are needed on all of these factors. Consider a common example variable – the probability that an animal destined for movement or import is infected with a specific pathogen. This probability will be calculated in terms of prevalence of disease, which in turn depends on incidence and duration of infection; incidence may vary with region, breed or age. The probability of an infected animal being selected for import will also depend on whether or not the selection process is random (maybe only breeding females of a particular age are imported). Therefore information must be collected on all of these factors and combined in the relevant way.

Seasonality and spatial variation of risk

Remember that when considering the factors affecting risk it is important to consider temporal and spatial variation in any factors that may produce seasonal and spatial patterns in risk. There may be seasonal climatic factors that affect the likelihood of virus surviving along pathways, and also the value chains themselves may be subject to seasonal variation, especially in volumes of flow (special festival markets, higher demand for specific types of

BOX 12

Some factors affecting likelihood of disease transmission (e.g. H5N1 HPAI)

1. Likelihood that virus is present at point A.
 - It is important to consider anything that can spread disease. Typically for any contagious disease we need to consider live animals, dead animals, animal products and fomites, and most importantly, people, vehicles and other equipment/materials with which livestock may have contact. Because of its obvious exposure to animals, the potential that feedstuff could be contaminated with virus should always be considered.
 - It is also important to consider viral load – whether the item or process is likely to be associated with a huge amount of virus or carrying only traces.
2. Likelihood that virus is detected and reported as it moves through the chain:
 - surveillance, clinical disease, other methods;
 - awareness, visibility, skill, motivation, incentive, time.
3. Likelihood that virus survives to arrive at point B:
 - innate survival characteristics of the virus;
 - routine (not specially enforced for HPAI) measures, treatments, etc., that limit virus viability – routine washing, disinfection, heating cooking, drying; when considering these factors it is important to get some idea of compliance and variability in application;
 - journey time, environment, weather (sun, heavy rain, etc.).
4. Likelihood that animals at point B are exposed and infected:
 - opportunities for contact – are new livestock separated from farm stock (quarantine) – are farm visitors kept away from livestock?;
 - infectious dose required – if stock are exposed, what is the chance they get an infectious dose of virus?;
 - susceptibility – how susceptible to infection are the livestock, for example, are they vaccinated or otherwise immune?

product, etc.). There may also be regional specialization in production and/or marketing of particular products.

Volume of traffic – net likelihood

The net likelihood of virus release and exposure of poultry and humans at different places in the chains depends on a combination of factors: a sort of “unit likelihood”, and a volume-of-traffic multiplier (the value chains should provide an assessment of this). For example, although the likelihood of exposure of poultry to virus through delivery of feed may be quite low per delivery, the likelihood will increase as the frequency of deliveries increases (more chances per unit time to get exposed). Commercial units may have in place more risk mitigating biosecurity measures applying to farm visitors than to backyard flocks, but they may have higher frequency of human traffic; therefore the net likelihood that commercial

poultry are exposed to virus can be high (and the consequences of exposure and infection in these units can also be high).

Volume of traffic affecting the level of exposure to risk and the potential onward impact of infection may well be seasonally affected, leading to seasonal high risk times.

Qualitative likelihood (probability) estimation

Arriving at a qualitative probability estimation involves two steps:

- Put the information (derived from data collected) together with the risk pathway:
 - it is useful to use a tabular framework;
 - this makes the process systematic, evidence-based and encourages transparency (to allow peer review and informed discussion of the results).
- Draw logical conclusions:
 - compare requirements for each step with actual situation – is it likely or unlikely?;
 - is overall probability very low, low, medium or high?

It can be useful to arrange the steps of a risk pathway within the column of a table to which further columns can be added describing the important influencing factors at each step and gathered information about those factors leading to the probability estimations at each step. Table 5 shows an example in which the risk being assessed is the risk of importing pigs infected with classical swine fever (CSF) virus.

There are many tools that can be used in qualitative approaches, including:

- identification and characterization of risk factors within value chains, particularly taking into account what is known about relative risks, exposure levels, volume of traffic

TABLE 5
Tabulation of a risk pathway analysis for the risk of importing pigs infected with classical swine fever (CSF) virus

Risk pathway step	Factors influencing probability (risk factors)	Relevant information	Probability level (qualitative estimation)
CSF infection exists at source of live pigs	Depends on the location of source	Pigs are sourced from a country that is <i>not</i> free from CSF	High
Pigs selected for shipment are infected	Depends on disease prevalence at source and on conditions of selection	Outbreaks have been recorded in the source area within the last year There are no health conditions imposed on farms sending pigs for export	High
Infected pigs are <i>not</i> detected by health inspection	Depends on application of regulations by veterinary authorities and on ease of detection	Pigs are subjected to rapid visual inspection at loading CSF infection can be subclinical	High
Infected pigs are <i>not</i> detected at control post at province border	Depends on operation and facilities at border and also on route taken	Shipments of pigs are only visually inspected and only when the border post is manned (border remains open 24 hours, but no veterinary staff present at night) Pigs may enter the country by routes where no border posts exist.	High

and potential impacts;

- scoring methods may be applied – in combination with risk characterization, drawing on expert opinion;
- risk ranking – based on scores or simply putting risks in rank order based on reasonable criteria;
- expert opinion – drawing on experience with other diseases, or same disease in other countries.

Most likely a semi-quantitative, categorical, ranking type of approach will be used. Qualitative analysis results in judgemental categorization of likelihood of an unwanted outcome occurring (e.g. very low, low, medium and high). An example of this as used by Defra in the United Kingdom (Defra, 2002) provides the following guidance as to the meaning of the different levels of likelihood:

Likelihood		Descriptor
VL	very low	<i>Rare</i> (risky event may occur in exceptional circumstances)
L	low	<i>Possible</i> (the risky event may occur in the next three years)
M	medium	<i>Likely</i> (the risky event is likely to occur more than once in the next three years)
H	high	<i>Almost certain</i> (the risky event is likely to occur this year or at frequent intervals)

Impact/consequence assessment

Risk assessment involves estimating both the likelihood that an unwanted outcome will occur and the magnitude of the impact of this occurrence.

To arrive at a final estimation of risk, some account must be taken of the impact of the unwanted outcome. The overall level of risk is defined as a product of the likelihood of an unwanted outcome occurring and the impact resulting should it occur (the consequence).

$$\text{RISK} = \text{likelihood} \times \text{impact}$$

The impact or consequences of the risky event can be ranked on a scale similar to that used for likelihood, from very low to high. This assessment would be based on various socio-economic and epidemiological criteria, specific to the hazard and risk in question.

For example, the scale of the consequence of virus transmission at any point in a live-stock value chain will be broadly related to consideration of the following:

- potential for amplification of infection (size of any resulting outbreak);
- potential for spatial spread (especially spread to new geographic areas);
- potential for spread across species (e.g. spread of HPAI from ducks to chickens or from poultry to humans);
- potential economic losses (as a result of the outbreak itself and of the control measures);
- potential humanitarian losses (loss of livelihoods, loss of human lives, etc.).

These are issues that can be addressed by value chain analysis. The potential impact of infection at any particular point depends heavily on how the people affected at that point react. Biocontainment of a disease outbreak is mainly a public good and there may be little

private incentive to contain a disease outbreak once it has occurred on a farm. Strong leadership and rapid reaction from state veterinary services are required to minimize impacts of disease outbreaks. Ideally the responses of the veterinary service can be targeted and prioritized at the points in the value chains where the potential impact of infection is greatest. Understanding the economic aspects of value chains, particularly the private incentives for biosecurity and disease reporting, is an important part of this prioritization process.

This allows a qualitative risk category to be assigned based on the combination of its likelihood and its impact. An example of a qualitative risk estimation scheme used by Defra in the United Kingdom is shown in Figure 12 (Defra, 2002). The H-star (H*) risks, with both a high likelihood of occurrence and a high impact, demand immediate attention.

The overall risk assessment

In summary:

- The risk pathway is a series of conditions that must be met, or events that have to occur, in order for the unwanted outcome to occur.
- At each step of the risk pathway a question is posed about the probability of the condition being met, or the event occurring.
- Factors that influence probability are considered, and an estimation is made of the likelihood (probability) using data/information about those factors.
- Estimations of probability for each step of the pathway are made (based on available information) and an estimation of the overall probability across the whole pathway.

FIGURE 12
Qualitative risk assessment scheme used by Defra in the United Kingdom

	H	M	M	H	H*
↑	M	L	M	M	H
Likelihood	L	VL	L	M	M
	VL	VL	VL	L	M
		VL	L	M	H
				Impact → →	

Source: Defra (2002)

- An overall assessment of risk is made based on:
 - the probabilities along the pathway;
 - the degree of exposure (e.g. volume of commodity flow per year, number of times pathway active);
 - the impact of the unwanted event.

Risk pathway analysis forces close study of the factors that determine the probability (risk factors) of an unwanted outcome. It can be argued that understanding how and to what extent risk factors affect the overall probability of the unwanted outcome through a pathway is the most important knowledge required in order to design a risk management strategy.

The methodology described in this document focuses on a semi-quantitative or qualitative approach. Nevertheless, the computational discipline in the quantitative approach provides results that are useful to bear in mind when carrying out non-quantitative assessments:

- **The overall probability get smaller the more steps there are in a pathway:**
 - Along a pathway or a chain of events we multiply probabilities – this makes the overall probability lower the more stepwise probabilities there are to multiply (because probability is always between 0 and 1).
 - Therefore, the probability of infection by way of any one pathway will tend to be lower the higher the number of steps in the pathway. From a risk management/control point of view, each step represents a chance for the chain to be broken.
- **The more times you take a risk – the more likely it becomes that an unwanted outcome will happen:**
 - If you roll a die only twice it is quite likely that you will not get a six – if you roll it 100 times it is quite unlikely that you will not get a six.
 - Quantitative risk assessment estimates a probability of the unwanted outcome per traverse of the risk pathway. In other words, each traverse of the pathway represents a separate throw of the die. The more times the die is thrown the probability of scoring a six at least once increases. It follows that an important factor determining the probability of, for example, importing an infected animal over time (e.g. annually) is the number of times the die is thrown, i.e. the frequency and number of animals imported.
- **The more ways there are for something to happen, the more likely it is that it will happen:**
 - With any one roll of two dice you are more likely to score a seven than a two (because a seven results from any combination of 1+6, 2+5, 3+4, only 1+1 gives two).
 - Likewise, the more different pathways there are by which infection of a flock can be caused, the higher the overall probability that the flock gets infected.

RISK CONTROL – USING RISK PATHWAYS TO IDENTIFY RISK CONTROL POINTS

Risk pathway analysis provides a framework to understand how risk factors influence the likelihood of an unwanted outcome. This in turn leads to identification of potential risk control points, where action can be taken to control and minimize risks.

There could be many, many places in the value chains where measures could be considered that could reduce or control risk. But the trick in strategic planning of efficient and sustainable measures is to identify those measures that have the most chance of having the biggest impact at the least cost.

The aim is to identify the critical links in the value chains that must be made safe or closed off in order to reduce disease risk to an acceptable level, while still allowing the value chain to operate. Risk reduction in a chain may be achieved by a combination of several measures (none of them necessarily 100 percent effective) at a number of points in a chain.

The risk pathway approach to risk control is illustrated here using an example that addresses the risk of classical swine fever (CSF) entering an area from outside.

Risk pathways – an example (CSF)

How might CSF virus enter a province?

