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USAID Mekong ARCC Climate Change Impact and Adaptation Study

Livestock Report

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The USAID Mekong ARCC project is a five- year program (2011-2016) funded by the USAID Regional Development Mission for Asia (RDMA) in Bangkok. The larger project focuses on identifying the environmental, economic, and social effects of climate change in the Lower Mekong Basin (LMB), and on assisting highly exposed and vulnerable rural populations in ecologically sensitive areas adapt to climate change impacts on agricultural, fisheries, livestock, ecosystems, and livelihood options.

This phase of the project was led and implemented by ICEM, and focuses specifically on predicting the response of the key livelihood sectors – agriculture, livestock, fisheries, rural infrastructure and health, and natural systems – to the impacts associated with climate change, and offering broad-ranging adaptation strategies to the predicted responses.

This volume is part of the USAID Mekong ARCC study set of reports:

1. USAID Mekong ARCC Climate Change Impact and Adaptation Study: Summary
2. USAID Mekong ARCC Climate Change Impact and Adaptation Study: Main Report
3. USAID Mekong ARCC Climate Change Impact and Adaptation Study on Agriculture
4. USAID Mekong ARCC Climate Change Impact and Adaptation Study on Livestock
5. USAID Mekong ARCC Climate Change Impact and Adaptation Study on Fisheries
6. USAID Mekong ARCC Climate Change Impact and Adaptation Study on Non Timber Forest Products and Crop Wild Relatives
7. USAID Mekong ARCC Climate Change Impact and Adaptation Study on Protected Areas
8. USAID Mekong ARCC Climate Change Impact and Adaptation Study: Socio-economic Assessment

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SUMMARY

Livestock production systems in the LMB range from traditional smallholder livestock-keeping systems to large highly productive commercial enterprises. Traditional systems are small-scale, low intensity, low-input, low-output systems, typically raising stock of local genetics and with limited market orientation. They contribute well over 90% of total numbers of producers in the LMB, and over 50% of total production. These systems dominate the higher elevation forested and more sloping ecozones and typically are associated with low-income, vulnerable households. Women, the elderly, and children are often responsible for household livestock, providing them with an important source of cash income and increased social standing.

In Gia Lai, for example, women take the lead role in raising pigs because this activity normally occurs around the home. Lower pig productivity and higher mortality may reduce the income-earning potential of women. Pigs are also an important form of savings and an asset in times of emergency. Loss of these assets may reduce the capacity of women to provide food for their family in times of scarcity. Small- and medium-scale commercial operations are most vulnerable and have limited capacity to adapt.

Drivers in the livestock sector

Alongside expected climate changes, the LMB is undergoing significant socio-economic and physical changes affecting livestock production, consumption, and livelihoods. Increases in household incomes have led to increasing domestic demand for livestock-derived products. Globalization and increasing links to global markets is increasing competition and subsequent pressure on domestic production.

The high human and livestock populations, number of livestock-raising households, and the nature of production in the LMB contribute to emerging infectious disease risks, notably zoonoses; outbreaks and endemic diseases are major production and public health concerns.

Mechanization and the introduction of higher productivity genotypes has had varied levels of success impacting yields, costs of production, and disease risks. Increasing concern over and investment in food safety and quality assurance is driving regulatory changes. Agricultural policy and policymaking processes vary widely at sub-national, national, and regional levels but environmental concerns are gaining more weight. Transparency and associated issues of good governance remain a challenge.

Methodology

The study applied the ICEM Climate Change Vulnerability Assessment and Adaptation (CAM) methodology to key livestock systems identified in each of the hotspot provinces as described in the USAID Mekong ARCC Climate Change Impact and Adaptation Study Main Report. The vulnerability assessment follows a recognized approach of assessing the exposure and sensitivities to climate change threats, and the likely impacts that may result. When the impact is combined with the adaptive capacity of the species, a ranking and analysis of their vulnerability can be made.