First, list the possible routes by which CSF may enter (carriers of virus), for example:

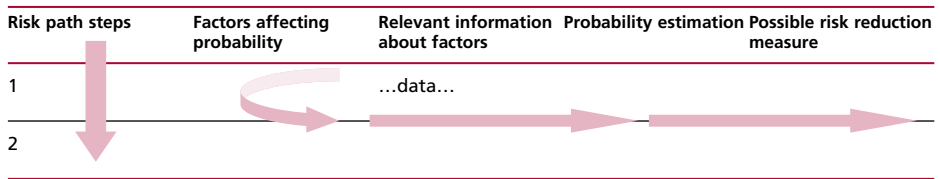
- infected live pigs for slaughter;
- infected live pigs for fattening;
- infected live sows for breeding;
- fresh meat from infected pigs;
- virus carried on faeces-contaminated vehicles.

Second, construct risk pathways and make a qualitative estimation of likelihood for each possible route. An example is shown in Table 5 (CSF entry via infected live pigs for slaughter). Similar pathway analyses for the other routes are needed.

The important question is: How can risk be controlled or minimized? This is answered by identifying risk control points where it is feasible to take action to reduce risk. Each step on a risk pathway is also a potential opportunity to reduce risk.

In qualitative risk assessment/management all relevant information can be presented in a tabular format so that the evidence base for risk management decisions is transparent.

Step (control point)	Action to reduce risk
CSF infection exists at source of live pigs	Gather information about CSF prevalence and source pigs from CSF low risk areas
Pigs selected for shipment are infected	Source pigs from assured farms that are free of disease outbreaks
Infected pigs are not detected by health inspection	No measures available – depends on other province veterinary services
Infected pigs are not detected at control post at province border	Improve border post inspection – 24-hour manning, better facilities, ensure all pigs move through post



A further stage of the analysis is to consider the risk of possible spread of infection in local pigs (which is an important consideration for the assessment of possible consequences/impact of disease introduction from outside).

The risk pathways need to be extended leading to a possible local outbreak.

The starting points here are that CSF virus has entered. What, then, are the pathways that lead to an outbreak in pigs? There will be several pathways depending the starting point.

EITHER CSF virus has entered the province by way of infected live pigs for slaughter

1. Infected pigs are slaughtered
2. Infected meat is purchased by a pig keeping household
3. Infected meat scraps are fed to household pigs
4. CSF outbreak occurs in the province

1. Infected pigs are not slaughtered
2. Infected pigs are taken by trader for fattening
3. Trader mixes pigs with others at home
4. Trader sells pigs that have been in contact with infected pigs
5. CSF outbreaks occur in the province

OR CSF virus has entered the province by way of infected live pigs for breeding

1. Breeder mixes pigs with others at home
2. Breeder sells pigs that have been in contact
3. CSF outbreaks occur in the province

As before, the level of probability at each step of the pathways must be assessed, for example, what is the probability that pigs brought in for slaughter are not slaughtered?

The critical control points and the measures that can be used to reduce risk are identified; for example, can the practice of pigs being brought in for slaughter and instead being kept on for fattening be prevented?

Measures to reduce the risk of outbreaks come under the general heading of biosecurity¹³ and include:

- health checking of new stock before purchase;
- quarantining of new stock on farms before mixing with others;

¹³ The reader is directed to the FAO Animal Production and Health Paper 165 *Biosecurity for Highly Pathogenic Avian Influenza - Issues and options*, FAO, Rome, 2008.).

- prevention of sale of stock from farms soon after purchase of new animals;
- prevention of feeding kitchen scraps to livestock;
- use of cleaning and disinfection by visitors to farms;
- prevention of contact between visitors and livestock;
- “all-in, all-out” stocking systems.

In addition to measures that actively reduce risk, disease surveillance is very important. Surveillance is a line of defence against disease spread. If infection does occur a sensitive surveillance system should detect it early, before there has been opportunity to spread far.

Having sensitive disease surveillance systems in place and a rapid controlling response to infection can reduce the impact of disease outbreaks. Lower impact of an animal disease means that the assessed risk is less. Therefore surveillance linked with a rapid controlling response is a general risk reduction measure. Where no reliable risk control measures can be identified along a risk pathway (e.g. measures to control risk of infection of domestic poultry through contact with wild migrating birds) targeted disease surveillance is a risk management response option.

Annex 2

Developing and analysing enterprise budgets¹⁴

An enterprise budget is an economic representation of an activity in all its aspects: production, processing or marketing of a product. It is a relatively simple tool and is therefore ideal when working with communities (see Galpin *et al.*, 2000 for a careful description of how it can be used as a participatory method). If it is well used an enterprise budget can also be a very useful tool for identifying opportunities and constraints of value chain activities and for understanding part of the motivation behind people's attitudes towards disease prevention and control.

OBJECTIVES

The objectives of an enterprise budget are as follows:

- Describe a value chain activity through the simple representation of its inputs and outputs.
- Identify the important inputs and examine efficiency questions of the key outputs and inputs.
- Compare the economic profitability and efficiency of different people in the value chains on the basis of collected data from different people in the value chain.
- Assess if changes from one form of value chain activity to another are profitable.

In the context of analysing disease risk in livestock value chains, an objective may be to assess the economic impact of disease and/or risk mitigation measures on the chain as a whole and on individual people in the chain.

DEVELOPING AN ENTERPRISE BUDGET ANALYSIS

Within the community an enterprise budget can be developed using a modified seasonal calendar. Interviews could be held with a key informant or with a target group to focus on a value chain activity. The participants would be asked to identify particular outputs, labour and other inputs, specifying their quantities and values and when they occur. The layout for such a calendar is shown in Table 6.

Data from the communities, supplemented with secondary data on prices, can be used by the analysts who would perform an enterprise budget analysis outside the community. The purpose of this is to carry out a more detailed estimation of costs and their importance, the impact of changes, (e.g. changes in the availability of inputs, changes in demand for products, and other changes in the operation of the value chain brought about by disease and/or risk mitigation measures).

¹⁴ This annex is adapted from Practical tools for researching successful non-timber forest products commercialization - a methods manual by Elaine Marshall *et al.* (2006).

TABLE 6
Seasonal calendar format to develop a participatory enterprise budget

Output / Inputs	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Outputs												
Labour inputs												
Other inputs												
Estimation of profitability	Value of outputs minus the value of inputs											

TABLE 7
Estimation of the annual output for a small-scale hen egg laying enterprise

Output	Unit	Quantity	Price Bs*	Value Bs
				Total
Spent hens	Bird	185	10.47	1 937
Eggs	Unit	45 371	0.07	3 176
Less cost of pullets	Bird	200	-8.5	-1 700
Total sales				3 413

* Bs = Boliviano, the official Bolivian currency. In November 2005 the exchange rate was US\$1 = Bs 0.8.

Steps in developing the enterprise budget analysis

This will be illustrated with an example of an enterprise budget developed for a small-scale hen egg laying enterprise in a community in Bolivia. Cash values are presented in US dollar equivalents.

Step 1: Outputs

The first step in the construction of an enterprise budget is to identify all the products from the activity, the quantities produced and value per unit of each product. It is recommended that replacement livestock (pullets) are taken into account at this stage, but there is flexibility on this point. Some analysts prefer to include these basic inputs in the variable costs that are described below.

It is recognized that some outputs may be used within the same household (such as the consumption of eggs, use of manure on crops, etc.) or may be given as gifts to meet social obligations within the community. An enterprise budget recognizes these outputs and where possible, places a value on them by taking the local market value or by asking the communities what value they would place on these outputs. Even if they are not valued they should be included in the list of outputs.

Table 7 presents the annual total or gross sales for a small-scale hen egg laying enterprise.

This simple calculation provides information on the scale of the enterprise and can also be combined with key inputs and costs to examine efficiency issues. The latter is discussed in more detail below.

Step 2: Variable costs

The next step is to identify the costs that directly relate to the value chain activity and that vary with the amount of product produced. These costs are called variable costs. The most important variable costs often are labour, but because it is difficult to assign values to family labour inputs these will be discussed separately in the next section.

In the small-scale hen laying unit a number of variable costs were identified and these are presented with the quantities used, their unit price and their total value in Table 8.

This simple calculation can be used to determine the relative importance of individual variable costs and the variable costs in general.

Step 3: Labour costs

This involves identifying and estimating the cost of labour used by the activity. It is important to remember that labour may vary in terms of whether it is supplied by men, women or children; the skill levels of the labour used; and if the labour input is seasonal. Therefore, all of these issues need to be taken into account in order to put a value on labour, as labour rates will vary with gender, age, skill and the season in which they are supplied. The seasonality of labour inputs is particularly important in agricultural activities that generally have seasonal peaks in labour demand.

The Bolivian egg laying activity employed women and men, and there was no seasonality in the activity. The estimation of the costs of labour for this enterprise is presented in Table 9.

Activities where there are labour inputs from men and women with different skills at different points in the year will be more complex than the example provided in Table 9. The estimation of returns to labour inputs is examined in more detail in section 2.1.

TABLE 8
Estimation of the variable costs for a small-scale hen egg laying enterprise

<i>Variable costs</i>	Unit	Quantity	Price Bs	Value Bs
				Total
Early feed	Kilo	2 000	0.18	360
Later feed	Kilo	6 500	0.16	1 040
Vaccines	Unit	200	0.08	16
Other medication	Unit	200	0.1	20
Veterinary services	Unit	1	300	300
Water	Unit	1	125	125
Total variable costs				1 861

TABLE 9
Estimation of the labour costs for a small-scale hen egg laying enterprise

<i>Labour costs</i>	Unit	Quantity	Price Bs	Value Bs
				Total
Women	Days	31	20	617
Men	Days	27	20	533
Total labour costs				1 150

Step 4: Fixed costs

Some costs involve the purchase of equipment that lasts for more than one year, and is used for different activities within the family economy or livelihood strategy. For example, a machete will probably last for two or three years and be used in the harvesting of fruits, the chopping of firewood and the harvesting of grain crops. It would therefore be incorrect to assign the whole cost of this machete to a single value chain activity as the machete will be used for more than one year and also in other activities.

These types of costs are called fixed costs and usually include:

- regular paid labour or permanent staff, as well as an estimate of the value of any unpaid (usually family) labour;
 - where family labour inputs vary according to gender and age this should be reflected in the analysis by separating labour inputs into men, women and children;
- depreciation of equipment, machinery, vehicles, some buildings, etc. (see below for a further explanation of this concept and how to calculate depreciation);
- maintenance and repairs;
- fuel and oil costs where these cannot be assigned to a particular enterprise;
- rent (both paid rent and estimated or notional rent on land owned by the person in the chain);
- gas, water and electricity costs where these cannot be assigned to a particular enterprise;
- paid management costs;
- paid interest (see below for a complete explanation).

While discussing payments for labour, it is worth mentioning payments in kind. Where casual or permanent paid staff is paid partly with produce the value of such payments should be included as a fixed cost.

What to do about depreciation?

Depreciation is not a cash value cost, but an estimate of the amount by which the value of a capital item falls in a given period. Therefore, it represents a cost of ownership of that item. The inclusion of such a cost in an enterprise budget ensures that in the future when this object needs to be replaced there will be sufficient money available to do so. Where depreciation is not taken into account and the contribution of capital items is important there can often be a false sense of making large profits in the early years of a business. If this money is not reinvested during this period, problems could well arise when capital items need to

be replaced. One of the common problems of many businesses is that replacement costs for capital items are not taken into account.

Depreciation may occur for three reasons:

1. Obsolescence
2. Gradual deterioration with age
3. Wear and tear with use

The first two factors limit the economic life of a machine or capital item; the third limits the life of the item in terms of hours or days of use.

There are several common methods of calculating depreciation; the simplest way is the straight-line method. For capital items such as basic tools (machetes, spades, etc.) or buildings, the straight-line method is preferred and more compatible with many of the basic technologies used in livestock value chains and household or village level processing.

In the example of the egg laying enterprise a hen house was identified as an important fixed cost. The cost of constructing the house was Bs 500, which would be a very large cost for a small enterprise to bear in one year. However, the house was estimated to have a useful life of 20 years, but with no salvage value at the end of this period. Using the straight-line depreciation method an annual cost of Bs 25 was estimated for the house (see Table 10).

What to do about interest?

In an enterprise budget it is a common convention to estimate interest as the interest charged on half the initial cost of any capital item¹⁵. For example, the family involved in the egg laying enterprise is estimated to have invested Bs 573 in equipment: Bs 500 on the house, Bs 30 on egg baskets, Bs 30 on wire netting and Bs 13 on a bucket. The interest rate in the region was 20 percent. The interest included in the enterprise budget for this activity is Bs 57 per year (see Table 10).

Table 10 presents an estimation of the fixed costs for the egg laying enterprise in a Bolivian community.

As is the case with variable costs, this calculation identifies important individual fixed costs and shows whether fixed costs in general are important in the cost structure of the activity. Where fixed costs are relatively high in relation to other costs there is a need to increase the overall volume of product produced, processed or marketed so as to reduce the cost per unit of product.

Analysis

The analysis of an enterprise budget estimates the output (gross sales) and splits costs as follows:

1. Variable costs – the purchase of replacement stock has been included in the output section.
2. Labour costs – divided into men, women and children, skills and seasonality.
3. Fixed costs – where equipment is used and has a usable life, straight-line depreciation is generally used to calculate the costs, and interest costs are calculated based on half the value of the equipment multiplied by the lending interest rate.

¹⁵ Note that this basic method assumes simple rather than compound interest.

TABLE 10
Estimation of the fixed costs for a hen egg laying enterprise

<i>Fixed costs</i>	Unit	Quantity		Price Bs		Value Bs
						Total
Equipment depreciation	Unit	Number	Price	Life (years)		
House	Unit	1	500	20	25.00	25
Egg baskets	Unit	30	1	1	1.00	30
Wire netting	Metre	30	1	1	1.00	30
Bucket	Unit	1	13	3	4.33	4
Transport	Unit	6			50.00	300
Transaction costs (other)	Unit	1			20.00	20
			Rate		Amount	
Interest	Unit	1	20.00%		57.32	57
Total fixed costs						466

Further analysis is required to determine various measures for economic profitability and for improving productivity. In addition, by combining information on total costs it is possible to identify costs of key inputs to the value chain activity and focus on how these costs can be controlled or reduced. Sensitivity analysis can be carried out on these costs to assess how much prices of these inputs can increase before making the activity unprofitable. A brief description of these key analysis methods is provided in the following sections.

Gross margin analysis

A gross margin is defined as the enterprise output minus its variable costs:

$$\text{ENTERPRISE GROSS MARGIN} = \text{OUTPUT} - \text{VARIABLE COSTS}$$

In the value chain analysis this can be varied a little to have a gross margin as explained above and a gross margin less labour costs, as follows:

$$\text{ENTERPRISE GROSS MARGIN (less labour)} = \text{OUTPUT} - \text{VARIABLE COSTS} - \text{LABOUR COSTS}$$

Enterprise profit

An enterprise budget is the difference between the total value of the outputs and the total costs (variable, labour and fixed). The answer is the profit from the value chain activity:

$$\text{ENTERPRISE BUDGET (PROFIT)} = \text{OUTPUT} - \text{VARIABLE COSTS} - \text{FIXED COSTS}$$

In our example of the hen egg laying activity the gross margin and enterprise profit are presented in Table 11.

The hen egg laying enterprise has a positive gross margin even when taking into account labour costs, but incurs a small loss when taking into account the fixed costs. Note that the outputs and costs are all detailed in Table 7 to 10.

TABLE 11
Estimation of the gross margin and enterprise profit for hen egg laying enterprise

	Total (Bs)
Total output	3 413
Total variable costs	1 861
Gross margin (GM)	1 552
Total labour costs	1 150
GM less labour costs	402
Total fixed costs	466
Total costs	5 177
Enterprise budget (profit)	- 64

Identifying the important inputs

The enterprise budget details all the inputs and their costs. Each input has its own importance in terms of ensuring that the value chain activity produces an output that can either be used, consumed or sold, but not all inputs are of equal importance in terms of their impact on the economic profitability of the activity. To identify which inputs are of greatest importance with regard to economic profitability it is recommended that the percentage of total costs for each input is calculated:

$$\text{Percentage of Total Costs for Input 1} = (\text{Cost of Input 1} / \text{Total Costs}) \times 100$$

Applying this analysis to the hen egg laying enterprise, the most important costs are the pullets, feed and labour, with fixed costs being of low importance (see Table 12).

This activity has a cost structure where the costs that vary with the scale of the activity are the most important in terms of total costs. It is possible to infer from this that the capital required to establish a hen laying activity is largely the purchase of pullets, which may require an agreement with the suppliers and/or credit providers.

Productivity and efficiency measures

Gross margins and the enterprise budget are absolute measures, which indicate if a value chain activity will make money. However, they give no indication of how well the value chain producers, processors or marketers use resources or their cost per unit produced. To estimate how well resources are used we need to identify what is the most important input and use this as a denominator to measure the productivity of an enterprise.

$$\text{Enterprise Productivity Measure} = \frac{\text{(Enterprise Profit plus the Key Input Cost)}}{\text{Number of Units of the Key Input}}$$

With regard to the measure of efficiency it is necessary to calculate the cost per unit of output for the activity in the following way:

TABLE 12
Cost structure of the hen laying enterprise

Cost Item	Cost	
	Value (Bs)	%
Pullets	1 700	32.8
Feed	1 400	27.0
Other variable costs	461	8.9
Total variable costs	1 861	35.9
Total labour costs	1 150	22.2
Total fixed costs	466	9.0
Total costs	5 177	100.0

$$\text{Enterprise Efficiency Measure (cost per unit output)} = \frac{\text{Total Costs}}{\text{Number of Units Output Produced}}$$

Alternatively we can estimate the efficiency in terms of the profit generated per unit of key output produced:

$$\text{Enterprise Efficiency Measure (profit per unit output)} = \frac{\text{Enterprise Profit}}{\text{Number of Units Output Produced}}$$

Difficulties arise where the analysis attempts to compare the efficiency of different activities along the value chain, but the key output for each activity changes as the product is processed. In the egg laying example, the analysis used the egg as the key output measure. It is necessary in this calculation to estimate the cost per egg produced, collected and traded. The efficiency measures for the different people in this egg chain are shown in Table 13.

It is interesting to note that in this example the costs per unit of the key output decrease along the chain. The cost structure for the different value chain activities also vary where the production and collecting activities are dominated by variable costs, whereas the trading activities involve significant costs in the purchase and storage of eggs.

Sensitivity analysis

The above analyses are static, which means that the quantities and prices for inputs and outputs do not vary. In real situations this is not the case and it is important to assess what would happen if there were changes in prices for outputs and inputs. However, it is not necessary to test changes in the prices of all inputs. The analysis that identified the key inputs provides information on which input prices need to be tested to see how far they can vary before an activity has a negative profit. Where small variations put the enterprise in difficulties, the value chain activity can be said to be sensitive to variations in price of this input.

TABLE 13
Estimation of the cost and profit per egg for the different people in an egg chain

Person	Per 1 000 eggs	
	Cost (Bs)	Profit (Bs)
Producer	114.10	-1.41
Collector	25.60	15.24
Trader	14.20	25.41

NOTES OF CAUTION

There are a number of issues that need to be considered when using enterprise budget analysis:

1. The presentation of gross margin and enterprise profit should be accompanied with an explanation of how these figures have been calculated.
2. Similarly, when comparing gross margins and enterprise profits between producers and communities it is important to have at hand the calculations for all the inputs and outputs.
3. Ideally, the enterprise budgets produced should come from a group of value chain producers, processors or marketers in order to have an average budget. However, this may not always be possible, particularly where there are very few value chain traders. Here caution is needed when trying to extrapolate an enterprise budget from very little observation for a large area.

Annex 3

Outline for information gathering on poultry value chain

This is an example of information gathering at province level in Viet Nam.

OBJECTIVE

The objective is to generate comprehensive information on all parts of the chicken, duck and other poultry value chains in the province, i.e. input suppliers, big farms, main chicken, duck and other poultry villages and communes, markets, etc. It is important to include the overall organization of egg production and marketing; for example, how households in villages balance between eating/selling eggs and incubating eggs (duck embryonated eggs are also produced for eating). To establish an overview of poultry production in the province the following information is necessary:

- relative abundance and importance of different species and types in the province: chickens (layers, broilers, breeders), ducks (layers, meat, breeders), and other species;
- large-scale high-investment commercial poultry sites;
- low-investment commercial producers (buy feed and replacement birds; sell produce; distribution; concentrations in particular communes or villages);
- supporting infrastructure for inputs (supplies of feed, birds or fertile egg, day-old chicks, pullets, etc.; veterinary inputs);
- household, non-commercial poultry and micro-commercial (distribution; concentrations in particular communes or villages);
- marketing (local and provincial markets; dealers; product destination).

In addition, it is important to investigate the following:

- trends in poultry production (expanding or contracting sectors);
- seasonality of demand and production;
- effects of HPAI situation;
- by-products and waste management (feathers, manure, dead birds, etc.);
- how the big producers and traders market their produce.

Registration and regulation:

- Are there registers of poultry producers? Is there a database? If so, what does it contain?
- Is compliance with regulations associated with requirements to register? How are regulations enforced (penalties, incentives) and supported through the provision of information/extension/education?

DIAGRAMS AND MAPS

It may be necessary to experiment with different methods of visualizing the value chains. Spatial mapping can be useful for discussion in workshops in order to produce:

- a provincial map of all chicken, duck and other poultry markets;
- a provincial map of all large chicken, duck and other poultry sector infrastructure;
- population distributions of chicken, duck and other poultry, by scale and sector.

Spatial mapping alone is not sufficient to visualize the functional aspects of the value chains; process maps are also required. These can be used more effectively to examine **who, where, when and how** at each of the key points along the chain.

POINTS TO REMEMBER

Include all poultry species:

- Chickens
- Ducks
 - Given the potential importance of ducks both in terms of population production and epidemiology of HPAI, ensure that information is collected in adequate detail.
- Muscovy ducks
- Other poultry species such as quail, geese and turkeys

Include all the different types of products originating from chicken, duck and other poultry species chains, including:

- Live birds
 - day-old chicks
 - birds ready for the next stage of production: pullets for laying, birds ready for the next stage of fattening
 - finished birds ready for meat consumption
- Meat
 - market-killed and dressed carcasses
 - home-killed carcasses taken to markets
 - slaughterhouse-killed and processed
 - whole carcass, pieces, etc.
- Offal (heads, feet, organs, intestines, blood)
- Eggs
 - fertile eggs for breeding purposes
 - embryonated eggs for eating
 - table eggs for eating
- Manure (litter)
- Feathers (Viet Nam is one of the biggest duck feather producers in the world)
- Fighting cocks

Be aware of the seasonality of the value chains. The chains will not be static, but will change according to:

- seasonal availability of feed for the poultry (in Viet Nam probably more so for grazing ducks);
- seasonal demand for poultry products, especially during the Tet (Lunar New Year) festivals.

Be aware of the dynamic nature of value chains. Different types of producers/traders, etc., may enter and leave the chains during the seasonal peaks or at other times in response to other drivers such as feed price fluctuations (may be seasonal or not). These dynamics could be an important component for the epidemiology of disease (temporal and spatial patterns).