The impact of climate change on livestock systems

Average maximum ambient temperature increases of up to four or five degrees Celsius, projected for parts of the LMB, will reduce productive performance and increase behavioral problems, morbidity, and mortality in the majority of livestock units without investment in cooling systems. Productivity losses and increased mortality rates, particularly among young and immuno-compromised stock will negatively affect farmer incomes and may increase prices of livestock-derived products, or drive increasing demand for imported products. The overall vulnerability assessment results for livestock in the LMB are summarized in the table below.

Livestock category	Impact	Adaptive capacity	Vulnerability
Smallholder cattle/buffalo	Low	Low	*Medium*
Dairy/large commercial	Very high	High	*High*
Small commercial pig	High	Medium	*High*
Smallholder low input pig	Low	Low	*Medium*
Small commercial chicken	Very high	Low	*Very high*
Scavenging chicken	Low	Low	*Medium*
Field running layer duck	Very low	Low	*Low*
Wild species vulnerability			
Banteng (esp. Mondulkiri)	High	Very low	*Very high**
Eld's deer (esp. Mondulkiri)	High	Very low	*Very high**
Sus scrofa	Low	Very low	*High*
Wild Poultry	Medium	Very low	*High*

*Assuming greater human and domestic stock incursion into habitats with climate change and ↑ disease risks and stresses due to hunting and competition.

Commercial production systems are becoming increasingly prominent in the LMB where they tend to be concentrated in the low-lying areas. They are most prominent in Vietnam and Northeast Thailand, and are becoming increasingly prevalent near Phnom Penh and Battambang in Cambodia. *High-performance breeds managed in high-density systems will be negatively affected by expected climate changes.* Temperatures above the upper critical value for specific animals will impact productivity and increase behavioral problems in intensely stocked systems. This effect will be most notable among poultry and pigs housed in higher stocking densities in more commercially oriented systems.

Drought, extreme temperatures, and even increases in rainfall will likely affect the availability and price of local feed sources and ingredients, resulting in significant impacts on smallholders. Drier dry seasons will likely increase the length and severity of low-feed periods for grazing stock and those fed predominantly on local raw feeds – systems that are already stressed with stock typically already scoring low on body condition.

Negative impacts on feed availability caused by drought and flooding will reduce stock condition and resilience to disease challenges. The quantity and quality of disease vector breeding sites will be altered by changes in the environment, particularly water availability. Greater climatic variability may include unseasonable rainfall in some areas, increasing stagnant water and increasing the availability of breeding grounds for mosquitoes. The need for greater feed preservation and storage may also encourage rodent problems.

Changing weather systems will influence the likelihood of pathogen transmission through fomites. Wetter wet seasons are likely, overall, to exacerbate current internal and external parasite problems: nematode infections are a common constraint to livestock production in the LMB, for example. Parasitic infestation is typically seasonal and associated with the wetter conditions, which are expected to increase.

Climate change is also expected to increase weather extremes, which will have negative impacts on livestock raising. Livestock may be lost through these increasingly frequent, extreme events. Flash and heavy flooding events already claim significant numbers in the region annually. The heavy floods in Cambodia in September-October 2011, for example, caused severe losses among all livestock. Two-thirds of households with livestock reported losing animals as a result of the flood (FAO-WFP 2012).[1] Stock losses due to the flood are estimated at 70% for poultry, 23% for pigs, and 5% for cattle (CARE 2012).[2] Over 55,000 head of livestock were lost during the 2009 floods in Thailand (MRC 2010).[3] In Lao PDR during the 1996 floods, households lost, on average and across wealth categories, half their cows and/or buffaloes (WFP 2012).[4]

In conclusion, for l**ow-input systems,** 'local' breeds have greater *internal* adaptive capacity to climate change but lower *external* adaptive capacity. Climate change will exacerbate nutritional problems reducing value and increasing disease risk in many areas. **Small and medium 'commercial' systems** are raising higher performance breeds under greater stress. They have a lower *internal* adaptive capacity but typically greater *external* capacity to adapt to climate changes.

Projected temperature increases will raise costs of livestock production in the LMB. Climate change will alter disease risks for all livestock systems; in concert with other developments, disease risk is likely to increase. Wild species in the LMB are most threatened by changes in bovine production practices secondary to climate change; for example, increases in grazing of protected areas will increase the risk of disease transmission and the threat of hunting.