EXAMPLE OF AN OUTLINE FOR A WORKSHOP WITH GOVERNMENT VETERINARY SERVICES AND LIVESTOCK AND TRADE STAFF AT PROVINCE LEVEL¹⁶

The workshop included representatives from:

- Province Sub-Directorate of Animal Health (SDAH) (veterinary services)
- Province Department of Agriculture and Rural Development (DARD)
- Province Department of Trade & Tourism (market department)
- District Veterinary Station

Different approaches

While the overall aim and final results were the same (see objective above) different approaches to getting the key information were tried at different times in different provinces.

Farm-to-products approach

The initial focus is spatial in that it concentrates on locating all important components of poultry value chains within a province and then finding out through questioning what these components produce and how they are linked.

Products-to-farm approach

The initial focus was on the products – asking what poultry products are produced in a province and then finding out through questioning where the production units are, how they are organized and linked, and how inputs are supplied.

A checklist of the important components of poultry value chains

The following information can be gathered and entered into tables.

- Infrastructure: essential inputs, large-scale producers and slaughtering
 - feed-mills
 - breeder units (try to distinguish between grand parent and parent stock)
 - hatcheries (try to distinguish between traditional and mechanized systems)
 - large-scale layers or fatteners
- Slaughterhouses or slaughter points
- Distribution of smaller-scale production
 - identify districts, communes and villages where chicken, duck and other poultry production is concentrated; perhaps start with official census figures, broken down as far as possible to commune level.

¹⁶ Producers, traders and marketers should also be consulted through workshops, focus groups and/or individual interviews. It is usually better to deal with these stakeholders separately from government authority staff. Examples of interview checklists for these stakeholders are given in Annex 4.

- Markets
 - Where chicken, duck and other poultry, eggs or other chicken, duck and other poultry products are sold.

Annex 4

Semi-structured interview guides for different poultry-related sites

These guides are designed to capture data necessary for value chain analysis and for risk and biosecurity audits. They include detailed data requirements for site-specific risk assessment, taking the poultry sector as an example (developed during Wellcome Trust project Ref: 079282/Z/06/Z).

For value chain analysis, the following data are needed:

- descriptive data (describing type, size, etc.);
- input/output data (descriptive data about important links on input and output).

Descriptive and input/output data are an important component of value chain analysis.

For site-specific risk assessment, the following data are needed:

- risk-in data – data that contributes to assessment of risk that virus enters the site (probably some data contributes to both “in” and “out”);
- protection-in data – data that contributes to assessment of protection against virus entry (probably some data contributes to both “in” and “out”);
- risk-out data – data that contributes to assessment of risk that virus leaves the site including assessment of consequences of this, i.e. need to distinguish between virus leaving in poultry destined for slaughterhouse and in poultry leaving for live bird markets, etc. (probably some data contributes to both “in” and “out”);
- protection-out data – data that contributes to assessment of protection against virus exit (probably some data contributes to both “in” and “out”).

Risk in/out and protection in/out data can be used to provide both risk scores and protection scores for the locations. However, depending on the wording used, it might not be clear whether a factor should be recorded as a risk or as a protection; for example, “birds stay overnight in market” could be a risk factor, but “birds not allowed to stay overnight” would be a protective factor. Either way is acceptable, provided double counting is avoided.

Also, while data collection and risk assessment are described here as “site-specific”, the same data will be used to assess risk all along the risk pathways, i.e. risk within production and marketing processes in which the different sites are located.

FEED PLANTS

Feed plants should have no livestock population on site. Feed plants are important in virus transmission through the following possible mechanisms:

- ingredients of the feed may be contaminated with virus at the source or in transit, and contamination may not be removed during feed processing;
- feed may be contaminated during or after processing by wild birds or by fomites (contaminated vehicles, equipment and personnel entering the site and handling feed);

- feed delivery vehicles may be contaminated during delivery routes and may spread virus between farms.

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Overall data

- How long has the unit been operating?
- Is its operation seasonal?
- Is any formal registration process required to establish a feed mill? If so, what kinds of regulations exist and what do they mean in reality?
- Are there any written records of activities?

Descriptive data

- type of products;
- capacity/throughput (t per day/week/month).

Input/output data

- source of raw materials (local, province, region, national, international);
- distribution (local, province, region, national, international).

Risk data - site-specific

Risk-in

- source of raw materials (high risk sources?).

Protection-in

- hygiene routines (C&D) on all material vehicles/equipment/personnel entering the site.

Risk-out

- distribution – geographic area and volume;
- use of non-specialist transporters.

Protection-out

- hygiene routines (C&D) on all material, vehicles, equipment and personnel leaving the site.

GRAND PARENT AND PARENT FLOCKS

These farms are at the top of the pyramid of commercial poultry population. Live chicks are being supplied to the commercial farm sector via fertile eggs and hatcheries. If infection occurs at these levels, there is huge potential for spreading infection to a large number of farms over wide geographic areas.

Virus transmission may occur through the following possible mechanisms:

- feed contaminated with virus at source or in transit;
- virus introduced with replacement birds;

- virus carried in by wild birds;
- virus carried in/out by fomites;
- virus carried out with fertile eggs – contaminated shells and/or packaging;
- virus carried out with spent birds;
- virus carried out with farm waste.

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Overall data

- How long has the unit been operating?
- Is its operation seasonal?
- Are any formal registration processes required to establish a grand parent/parent farm?
- If so, what kinds of regulations exist and what do they mean in reality?
- Are there any written records of activities?

Descriptive data

- type of farm (layer/broiler/duck, parent flock, grand-parent flock, with or without hatchery);
- capacity (standing bird population);
- population turnover (batches per year);
- replacement stock introduced as fertile egg, day-old chicks (DOC), point-of-lay (POL) pullet;
- type of product leaving the farm (table egg, fertile egg, DOC, starter grower, POL pullet, live meat bird, live spent hen, slaughtered bird) – there may be more than one category;
- products (finished birds, intermediate stage birds) and by-products (manure/litter, feathers, etc.);
- production (eggs per month, birds sold per month); data is not necessary for all products, just for the main ones.

Input/output data

- replacement stock suppliers (within province or outside province, including details, if known);
- feed suppliers (local, province, region, national, international);
- destination of products and intermediate birds (local, province, region, national, international).

Inputs

- *source of birds* – how obtained (markets, dealers); single or multiple sources; contracts; linkages; health status and/or health checks on birds;
- *replacement stock suppliers* (within province or outside province including details, if known);
- *source of feed* – always same source; contracts; how delivered (single or part of a round);
- *feed suppliers* (local, province, region, national, international);

- *medicines and vaccines* – source (private or government); delivery (government, private or own veterinarian or technician);
- Are there contractual arrangements between supplier and buyer? These could range from casual one-off purchases to legal contracts; but even regular purchases from one or two suppliers without any written contract imply that there is some trust in the relationship. Such relationships could be important in subtly enforcing change and improvement.

Outputs

- *destination of product and intermediate birds* (local, province, region, national, international);
- *sales or otherwise* – for each output, how sold and to whom (markets, dealers); always same dealers/customers; contracts; linkages; health status and/or health checks required and by whom (dealer, customer or government).
- Are there contractual arrangements between supplier and buyer? These could range from casual one-off purchases to legal contracts; but even regular purchases from one or two suppliers without any written contract imply that there is some trust in the relationship. Such relationships could be important in subtly enforcing change and improvement.

Risk data – general issues

Biosecurity

- *staff working on site* – number/type; provision of clothing, washing facilities; entry/exit routines; rules for staff who keep poultry at home);
- *C&D routines at the farm* – frequency; all-in, all-out; disinfectant; downtime between batches;
- *visitors* – rules and routines, vehicles (C&D);
- *boundary security* – fences and entrances;
- *rodent control and wild birds* – control methods; frequency; access; recognized problem; feed stores open or secure;
- *handling of waste* – litter, packaging/crates/cages.

Health plans – vaccination protocols

- any written standards of procedures?

Risk data – site-specific

Risk-in

- replacement stock introduced as fertile egg, DOC, starter grower or POL pullet;
- source of replacement stock 1 (local, province, region, national, international);
- source of replacement stock 2 (market, regular trader, many traders, contract supplier, integrated supplier);
- source of feed 1 (local, province, region, national, international);

- source of feed 2 (market, regular trader, many traders, contract supplier, integrated supplier);
- poultry have access to open water;
- frequency of movements onto farm: non-staff people per week, non-staff vehicles per week (This level of detail is difficult to achieve. It might be reasonable to assume, for the purposes of a preliminary risk assessment, that the frequency of movements has some relationship to the scale of the farm; however, bigger farms will have bigger feed stores and will sell birds in bigger batches, i.e. bigger truckloads, less frequency of movement.);
- duck flocks nearby;
- wild birds gather nearby.

Protection-in

- boundary biosecurity – unwelcome visitors are effectively kept out by fence/gates (yes/no – or 3 or 5 point scale);
- staff biosecurity – entry hygiene regulations (yes/no – or 3 or 5 point scale – e.g. shower, change clothes, change boots only, disinfect boots, nothing);
- essential visitor biosecurity – entry hygiene regulations (yes/no – or 3 or 5 point scale – e.g. shower, change clothes, change boots only, disinfect boots, nothing)
- vehicle-in biosecurity – C&D (scale: jet spray and disinfect, backpack sprayer, wheel dip with regular change of disinfectant, dirty wheel dip, nothing);
- wildlife biosecurity – sheds and/or feed stores accessible to wild birds (yes/no – or 3 or 5 point scale);
- poultry kept away from areas of open water such as ponds and lakes;
- frequency of vaccination – never, campaign 1 year, campaign 2 years, campaign 3 years, according to production schedule.

Risk-out

- main product sold to (local market, small trader, wholesaler, contract buyer, integrated processor);
- main product destination (local, province, national, international);
- manure disposal (on site, sold within province, sold national);
- frequency of movements onto farm: non-staff people per week, non-staff vehicles per week. (This level of detail is difficult to achieve. It might be reasonable to assume, for the purposes of a preliminary risk assessment, that the frequency of movements has some relationship to the scale of the farm; however, bigger farms will have bigger feed stores and will sell birds in bigger batches, i.e. bigger truckloads, less frequency of movement.)

Protection-out

- staff biosecurity – exit hygiene regulations (yes/no – or 3 or 5 point scale – e.g. shower, change clothes, change boots only, disinfect boots, nothing);
- essential visitor biosecurity – exit hygiene regulations (yes/no – or 3 or 5 point scale – e.g. shower, change clothes, change boots only, disinfect boots, nothing);

- vehicle out biosecurity – C&D (scale: jet spray and disinfect, backpack sprayer, wheel dip with regular change of disinfectant, dirty wheel dip, nothing);
- manure is composted before disposal (yes/no);
- sick birds are culled and disposed of on site (yes/no);
- dead bird disposal (disposed of on site – yes/no);
- frequency of vaccination – never, campaign 1 year, campaign 2 years, campaign 3 years, according to production schedule.

The following hygiene measures do not directly prevent virus entry or exit but would limit/slow down the spread within a farm, thereby perhaps reducing the risk of virus exit.

- on site biosecurity – hygiene between sheds (scale based on descriptors, e.g. change clothes, change boots only, disinfect boots, nothing);
- on site biosecurity – hygiene between batches (scale based on descriptors, e.g. all-in, all-out with full C&D, all-in, all-out with basic cleaning, continuous occupation with occasional cleaning, nothing);
- on site surveillance and control of disease – How effective is it? The critical question is: How fast would a problem be recognized and acted upon?

HATCHERIES

Hatcheries are potential “choke points” in poultry value chains. There may be relatively few hatcheries taking fertile eggs from a number of parent flocks and distributing chicks/ducklings to a large number of flocks. Hatcheries vary enormously in size and sophistication; there are mechanized large-scale hatcheries, but there are also small-scale local hatcheries using minimal technology.

Virus transmission may occur through the following possible mechanisms:

- virus carried in by wild birds;
- virus carried in by local domestic poultry;
- virus carried in with fertile eggs – contaminated shells and/or packaging;
- virus carried in/out by fomites;
- virus carried out with chicks/ducklings;
- virus carried out with hatchery waste.

Overall data

- How long has the unit been operating?
- Is its operation seasonal?
- Are any formal registration processes required to establish a hatchery?
- If so, what kinds of regulations exist and what do they mean in reality?
- Are there any written records of activities?

Descriptive data

- type of farm (type of eggs, dedicated hatchery or breeder flock-associated, any chick/duckling rearing) – does hatchery also deal in feed?;
- capacity (number of eggs per batch);
- population turnover (batches per year);

- type of product leaving the farm (species and type of eggs hatched, any table eggs sold, embryonated egg, DOC/duckling, starter grower, POL pullet) – there may be more than one category;
- production (eggs per month, birds sold per month) – data not necessary for all products, just for the main ones.

Input/output data

Inputs

- *source of fertile eggs* – how obtained (markets, dealers); single or multiple sources; contracts; linkages; health status and/or health checks on birds supplying eggs;
- *medicines and vaccines* – source (private or government); delivery (government, private or own veterinary or technician);
- Are there contractual arrangements between supplier and buyer? These could range from casual one-off purchases to legal contracts; but even regular purchases from one or two suppliers without any written contract imply that there is some trust in the relationship. Such relationships could be important in subtly enforcing change and improvement.

Outputs

- *products* – chicks/ducklings and their by-products (manure/litter, feathers, etc.);
- *production levels* – eggs incubated per cycle; length of cycle; normal hatchability;
- *sales or otherwise* – for each output, how sold and to whom (markets, dealers); always same dealers/customers; contracts; linkages; health status and/or health checks required and by whom (dealer, customer or government);
- *chick/duckling rearers* – any nursery associated with the hatchery that rears to three weeks, for example, and sells on to:
 - *fertile egg suppliers* (within province or outside province, including details, if known);
 - *feed suppliers* – if applicable (local, province, region, national, international);
 - *destination of product* (local, province, region, national, international).
- Are there contractual arrangements between supplier and buyer? These could range from casual one-off purchases to legal contracts; but even regular purchases from one or two suppliers without any written contract imply that there is some trust in the relationship. Such relationships could be important in subtly enforcing change and improvement.

Risk data – general issues

Biosecurity

- *staff working on site* – number/type; provision of clothing, washing facilities; entry/exit routines; rules for staff who keep poultry at home);
- *C&D routines at the farm* – frequency; all-in, all-out; disinfectant; downtime between batches;

- *visitors* – rules and routines, vehicles (C&D);
- *boundary security* – fences and entrances;
- *rodent control and wild birds* – control methods; frequency; access; recognized problem; feed stores open or secure;
- *handling of waste* – litter, packaging/crates/cages.

Health plans – vaccination protocols

- any written standards of procedures?

Risk data - site-specific

Risk-in

- source of fertile egg 1 (local, province, region, national, international);
- source of fertile egg 2 (market, regular trader, many traders, contract supplier, integrated supplier);
- source of feed 1 (local, province, region, national, international);
- source of feed 2 (market, regular trader, many traders, contract supplier, integrated supplier);
- frequency of movements onto farm: non-staff people per week, non-staff vehicles per week. (Perhaps this level of detail is where it gets unrealistic. It could be reasonable to assume, for the purposes of a preliminary risk assessment, that the frequency of movements has some relationship to the scale of the farm, but bigger farms will have bigger feed stores and will sell bigger batches of birds, so perhaps not.);
- domestic poultry have access to hatchery;
- duck flocks nearby;
- wild birds gather nearby.

Protection-in

- boundary biosecurity – unwelcome visitors are effectively kept out by fence/gates (yes/no – or 3 or 5 point scale);
- staff biosecurity – entry hygiene regulations (yes/no – or 3 or 5 point scale – e.g. shower, change clothes, change boots only, disinfect boots, nothing);
- essential visitor biosecurity – entry hygiene regulations (yes/no – or 3 or 5 point scale – e.g. shower, change clothes, change boots only, disinfect boots, nothing);
- vehicle-in biosecurity – C&D (scale: jet spray and disinfect, backpack sprayer, wheel dip with regular change of disinfectant, dirty wheel dip, nothing);
- wildlife biosecurity – sheds and/or feed stores accessible to wild birds (yes/no – or 3 or 5 point scale).

Risk-out

- main product sold to (local market, small trader, wholesaler, contract buyer, integrated processor);
- main product destination (local, province, national, international);
- manure and other waste disposal (on site, sold within province, sold national);

- frequency of movements onto farm: non-staff people per week, non-staff vehicles per week. (This level of detail is difficult to achieve. It might be reasonable to assume, for the purposes of a preliminary risk assessment, that the frequency of movements has some relationship to the scale of the farm; however, bigger farms will have bigger feed stores and will sell birds in bigger batches, i.e. bigger truckloads, less frequency of movement);

Protection-out

- staff biosecurity – exit hygiene regulations (yes/no – or 3 or 5 point scale – e.g. shower, change clothes, change boots only, disinfect boots, nothing);
- essential visitor biosecurity – exit hygiene regulations (yes/no – or 3 or 5 point scale – e.g. shower, change clothes, change boots only, disinfect boots, nothing);
- vehicle-out biosecurity – C&D (scale: jet spray and disinfect, backpack sprayer, wheel dip with regular change of disinfectant, dirty wheel dip, nothing);
- manure and other waste is composted/incinerated before disposal (yes/no);
- dead bird disposal (disposed of on site – yes/no);
- frequency of vaccination – never, campaign 1 year, campaign 2 years, campaign 3 years, according to production schedule.

The following hygiene measures do not directly prevent virus entry or exit but would limit/slow down the spread within a farm, thereby perhaps reducing the risk of virus exit.

- on site biosecurity – hygiene between sheds (scale based on descriptors, e.g. change clothes, change boots only, disinfect boots, nothing);
- on site biosecurity – hygiene between batches (scale based on descriptors, e.g. all-in, all-out with full C&D, all-in, all-out with basic cleaning, continuous occupation with occasional cleaning, nothing);
- on site surveillance and control of disease – How effective is it? The critical question is: How fast would a problem be recognized and acted upon?

COMMERCIAL POULTRY FARMS

Farms are important in disease transmission through the following possible mechanisms:

- feed contaminated with virus at source or in transit;
- virus introduced with replacement birds;
- virus carried in by wild birds;
- virus carried in/out by fomites;
- virus carried out with sick birds;
- virus carried out with finished broilers;
- virus carried out with table eggs – contaminated shells and/or packaging;
- virus carried out with spent birds;
- virus carried out with farm waste.

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Overall data

Some or all of these data (e.g. detailed biosecurity and other data) may be difficult to get for individual sites. Nevertheless, it could still be useful to “populate” the map database

with default data based on case studies, i.e. use typical observed biosecurity data for all farms within certain size bands. This at least gives people a starting point from which to add refinement as data become available.

- How long has the unit been operating?
- Is its operation seasonal?
- Are any formal registration processes required for establishing a farm?
- If so, what kinds of regulations exist and what do they mean in reality?
- Are there any written records of activities?

Descriptive data

- type of farm (layer, broiler, duck flock meat, duck flock layer);
- capacity (standing bird population);
- population turnover (batches per year);
- replacement stock introduced as fertile egg, DOC, starter grower, POL pullet);
- products – finished birds, intermediate stage birds and by-products (manure/litter, feathers, etc.);
- type of product leaving the farm (table egg, fertile egg, DOC, starter grower, POL pullet, live meat bird, live spent hen, slaughtered bird) – there may be more than one category;
- production (eggs per month, birds sold per month – data is not necessary for all products, just for the main ones).

Input/output data

- replacement stock suppliers (within province or outside province, including details, if known);
- feed suppliers (local, province, region, national, international);
- destination of product and intermediate birds (local, province, region, national, international).

Inputs

- *source of birds* – how obtained (markets, dealers); single or multiple sources; contracts; linkages; health status and/or health checks on birds;
- *replacement stock suppliers* (within province or outside province, including details, if known);
- *source of feed* – always same source; contracts; how delivered (single or part of a round);
- feed suppliers (local, province, region, national, international);
- medicines and vaccines – source (private or government); delivery (government, private or own veterinarian or technician);
- Are there contractual arrangements between supplier and buyer? These could range from casual one-off purchases to legal contracts; but even regular purchases from one or two suppliers without any written contract imply that there is some trust in the relationship. Such relationships could be important in subtly enforcing change and improvement.

Outputs

- *destination of product and intermediate birds* (local, province, region, national, international)
- sales or otherwise – for each output, how sold and to whom (markets, dealers); always same dealers/customers; contracts; linkages; health status and/or health checks required and by whom (the dealer, customer or government);
- Are there contractual arrangements between supplier and buyer? These could range from casual one-off purchases to legal contracts; but even regular purchases from one or two suppliers without any written contract imply that there is some trust in the relationship. Such relationships could be important in subtly enforcing change and improvement.

Risk data – general issues

Biosecurity

- *staff working on site* – number/type; provision of clothing, washing facilities; entry/exit routines; rules for staff who keep poultry at home);
- *C&D routines at the farm* – frequency; all-in, all-out; disinfectant; downtime between batches;
- *visitors* – rules and routines, vehicles (C&D);
- *boundary security* – fences and entrances;
- *rodent control and wild birds* – control methods; frequency; access; recognized problem; feed stores open or secure;
- *handling of waste* – litter, packaging/crates/cages.

Health plans – vaccination protocols

- any written standards of procedures?

Risk data - site-specific

Risk-in

- replacement stock introduced as fertile egg, DOC, starter grower or POL pullet;
- source of replacement stock 1 (local, province, region, national, international);
- source of replacement stock 2 (market, regular trader, many traders, contract supplier, integrated supplier);
- source of feed 1 (local, province, region, national, international);
- source of feed 2 (market, regular trader, many traders, contract supplier, integrated supplier);
- poultry have access to open water;
- frequency of movements onto farm: non-staff people per week, non-staff vehicles per week. (This level of detail is difficult to achieve. It might be reasonable to assume, for the purposes of a preliminary risk assessment, that the frequency of movements has some relationship to the scale of the farm; however, bigger farms will have bigger

feed stores and will sell birds in bigger batches, i.e. bigger truckloads, less frequency of movement);

- duck flocks nearby;
- wild birds gather nearby.

Protection-in

- boundary biosecurity – unwelcome visitors are effectively kept out by fence/gates (yes/no – or 3 or 5 point scale);
- staff biosecurity – entry hygiene regulations (yes/no – or 3 or 5 point scale – e.g. shower, change clothes, change boots only, disinfect boots, nothing);
- essential visitor biosecurity – entry hygiene regulations (yes/no – or 3 or 5 point scale – e.g. shower, change clothes, change boots only, disinfect boots, nothing);
- vehicle-in biosecurity – C&D (scale: jet spray and disinfect, backpack sprayer, wheel dip with regular change of disinfectant, dirty wheel dip, nothing);
- wildlife biosecurity – sheds and/or feed stores accessible to wild birds (yes/no – or 3 or 5 point scale);
- poultry kept away from areas of open water such as ponds and lakes;
- frequency of vaccination – never, campaign 1 year, campaign 2 years, campaign 3 years, according to production schedule.

Risk-out

- main product sold to (local market, small trader, wholesaler, contract buyer, integrated processor);
- main product destination (local, province, national, international);
- manure disposal (on site, sold within province, sold national);
- frequency of movements onto farm: non-staff people per week, non-staff vehicles per week. (This level of detail is difficult to achieve. It might be reasonable to assume, for the purposes of a preliminary risk assessment, that the frequency of movements has some relationship to the scale of the farm; however, bigger farms will have bigger feed stores and will sell birds in bigger batches, i.e. bigger truckloads, less frequency of movement).