Adaptation

Improving livestock nutrition, health, and market access will improve household and stock resilience to climate change throughout the LMB while promoting economic development and reducing food insecurity, poverty, and vulnerability. There are five broad strategies to improve livestock development and increase resilience to climate change:

Nutrition: The quality and quantity of feed production, storage, and the nutritional balance of diets needs to be increased to reduce undernourishment. These measures involve improving the use of

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[1] FAO/WFP (2012) 'Crop and Food Security Update Mission to Cambodia: Report', Rome

[2] CARE, Catholic Relief Services, Oxfam and PACT (2012) 'Drowning in Debt: The Impact of the 2011 Cambodia Floods on Household Debt: A Survey of Poor Households in Three Affected Provinces'

[3] MRC (2010) 'Proceedings of the 8th Annual Mekong Flood Forum Vientiane, Lao PDR, 26 – 27 May 2010'

[4] WFP (2012) 'Risk and Vulnerability Analysis: Lao PDR' http://www.foodsecurityatlas.org/lao/country/vulnerability/risk-analysis

current resources, e.g., crop residues and wild forages, while increasing the level of forage cultivation. Also, it requires more effective technology transfer regarding critical techniques in cultivation methods and feed preservation. An important but difficult measure to implement is reducing grazing pressure on protected areas, which will reduce contact with wild populations and associated disease. This adaptation strategy applies particularly to smallholder bovines and low-input pigs. Key hotspots are Mondulkiri and Khammouan Provinces.

Disease resistance: Internal resistance needs to increase to reduce the threat of disease through improvement of nutritional status, body condition, and vaccination levels. It also requires improved biosecurity to prevent the movement of diseases onto and off the farm and to reduce the risk of pathogens entering the herd or flock. Controlling and limiting the movement of livestock is recognized as the most important biosecurity measure for most diseases, but many important hazards can be carried on contaminated clothing, equipment, and vehicles. EcoHealth approaches are needed, which view livestock health and its management in terms of the overall health of the farming ecosystem. This priority adaptation strategy applies to all livestock systems and especially to the hot spots - Kien Giang and Chiang Rai Provinces.

Housing: Housing location and design should maximize natural ventilation and minimize exposure to extreme events. This strategy applies especially to small commercial pig and poultry. Hotspot provinces are Kien Giang and Chiang Rai.

Production planning and offtake: Production planning and reproduction management in breeder herds/flocks should be improved – reducing inbreeding, recognition of oestrus, and earlier weaning, for example. Increased offtake rates, where beneficial, promote controlled destocking to reduce pressure on stock, land, and/or nucleus herds and flocks with the additional benefit of increasing household incomes. Flood- and drought-prone areas will benefit most. Low-input cattle, pig, and poultry systems are a primary target for this strategy. Hot spot provinces include Gia Lai, Mondulkiri, and Khammouan.

Access to markets: Access to input and output markets and producer organizations needs to increase to reduce input costs, increase prices received, and reduce price volatility. The main target for this strategy is livestock producers in remote areas and, once again, the hot spot provinces include Gia Lai, Mondulkiri and Khammouan.

In conclusion, the adaptation strategy for livestock relates to nutrition, animal health, and markets. The focus needs to be on improving animal nutrition among smallholder low-input systems, particularly bovines; reducing disease risks for all livestock systems by increasing disease resilience and minimizing disease challenges; and increasing smallholder access to and information on input, services, and product markets.

ABBREVIATIONS

AEZ	Agro-ecological Zone
AGAL	FAO Livestock Information, Sector Analysis and Policy Branch
AH	Animal health
AI	Artificial insemination
ACIAR	Australian Centre for International Agricultural Research
ARCC	Adaptation and Resilience to Climate Change (project)
CSF	Classical Swine Fever
CBD	Convention on Biological Diversity
FAO	Food and Agriculture Organization of the United Nations
FMD	Foot and Mouth Disease
GLiPHA	FAO Global Livestock Production and Health Atlas
GMS	Greater Mekong Subregion
GSO	General Statistics Office of the Government of Vietnam
HS	Hemorrhagic Septicemia
ICEM	International Centre for Environmental Management
ILRI	International Livestock Research Institute
LMB	Lower Mekong Basin
LU	Standardized Livestock Units
PRRS	Porcine Reproductive and Respiratory Syndrome
SPS	Sanitary and Phytosanitary measures of the WTO
sq km	Square Kilometer
USAID	United States Agency for International Development
WTO	World Trade Organization