Protection-out

- staff biosecurity – exit hygiene regulations (yes/no – or 3 or 5 point scale – e.g. shower, change clothes, change boots only, disinfect boots, nothing);
- essential visitor biosecurity – exit hygiene regulations (yes/no – or 3 or 5 point scale – e.g. shower, change clothes, change boots only, disinfect boots, nothing);
- vehicle out biosecurity – C&D (scale: jet spray and disinfect, backpack sprayer, wheel dip with regular change of disinfectant, dirty wheel dip, nothing);
- manure is composted before disposal (yes/no);
- sick birds are culled and disposed of on site (yes/no);
- dead bird disposal (disposed of on site – yes/no);
- frequency of vaccination – never, campaign 1 year, campaign 2 years, campaign 3 years, according to production schedule.

The following hygiene measures do not directly prevent virus entry or exit but would limit/slow down the spread within a farm, thereby perhaps reducing the risk of virus exit.

- on site biosecurity – hygiene between sheds (scale based on descriptors, e.g. change clothes, change boots only, disinfect boots, nothing);
- on site biosecurity – hygiene between batches (scale based on descriptors, e.g. all-in, all-out with full C&D, all-in, all-out with basic cleaning, continuous occupation with occasional cleaning, nothing);
- on site surveillance and control of disease – How effective is it? The critical question is: How fast would a problem be recognized and acted upon?

TRADERS

Traders are potentially important vehicles for disease transmission through the following possible mechanisms:

- virus carried with marketed live birds;
- virus carried by contaminated carcasses/poultry products;
- virus carried by fomites – particularly poultry traders and their vehicles.

Overall data

- How long has unit been operational?
- Is its operation seasonal?
- Are there any written records of activities?
- Gender: male or female
- Education level
- Information sources (TV, radio, newspaper, mobile phone, personal contacts) for markets and on disease/disease outbreaks/disease control.
- Knowledge and information about price and demand (quantity and quality).
- Are there any formal registration processes to establish oneself as a trader?
- If so, what kinds of regulations exist and what do they mean in reality?

Scale and scope of operation

- scale – average numbers traded per day/week;
- scope – type of products traded.

Method of trade

- *source of birds* – how obtained (farms, households, other dealers); single or multiple sources; contracts; linkages; health status and/or health checks on supplier;
- *sales* – how sold and to whom (types of customer, markets, other dealers); always same dealers/customers; contracts; linkages; health status and/or health checks required and by whom (dealer, customer or government);
- *price fixing* – who fixes the prices; how; different price structures;
- *transport* – own or other means and what type;
- *trading routine* – *single or multiple pick-ups, etc.*;
- *holding of stock between buying and selling* – *does trader hold stock for number of days at own or at other premises?*;

- *Are there contractual arrangements between supplier and buyer? These could range from casual one-off purchases to legal contracts; but even regular purchases from one or two suppliers without any written contract imply that there is some trust in the relationship. Such relationships could be important in subtly enforcing change and improvement.*

Biosecurity

- *all staff – special clothing; entry/exit routines at customers' and own premises; do staff keep poultry at home?);*
- *C&D routines for transport vehicles – frequency; all-in, all-out; disinfectant; downtime between trips, use of boxes/cages, etc. (single or multiple use), etc.;*
- *handling of waste – litter, packaging/crates/cages.*

Health plans – vaccination protocols

- does trader organize vaccination of birds?

MARKETS, COLLECTION POINTS (WHERE TRADING MAY TAKE PLACE), DEALERS PREMISES

Markets are potentially important “nodes” for disease transmission through the following possible mechanisms:

- virus carried in/out with marketed live birds;
- virus carried in/out by contaminated carcasses/poultry products;
- virus carried in/out by fomites – particularly poultry traders and their vehicles;
- virus carried out in contaminated waste/washing water, etc.

The risk of a market getting infected depends mainly on the throughput and source of birds; the higher the throughput and the wider the catchment area, the higher the risk.

Major objectives of a market visit are:

- to document how the market operates and is regulated;
- to observe biosecurity/risky behaviours in markets;
- to get detailed information on trader behaviour and how traders interact in the value chain.

Data to be collected by observation and by interviews with market manager.

Overall data

- Is there any formal registration process for establishing a market? If so, what kinds of regulations exist and what do they mean in reality? Formality of contracts for traders to work in a market - do they have to pay for a stall or space? If they do, is this on a daily basis or over a longer time period?
- Are there any written records of activities?
- How does the market raise money? Do sellers pay a commission? If so, how much?
- Is there a manager? (yes/no)
- Who is the manager? (government official, private)
- What is his/her level of education/training?
- Contact with veterinary services. (official, informal)

- How does the market raise money? Is any money then invested in infrastructure?
- Any fees, etc.? (who pays – seller, buyer, both; to whom?)
- Formality of contracts for traders to work in a market – do they have to pay for a stall or space? If they do, is this on a daily basis or over a longer time period?

Market infrastructure

- floor surface
- buildings
- bird pens/cages
- roof
- drainage
- water supply
- slaughtering facilities and the frequency of use (type of slaughtering facility)
- cleaning facilities (supplies of detergents, disinfectants, etc.)

Human health protection

Any measures to protect people handling/slaughtering poultry:

- hand washing facilities;
- provision of masks and/or gloves.

Information about size of market

- frequency of market – daily, weekly, monthly, and day(s) of week;
- species and type of birds traded – also eggs;
- size of market for poultry;
- capacity – number of birds usually present at one time;
- throughput – number of birds traded each day, number of “sitting” sellers at the market (may be different from the suppliers);
- seasonal patterns in throughput – species and types of birds;
- what human population does the market serve?
 - village area
 - district area
 - larger regional or governorate area

Proportion of the market dedicated to poultry trading

- only component (100 percent of sales and purchases);
- main component (above 75 percent of sales and purchases);
- medium component (between 25 and 75 percent of sales and purchases);
- minor component (less than 25 percent of sales and purchases).

Species sold in the markets (also rabbits or other animals may be sold in close vicinity to the poultry). Please give an indication on poultry with regard to sales and purchases in terms of:

- predominantly chickens;
- predominantly ducks;
- mixture of chickens, ducks, geese and pigeons;

- numbers of sellers of each species, types of sellers;
- numbers of buyers of each species, types of buyers (buyers might themselves be traders as distinct from consumers);
- source of birds/produce for market (local, province, region, national, international);
 - predominantly industrial poultry units – indications on whether these are broilers or spent hens would be useful;
 - mixed industrial and backyard/rooftop birds;
 - predominantly backyard/rooftop birds;
- mechanics for the delivery of birds (where, when, how and whom they come from);
- distribution (local, province, region, national, international).

Availability of poultry inputs (wholesale, retail)

- feeds
- drugs and vaccines

Descriptive data

- type of place (market/collection point/dealers' premises);
- frequency of market and day(s) of week;
- species and type of birds traded;
- capacity – number of birds usually present at one time;
- throughput – number of birds traded each day, number of "sitting" sellers at the market (may be different from the suppliers);
- proportion of suppliers arriving by foot, bicycle, motorbike, truck.

Input/output data

- source of birds/produce for market (local, province, region, national, international);
- who sells at the market (producers, dealers);
- distribution (local, province, region, national, international).

Risk data – general issues

Biosecurity

- *health status and/or health checks on birds;*
- *staff working on site* – number/type; provision of clothing, washing facilities; entry/exit routines; rules for staff who keep poultry at home);
- *C&D routines at the market* – frequency, all-in, all-out, disinfectant; downtime between markets;
- *handling of waste* – litter, packaging/crates/cages, slaughter waste, offal.

Risk data - site-specific

Risk-in

- geographic source of birds/produce for market (local, province, region, national, international);

- farm type source of birds/produce for market (small-scale, large-scale, housed/free range, etc.);
- number of sellers usually supplying market, (few, many, categories);
- mixing of species:
 - by location within the market;
 - or by cages;
- access - number of entry points to the market area (location of stalls in relation to these points):
 - by foot or bicycle;
 - by vehicle.

Protection-in

Protection in depends heavily on C&D regimes for incoming people and vehicles.

- vehicle-in biosecurity – not appropriate to fully clean and disinfect loaded vehicles on entry to market; but, are dirty vehicles refused entry, do vehicles pass through wheel dips and/or are they cleaned and disinfected around wheels and chassis?;
- people-in biosecurity – do people have to clean footwear/pass through boot dip?;
- suppliers must comply with certification regulations (unlikely to get realistic data on this);
- suppliers must comply with vaccination certificates for traded birds.

Risk-out

The risk of virus leaving a market depends basically on two things: (i) the risk and extent to which virus can survive and multiply in the market; and (ii) whether or not live birds go out (and where they go, if we consider also the risk of further spread).

- number of buyers usually buying at the market;
- birds remain at market/site for over one day (overnight);
- birds from different sources are mixed within the market;
- live birds leave the market (for slaughter at next stop, or for further production);
- birds that are not sold at the end of the day (slaughtered and frozen or kept until next day), and are these birds mixed with new deliveries;
- waste handling from the market – litter, packaging/crates/cages, slaughter waste, offal;
- disposal of offal – observation of cats and asking vendors whether offal is given to the cats or other animals (or if they catch cats eating it).

Protection-out

Protection out depends heavily on C&D regimes for outgoing people and vehicles.

- market/site has regular empty days – stock completely cleared (+/- C&D);
- potential for cleaning and disinfecting the stalls (if cleaned, how often);
- market/site is subject to regular veterinary checks;
- vehicle-out biosecurity – C&D (scale: jet spray and disinfect, backpack sprayer, wheel dip with regular change of disinfectant, dirty wheel dip, nothing) or vehicles cleaned before loading up and leaving; dirty vehicles refused exit; special requirements for poultry traders;

- people-out biosecurity – Do people have to clean footwear/pass through boot dip?. Are there special requirements for poultry traders?

SLAUGHTER POINTS/HOUSES

Slaughter places are broadly similar to markets and are potentially important “nodes” for disease transmission. The main difference is that live birds should not leave the location and the destination of the product leaving the premises is not usually a farm where further contact with live birds would be likely. However, disease transmission could take place through the following possible mechanisms:

- virus carried in with live birds;
- virus carried in/out by fomites – particularly poultry traders and their vehicles;
- virus carried out by contaminated carcasses/poultry products;
- virus carried out in contaminated waste/washing water, etc.

Overall data

- Is there any formal registration process to establish a slaughterhouse? If there is, what kinds of regulations exist and what do they mean in reality?
- Are there any written records of activities?
- How does the slaughterhouse raise money?
- Is there a manager? (yes/no)
- Who is the manager? (government official, private)
- What is his/her level of education/training?
- Contact with veterinary services. (official, informal)
- Any fees, etc.? (who pays – seller, buyer, both; to whom?)
- Formality of contracts with poultry producers?

Slaughterhouse infrastructure

- floor surface
- buildings
- bird pens/cages
- roof
- drainage
- water supply
- cleaning facilities (supplies of detergents, disinfectants, etc.)

Human health protection:

Any measures to protect people handling/slaughtering poultry:

- hand washing facilities;
- provision of masks and/or gloves.

Descriptive data

- type of place (industrial processor or slaughter point);
- frequency of operation and day(s) of week;
- species and type of birds slaughtered;

- throughput – number birds processed each day;
- proportion of suppliers arriving by foot, bicycle, motorbike, truck.

Input/output data

- source of birds for slaughter (local, province, region, national, international);
- distribution (local, province, region, national, international).

Risk data - site-specific**Risk-in**

The risk of a slaughter place getting infected basically depends on the throughput and source of birds – the higher the throughput and the wider the catchment area, the higher the risk.

- source of birds for slaughter (local, province, region, national, international);
- number of sellers usually supplying (few/many, categories).

Protection-in

- vehicle-in biosecurity – not appropriate to fully C&D loaded vehicles on entry to market, but are dirty vehicles refused entry, do vehicles pass through wheel dips and/or are they cleaned and disinfected around wheels and chassis?;
- people-in biosecurity – do people have to clean footwear/pass through boot dip?;
- suppliers must comply with certification regulations;
- suppliers must comply with vaccination certificates for supplied birds.

Risk-out

Basically the risk of virus leaving a slaughter place depends on any treatments applied in processing that can destroy virus and especially on waste management.

- birds remain at slaughter place for over one day (overnight);
- birds from different sources are mixed together within the place;
- live birds leave the place not slaughtered (unlikely, but perhaps should be questioned);
- waste handling from the place (what criteria can be applied here to get concise data?).

Protection-out

- place is regularly cleaned and disinfected between slaughtering batches;
- place is subject to regular veterinary checks;
- vehicle-out biosecurity – C&D (scale: jet spray and disinfect, backpack sprayer, wheel dip with regular change of disinfectant, dirty wheel dip, nothing) or vehicles cleaned before loading up and leaving; dirty vehicles refused exit;
- people-out biosecurity – do people have to clean footwear/pass through boot dip?

VILLAGE POULTRY, HOUSEHOLD POULTRY, BACKYARD POULTRY, NON-COMMERCIAL POULTRY (PERHAPS DEFINED AS FLOCKS OF UP TO 20 OR 50 MAXIMUM)

In theory, it would be possible to produce risk scores (as for farms) for individual households or villages, but this cannot be mapped without creating a messy map.

A simple overview of risk should be based on density of different species and on whether there are major movements of risk carriers into and/or out of an area.

Note that a village may be at risk of infection because of the operation of commercial flocks within the village.

Annex 5

Example of a preliminary risk analysis table for risk of foot-and-mouth disease (FMD) in northern Viet Nam

TABLE 14
Example of a preliminary risk analysis table for risk of foot-and-mouth disease (FMD) in northern Viet Nam

Beef cattle and buffalo	Factors affecting risk	Comments (qualitative partial risk estimate)	Questions remaining
	Along the northern border of Viet Nam with Laos there are movements of cattle, buffaloes and pigs on a low scale in either direction, according to price fluctuations in one or the other country.		
	Approximately 50-100 head of buffaloes and cattle are said to be brought from Houa Phan, Xiang Khoang and Boli Khamxai (Laos) into the province of Nghe An in Viet Nam.		
Live animals	Cattle and buffaloes are not common in southern Viet Nam; the north is the main area for cattle production. Herds in the south are smaller than in the north and many animals are imported in order to meet the high demand in Ho Chi Minh City (HCMC) and in the south in general. Quality is not important for imports and even poor quality animals are brought in from Cambodia.	Demand for beef in Viet Nam is much higher than local supply. This means that imports are necessary and, at present, these are all unofficial and unregulated.	Data on Viet Nam beef consumption and local production
Intro-duction of FMD to country or area	The movement of cattle and buffaloes from and into China depends on the price differences. The main movement used to be from Viet Nam to China, but at present cattle are imported from China into Lao Cai. Some provinces in the south (for supply to HCMC) do not have enough animals for slaughter and therefore import them from Laos and Cambodia. Slaughterers of the Ha Tay province are not able to supply Hanoi from local stock and therefore they may buy animals from the north of Viet Nam but also from Laos and northern Cambodia, maybe even from further to the west (Myanmar).	Cattle and buffaloes are entering from FMD-affected countries and this is high risk.	
Animal products			
Fomites	The return of traders along with their vehicles and equipment creates opportunities for the introduction of FMD into Viet Nam.	Traders dealing in live animals can also transfer FMDV by fomites.	
Airborne			
Live animals	Most of the cattle and buffaloes imported to Viet Nam are for slaughter.		
Animal products			
Fomites			
Airborne			
Exposure of local livestock to FMDV		Exposure of local livestock is more likely via contacts during transport and/or in markets/collecting points, as well as by fomites from the slaughterhouses.	

(cont.)

Beef cattle and buffalo	Factors affecting risk	Comments (qualitative partial risk estimate)	Questions remaining
	Cattle and buffaloes are roaming and grazing free.		
	In remote and mountainous areas animals are moved from the highlands to the lowlands or are released into the forest for grazing when they are not needed as draught animals on the fields (seasonal movements).		
	In the lowlands and river areas animals are moved to the dykes for grazing.		
	High-risk movements of cattle from northern Vietnamese provinces bordering infected countries occur through two channels, into Vinh Phuc and Hai Duong provinces. Risk management of these pathways is unlikely to prevent the entry of carrier animals. Checks of health status are made by phone calls to counterparts in source provinces and veterinary clinical inspection on arrival. There are no measures such as pre- or post- movement isolation and testing, and disinfection of vehicles.	The risk of spread of FMD among local cattle and buffalo populations through direct live animal contact is high because (i) communal grazing is common; and (ii) live cattle are moved over long distances (not only for slaughter but also for further rearing/breeding).	
Live animals	The majority of the beef is consumed in Hanoi and HCMC; only a very small percentage is sold on district and province town markets.		
	Live animals are transported from Bac Giang and Thanh Hoa and slaughtered in small- scale slaughter points as another source of beef for Hanoi.		
Spread of FMD within area	Breeding cattle (crossbreeds) are moved from Hanoi to the northern regions of Viet Nam; fattening and beef cattle are brought from the neighbouring provinces (Vinh Phuc) into Hanoi (50 percent) and the other 50 percent is sold to southern Viet Nam and transported there by trucks (a four-day journey).		
	Beef supplied to Hanoi is slaughtered in slaughterhouses in Ha Tay. These slaughterhouses do not have veterinarian inspection.		
Animal products	Lao Cai has very simple slaughterhouses where the bones and hides are collected, but there is no further information available with regard to what happens to them. Participants agree that these by-products should be better controlled.	Most cattle are slaughtered in "low-tech" unregulated slaughterhouses. There is poor inspection, so FMD-infected animals may not be noticed and will be dealt with in the same way as healthy cattle. If hygiene measures are poor, there is a high risk of the spread of FMDV via fomites from the slaughterhouses. As slaughterhouse personnel often keep livestock, onward infection is highly possible (more likely to pigs than to other cattle).	
Fomites	Private slaughterhouses should move to more intensive production areas, but then they could not take advantage of cheap family labour and would have to employ workers, which is not economic for them. Also consumers are not prepared to pay a higher price for beef, which makes it difficult to upgrade the slaughtering/processing process as it would increase costs.		
Airborne	Wastewater from slaughterhouses is not disposed of safely. Household slaughterers often hold pigs, which can be an opportunity for the virus to spread.		

(cont.)

Beef cattle and buffalo	Factors affecting risk	Comments (qualitative partial risk estimate)	Questions remaining
<p>Spread of FMD to another country/area</p>	<p>Along the northern border of Viet Nam with Laos there are movements of cattle, buffaloes and pigs on a low scale in either direction, depending on price fluctuations in one or the other country.</p> <p>Tens of thousands of buffaloes are exported from Nghe An province via Laos to Thailand.</p>	<p>There are significant movements of cattle and buffaloes from northern Viet Nam to neighbouring countries that carry a high risk of spreading FMD.</p>	
<p>Live animals</p>	<p>The movement of cattle and buffaloes from and into China depends on the price differences. The main movement used to be from Viet Nam to China but at present cattle are imported from China into Lao Cai.</p> <p>Cattle and buffaloes are also exported to Laos and Thailand and are often stopped in Nge Anh to be quarantined, but only 10 000 animals can be checked at one time.</p> <p>A small percentage of buffaloes are exported to China via Hai Phong and Quang Ninh.</p>		
<p>Animal products</p>			
<p>Fomites</p>			<p>Traders dealing in live animals can also transfer FMDV by fomites.</p>
<p>Airborne</p>			

Annex 6

Example of a detailed risk assessment and risk mitigation analysis – Viet Nam

Entry of FMDV into Viet Nam and exposure of local livestock to FMDV

Risk issue

Briefly describe the risks to be addressed.

1. Entry of FMDV into Viet Nam – carried by infected live animals, products from infected animals, fomites (or airborne).
2. Exposure of local livestock to FMDV – carried by infected live animals, products from infected animals, fomites (or airborne).

Descriptive background

List key facts about the value chain that are relevant to disease transmission risk.

Note: The lists illustrate the characteristics of information obtained from workshops. The scoring criteria in the tables indicate the data that could be critical and therefore justify spending money to get better information.

- Viet Nam is surrounded by countries where FMD regularly occurs (Cambodia, Laos and southern China). Neighbouring countries do not vaccinate regularly or at all, or only vaccinate a small percentage of animals (Laos, Cambodia).
- There is only unofficial/informal trade (in live animals and animal products) between Viet Nam and its neighbouring countries. The driving forces are price differences that do not follow any seasonal trend but mainly depend on the relation between supply and demand.
 - Because of the high demand for beef in Viet Nam cattle and buffalo are imported from Laos into Viet Nam.
 - Along the northern border of Viet Nam with Laos there are cross-border movements of cattle, buffaloes and pigs on a low scale in both directions.
 - Because of the high demand for meat in HCMC cattle and buffaloes are moved between Cambodia and Viet Nam.
 - Pigs, cattle and goats (and sometimes milk), are informally traded across border with China; movements can be in either direction, depending on supply and demand and price changes. Lang Son is a main crossing point for animals and products traded with China. Cattle and buffaloes graze on both sides of the border; animals are also exchanged at weddings between ethnic groups living on both

sides of the border.

- Movements across borders are encouraged by price differences between China and Viet Nam. Prices in China are very often lower than prices in Viet Nam, and livestock are moved into Viet Nam. The prices for buffaloes and raw milk are currently higher in Viet Nam than in China, and therefore animals and products are moved into Viet Nam.
- The main market for informally imported livestock is Hanoi where most products are transported. Different persons are involved in the trade of animals with China. Often animals are imported from China for fattening or as breeding animals, but some also go direct to slaughterhouses.
- China and Viet Nam do not have a cross-border agreement for the control of FMD, and therefore quarantine of imported animals cannot be enforced.
- People can move freely across borders, as control is difficult because of the mountainous terrain (less so along the border between southern Viet Nam and Cambodia).
- Border Inspection Posts (BIPs) are poorly resourced; for example, Lao Cai has a veterinary station to check imported animals but it lacks sufficient personnel and equipment to undertake controls and checks and it does not have a laboratory.
- Farmers with properties close to the Chinese border import animal feed from China; trucks and bikes can cross the border without any control as the borders are mainly open. Sometimes cheap animal feed is imported to the Red River Delta and Hanoi area from China.
- Traders returning to Viet Nam with their vehicles and equipment create opportunities for introduction of FMDV carried on fomites.
- Dairy cattle are imported from FMD-free countries. One hundred percent of the reproduction is done using artificial insemination with imported semen; the government controls import of semen but not the distribution. Eighty percent of dairy products are still being imported.

Identification of critical control points

Key questions:

1. Is there a significant risk of the hazard at this step? (Use the criteria listed in the table to support conclusion.)
2. Do control measures exist at this step and, if not, can process at this step be modified?
3. Does the measure eliminate or reduce risk to acceptable level, i.e. impact on risk?
4. If answer to 2 and/or 3 is no, will a subsequent step eliminate or reduce risk to acceptable level?