CONVERSION FACTORS

Livestock Unit (LU) Conversion Factors:	
Cattle	0.65
Buffalo	0.70
Sheep and goats	0.10
Pigs	0.25
Poultry	0.01

Source: FAO-AGAL 2005a

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INTRODUCTION

1.1 USAID MEKONG ARCC PROJECT

The USAID Mekong ARCC project is a five- year program (2011-2016) funded by the USAID Regional Development Mission for Asia (RDMA) in Bangkok and implemented by DAI in partnership with ICEM and the World Resources Institute (WRI). The project focuses on identifying the environmental, economic, and social effects of climate change in the Lower Mekong Basin (LMB), and on assisting highly exposed and vulnerable rural populations in ecologically sensitive areas increase their ability to adapt to climate change impacts on water resources, agricultural and aquatic systems, livestock, ecosystems, and livelihood options.

USAID Mekong ARCC includes five major technical tasks in addition to overarching program management. These are:

1. Regional Platform Partner and Knowledge Center;
2. Climate Change Impact and Adaptation Study;
3. Ecosystem and Community-based Adaptation Initiatives;
4. Valuing Ecosystem Services in Economic Planning for the Lower Mekong River Basin; and
5. Scaling-Up Successful Approaches.

1.2 CLIMATE CHANGE IMPACT AND ADAPTATION STUDY

The aim of this component of the USAID Mekong ARCC project is to undertake a climate change vulnerability and adaptation study on the water resources, food security, livelihoods, and biodiversity of the LMB. The study has been led by ICEM and the study team is made up of 21 international and regional specialists.

The climate study lays the foundation for the whole USAID Mekong ARCC project by providing the scientific evidence base for identifying highly vulnerable and valuable agricultural and natural systems assets in the LMB, defining adaptation options and priorities, and guiding the selection of focal areas for enhancing existing adaptation strategies and demonstrating and testing new approaches. The study focuses on five themes: i) agriculture; ii) capture fisheries and aquaculture; iii) **livestock**; iv) natural systems; and v) socio-economics.

The objectives of the climate study are to take an ecosystems approach in:

1. **Identifying climate change impact and vulnerabilities** of rural poor and their environment - water resources, food security, livelihoods, and biodiversity (fisheries and wildlife);
2. **Identifying hot spots in the LMB** by providing a scientific evidence base to guide the selection of pilot project sites;
3. **Defining adaptation strategies for the main threats** to inform and guide community and ecosystem-based adaptation pilot projects; and
4. **Communicating the results** of the vulnerability assessment and adaptation planning.

The climate study has an LMB-wide perspective. It starts by analyzing basin-wide climate changes and vulnerabilities according to ecological and administrative boundaries. It takes the vulnerability and adaptation responses to species and habitat level but still from a basin-wide view. Necessarily the adaptation strategies proposed provide broad guidance – the site-specific adaptation plans under subsequent phases of the USAID Mekong ARCC project need to be developed with local communities and governments, using local knowledge and tailored specifically to suit local conditions; while at the same time drawing from the tool box set out in the Main Report and accompanying theme reports.

1.3 LIVESTOCK THEME

This report presents the results of the livestock evaluation components of the USAID Mekong ARCC study. It establishes an initial baseline of the current status, trends, drivers, and tolerances of key livestock production systems in the LMB and hotspot provinces; then uses this information to develop hotspot province vulnerability assessments; and ultimately adaptation options for livestock throughout the basin.

The content of the report is as follows:

Section 1 Livestock Baseline

***Methodology*:** presents the criteria for selecting species and systems, and provides further information on the methods used; identifies and characterizes the key species and systems by ecozone, province, and country; discusses livelihood and biodiversity considerations; and outlines the caveats and potential pitfalls in the methods of data collection and analysis used.

Livestock baseline: assessment of livestock species and systems vulnerability to specific climate change threats; includes examples of impacts from past extreme climatic events on livestock in the LMB; and summarizes potential climate change effects on current livestock systems.

***Hotspot baseline profiles*:** presents brief summary profiles of the key livestock systems in identified hotspot provinces of interest.

Section 2 Livestock System Vulnerability Assessments

Presents an overview of the vulnerability assessments conducted by hotspot

Section 3 Livestock adaptation

Describes methods and options for adaptation taking a livelihood development approach with the addition of a climate change 'filter' or 'lens'. Adaptation options proffered are neither specific nor exhaustive but identify and demonstrate methods of approaching livestock systems development, providing example interventions.

The report also includes significant resources in the annexes.

- **Annex 2**: provides an inventory of select livestock species and breeds.
- **Annex 3:** provides a reference database summarizing development, production, and climatic tolerances for key systems and species.
- **Annex 4**: provides the hotspot vulnerability assessments in greater detail than the summaries provided in section 3. While somewhat unwieldy it is hoped they will be a useful reference point for future project activities.

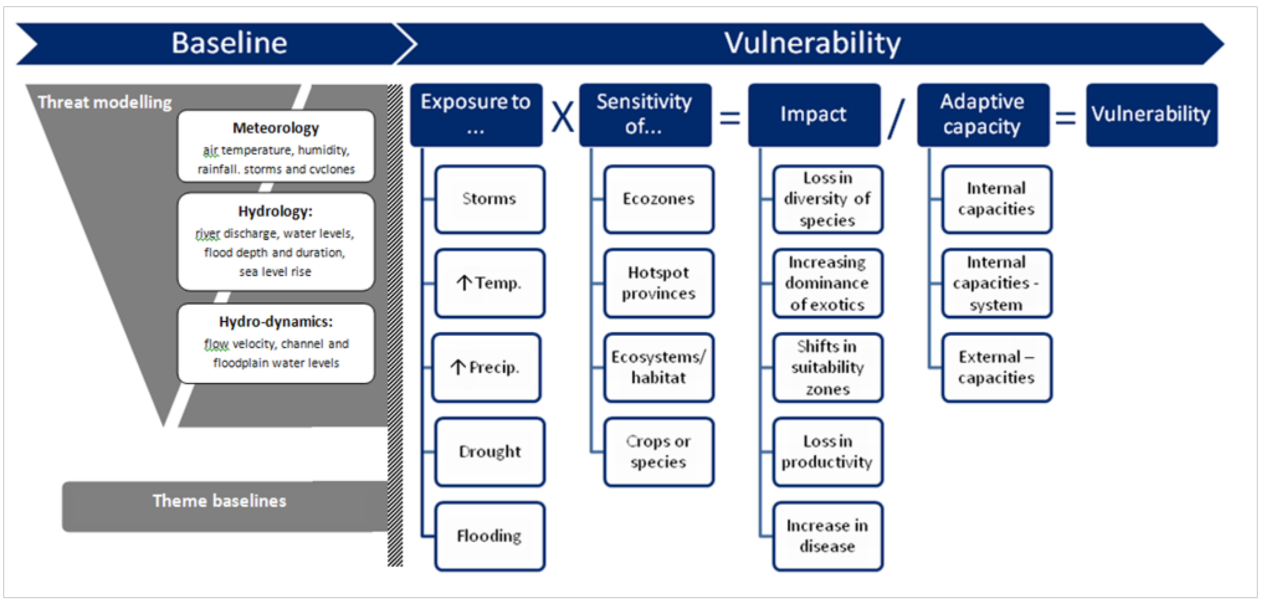
SECTION 1: LIVESTOCK BASELINE

1 METHODOLOGY

1.1 VULNERABILITY ASSESSMENT AND ADAPTATION PLANNING

The study applied the ICEM Climate Change Vulnerability Assessment and Adaptation (CAM) methodology to key livestock species and systems that were identified for each of the hotspot provinces as described in the Main Report. The vulnerability assessment follows a recognized approach of assessing the exposure and sensitivities to predicted climate change threats for the livestock species or system being considered, and determines the likely impacts that may result. When the impacts are combined with the adaptive capacity of the species or system, a ranking and analysis of their vulnerability can be made (Figure 1). A more detailed description of the CAM methodology is provided in the Main Report for the USAID Mekong ARCC study.