Risk location		Risk factors		Criteria for risk scoring and monitoring	Describe risk mitigation measures	Impact of risk mitigation on stakeholders (comments)
In value chain	Geographic	Factors that increase risk	Factors that decrease risk			
<i>Refer to value chain description</i>	<i>Refer to value chain description</i>	<i>Refer to risk pathways</i>		<i>Refer to value chain analysis</i>		
Informal trade/ movements of animals and products across borders (for details see value chain descriptions)	Border with China Border with Laos Border with Cambodia via southern and central Viet Nam	Viet Nam is surrounded by countries where FMD regularly occurs Neighbouring countries (Laos, Cambodia) do not vaccinate at all or only vaccinate a small percentage of animals Price differences that favour inward movement	Price differences that favour outward movement	Amount of circulation of FMDV in China, Laos and Cambodia, especially in parts near border Level of vaccination coverage and immunity in neighbouring countries	Control of disease in neighbouring countries Improvement of quality and communication of disease information As above	Needs regional approach
		Price differences that favour inward movement	Price differences that favour outward movement	Amount and direction of livestock and commodity price differences across borders Total amount of animals/ products moved inwards across border	Trade intervention Monitoring and sharing of economic information (e.g. an early warning system)	Needs regional approach
		People can move freely across borders as control is difficult because of the mountainous terrain BIPs are poorly resourced	Border with Cambodia is easier terrain to monitor	Number of animals/ product that cross border (difficult to estimate) Origin of animals/ products in relation to disease prevalence in source areas Proportion of movements that pass through BIPs Proportion of animals and product that pass through BIP, and that can be adequately screened	Provide information/ education to traders/ farmers about disease risks when trading across borders Encourage traffic to pass through BIPs Improve facilities at BIPs	Trade is currently unofficial, and traders will therefore avoid BIPs Passing through BIPs carries risk of prosecution and would potentially add transaction costs

(cont.)

In value chain	Risk location		Risk factors		Criteria for risk scoring and monitoring	Describe risk mitigation measures	Impact of risk mitigation on stakeholders (comments)
	Geographic	Refer to value chain description	Factors that increase risk	Factors that decrease risk			
Refer to value chain description		Refer to value chain description			Refer to risk pathways		Refer to value chain analysis
			The return of traders along with vehicles and equipment creates opportunities for introduction of FMDV into Viet Nam		Amount of unregulated agricultural cross-border traffic Proportion/number of BIPs with effective C&D facilities	Encourage traffic to pass through BIPs Improve facilities at BIPs Provide C&D facilities at multiple sites within country (not necessarily associated with BIPs) Enforce regulations on C&D of animal transport	Traders who engage in informal cross-border trade may be more willing to use C&D facilities that are independent of BIPs (and therefore do not expose them to risk of prosecution for informal trading) Needs cross-border cooperation If effective, should allow communities to interact safely
			There are cross-border ethnic communities within which livestock and products are freely exchanged		Extent of existing cross-border communities/ ethnic groups; amount of inhabited land, villages and fields that are within (?) km of border	Monitor disease in cross-border communities Cross-border cooperation among authorities Border vaccination belts Given that disease may circulate, set up border type controls around communities Monitor and regulate what passes into, through and out of cross-border communities	

(cont.)

In value chain	Risk location		Risk factors		Criteria for risk scoring and monitoring	Describe risk mitigation measures	Impact of risk mitigation on stakeholders (comments)
	Geographic	Refer to value chain description	Factors that increase risk	Factors that decrease risk			
Refer to value chain description		Refer to value chain description			Refer to risk pathways		Refer to value chain analysis
Import of dairy cattle			Dairy cattle are imported from FMD-free countries, e.g. in Europe, Australia, North America		Number of dairy cattle imported per year Origin of dairy cattle (FMD status of country) Reliability of import regulation/ certification	Ensure safe origin of imports Encourage import of embryos and semen rather than heifers	Dairy cattle and semen are sourced from non-neighbouring countries Trade is already well regulated Imports are low volume and high value
Supply of semen for artificial insemination of dairy cattle			Import of semen is controlled by the government Semen is sourced from FMD-free countries		Amount of semen imported per year Origin of semen (FMD status of country) Reliability of import regulation/ certification		
Supply of dairy products to consumers			Eighty percent of dairy products are still being imported There may be some informal imports of raw milk from China	Most dairy products are imported as processed product – many processes destroy FMDV	Amount of product imported per year Origin of product (FMD status of country) Processing of product, e.g. raw milk pasteurized/powdered, etc. Reliability of import regulation/ certification	Ensure safe origin for imports Ensure correct processing to remove risk of FMDV contamination	

(cont.)

In value chain description	Risk location		Risk factors		Criteria for risk scoring and monitoring	Describe risk mitigation measures	Impact of risk mitigation on stakeholders (comments)
	Geographic	Refer to value chain description	Factors that increase risk	Factors that decrease risk			
Refer to value chain description		Refer to value chain description			Refer to risk pathways		Refer to value chain analysis
<i>Exposure of livestock</i>							
Throughout the marketing chain, from borders to consumer	Within country part of value chain for informally imported animals and products up to consumer in Hanoi		Where animals are imported for the purposes of slaughter, exposure of local livestock and onward transmission of FMDV is lower than it is for breeding/fattening		Proportion of imported animals that go direct to slaughterhouse Proportion that go to live markets but where sales are mainly for slaughter Proportion that go to markets and are sold for further rearing (or go directly to further rearing farms)	Encourage slaughter near point of entry (this is longer term) Establish slaughtering facilities near borders so that it is meat that is moved rather than live animals	Needs a bigger study? What would be the impact of making informal trade official?
			Hygiene/biosecurity standards of slaughterhouses is generally not good in Viet Nam; thus risk of FMDV getting out of slaughterhouse and spreading to local livestock is significant When people buy meat they take it home and wash it. Then the rice is washed with the same water, and that water is then given to the animals on farm.		Criteria to score risk from slaughterhouse (effluent/waste/fomites)	Better regulation of slaughterhouses	Changed workload of veterinary inspection services Slaughtering costs increase – costs passed back to animal trader/producer and onward to consumer
					Proportion of imported animals that have own livestock Amount of waste-food feeding to home livestock	Controls on swill feeding	Big negative impact on smallholder pig keepers

(cont.)

In value chain	Risk location		Risk factors		Criteria for risk scoring and monitoring	Describe risk mitigation measures	Impact of risk mitigation on stakeholders (comments)
	Geographic	Refer to value chain description	Factors that increase risk	Factors that decrease risk			
Refer to value chain description		Refer to value chain description			Refer to risk pathways		Refer to value chain analysis
Rural pig production value chain	Widespread in northern provinces – particularly the Red River Delta (RRD)		Feeding of household food waste (swill) to household pigs is common practice.		Prevalence of swill feeding (broken down by different production systems); proportion of diet that is swill	Controls on swill feeding	Big negative impact on smallholder pig keepers
			Pigs are held free range and can come into contact with infected material		Prevalence of free ranging (broken down by different production systems)	Controls on free ranging of pigs	Big negative impact on smallholder pig keepers

1. Is there a significant risk of the hazard at this step? (Use the criteria listed in the table to support conclusion.)

- Risk associated with import of dairy cattle, dairy semen and dairy products can be considered insignificant – because this trade appears to be well regulated. Cattle and semen are sourced from FMD-free countries and most imported dairy products are processed, so that risk of FMDV contamination is removed, i.e. risk reduction measures are already in place that eliminate or reduce risk to acceptable level. An exception is the alleged informal trade in raw milk across the border with China. This is most likely small-volume, short-distance trade; in any case the situation needs clarification and monitoring. This issue is part of the overall informal trade issue.
- Informal trade presents a significant risk and should be separated into two types of cross-border trade (requiring different risk mitigation approaches):
 - i. long distance – feeding markets distant from the border;
 - ii. short distance – cross-border community trade/movements.

Trade in live animals carries higher risk than trade in products (but higher volume of product trade could increase overall risk – currently most livestock trade into, out of and within Viet Nam is in live animals; slaughter usually takes place near point of retail/consumption). Traders' vehicles, equipment, clothing, etc. may carry risk of fomite-carried virus introduction.
- Allowing free-ranging pigs to scavenge for food and feeding swill to pigs are both high risk practices that expose pigs to risk of FMD infection via the oral route.

2. Do control measures exist at this step and, if not, can the process at this step be modified?

Potential risk mitigation measures are listed in the table.

The key measures targeting long-distance informal imports are those that encourage informal trade to pass through better resourced BIPs. But how? Realistically, we might conclude that there are no feasible control measures at this point; therefore we must seek CCPs further along the chain. Possible measures include: improving surveillance within the country; better monitoring of slaughter stock; C&D regulations; provision of facilities for animal traders and transport within the country (to mitigate fomite spread risk). Monitoring the disease situations in neighbouring countries and monitoring the economic drivers for informal trade will help in providing early warning and in targeting in-country surveillance activities in time and space.

The risk associated with short-distance cross-border community trade may be better tackled by measures that treat cross-border communities as entire epidemiological units. Therefore risks of disease introduction, spread within and spread out from these communities are dealt with through bilateral veterinary authority collaboration.

Control of free-ranging pigs and banning or tighter regulation of swill feeding are measures that have been used in other countries to protect against risks of FMD and other diseases such as cattle swine fever (CSF).

3. Does the measure eliminate or reduce risk to an acceptable level, i.e. impact on risk?

For example, control of animal/product movement out of cross-border communities would reduce the risk to the rest of the country, as would vaccination within cross-border communities.

Control of free-ranging pigs and banning or tighter regulation of swill feeding would significantly reduce the risk of FMD spread through the slaughter of infected animals for consumption but not through direct animal-to-animal spread. If feasible, this measure would probably significantly reduce risk, but not eliminate it.

4. If the answer to 2 and/or 3 is no, will a subsequent step eliminate or reduce risk to an acceptable level?

In the case of long distance informal trade the risk cannot be reduced sufficiently at the borders. Therefore the risk must be addressed further along the informal marketing chain within the country. Unfortunately, because the chain is informal, it is difficult to intervene; therefore, as noted above, measures can only be targeted at reduction of the impact of the hazard, i.e. surveillance within the country and rapid outbreak response.

Identified CCPs and associated risk mitigation measures that could be recommended are as follows:

CCPs may be identified and associated with cross-border communities. More detailed consideration (involving the veterinary authorities and stakeholders) would be needed to define the practical measures to be implemented – here we have only described the characteristics of possible measures.

Although significant risk is identified with informal long-distance trade, particularly of live animals (especially cattle – see value chain descriptions), it is difficult to identify feasible risk reduction measures that can be directly applied to reduce the risk. Therefore, technically the borders would be identified as potential CCPs but currently without feasible risk reduction measures. Nevertheless, this identifies this issue as a critical risk issue that requires attention. In the longer term, ways need to be explored to formalize informal trade so that risk reduction measures can be applied.

One suggestion might be to provide slaughtering facilities close to BIPs, so that trade is encouraged via the BIP; in this way long distance transport of imported live animals within the country is avoided.

Control of free-ranging pigs and banning or tighter regulation of swill feeding is a potential measure, but this requires careful analysis of impact on smallholder producers before implementation.

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Classical risk assessment approaches for animal diseases are influenced by the probability of release, exposure and consequences of a hazard affecting a livestock population. Once a pathogen enters into domestic livestock, potential risks of exposure and infection both to animals and people extend through a chain of economic activities related to producing, buying and selling of animals and products. Therefore, in order to understand economic drivers of animal diseases in different ecosystems and to come up with effective and efficient measures to manage disease risks from a country or region, the entire value chain and related markets for animal and product needs to be analysed to come out with practical and cost effective risk management options agreed by actors and players on those value chains.

Value chain analysis enriches disease risk assessment providing a framework for interdisciplinary collaboration, which seems to be in increasing demand for problems concerning infectious livestock diseases. The best way to achieve this is to ensure that veterinary epidemiologists and social scientists work together throughout the process at all levels.

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