Figure 1. Parameters and issues considered in the CAM baseline and vulnerability assessment process



The vulnerability assessments were conducted at the hotspot province level. The results were then used to extrapolate broader findings and identify potential adaptation options for the LMB in general. The following hotspot provinces were selected on the basis of their exposure to climate change threats and representativeness of the LMB; more detail on this selection process is provided in the Main Report:

- Chiang Rai
- Gia Lai
- Khammouan
- Kien Giang
- Mondulkiri

To ensure a broad coverage of livestock production in the LMB the vulnerability assessments were undertaken for livestock systems rather than individual species. A multitude of parameters could be included in any given livestock classification system, such as: species, land demand, irrigation, production scale, flock/herd numbers, genotype, level of commercialization, end products, inputs, services employed, biosecurity levels, integration with cropping systems, ecological zones, livelihood zones, among many others. For the purposes of this assessment it was imperative that the system be relatively simple, and therefore user-friendly and reliable in distinguishing between systems. It should also be based upon data that can be verified to an adequate degree. Simplicity is required to minimize the likelihood of misclassification of systems and empirical evidence is needed to appropriately analyze and flesh out the data to give it meaning in the given context. Identification of key livestock systems is described further in Section 2.2.

On the basis of the specific tolerances identified for each system, which were collected in the baseline, expert judgment has been used to assess the level of vulnerability of livestock systems in the face of specific climate change-related threats. Threats considered include temperature change, precipitation change, changes in soil water availability, changes in frequency and intensity of drought, flooding, and storms. Climate change threat information for each hotspot province was provided by the study's modeling team; a detailed description of the modeling results is provided in the Main Report. To ensure consistency between the analyses of livestock systems the study team identified a series of criteria to assess exposure, sensitivity and adaptive capacity (Table 1).

Table 1. Criteria for exposure, sensitivity and adaptive capacity

Exposure	Sensitivity	Adaptive capacity
Type of shock	Breed	Species/breed
Duration	Housing system	Availability of/adaptability to other feed sources (**)
Frequency	Feeding system	Production system
Severity	Animal health risk (typical vaccination rate, level of biosecurity employed)	Accessibility of animal health/extension services (cost, quantity, quality, reputation)
Location of stock*	Value to household (cost of losses, livelihoods, food security)**	Outbreak responses (surveillance, compensation, etc.)
Location of relevant assets (feedstock, housing, etc.) *		Household wealth status and level of diversification**

**Relates primarily to extreme events, in terms of exposure, but there are also locality-specific impacts of other climate changes. Requires location-specific assessment*

***Location-specific assessment required*

1.2 SELECTION OF SPECIES/SYSTEMS

The project target area is defined by the lower Mekong river catchments and extends across four countries, Cambodia, Lao PDR, Thailand, and Vietnam, with a human population in the hundreds of millions and including 12 distinct ecological zones. The broad ecological and cultural diversity in the region has led to a diverse range and use of livestock systems.

The selection of species and systems was based on the following criteria:

- **Contribution to regional livestock numbers** - on the basis of total stock, livestock units (LU), number of livestock-raising households, and stock densities

- **Estimated monetary and employment contribution** to local/national economies
- **Broader consideration of contribution to household livelihoods and food security**: includes monetary and non-monetary contributions
- **Contribution to global genetic diversity:** i.e., indigenous breeds
- **Projected importance to regional production and consumption** in the medium term

1.3 SOURCES OF LIVESTOCK INFORMATION

Quantitative data has largely been sourced from the FAO Global Livestock Production and Health Atlas (GLiPHA) database. The GLiPHA database is built on data collected and processed by national institutions within each of the four project countries. These institutions are as follows:

- **Cambodia:** National Institute of Statistics Ministry of Planning
- **Lao PDR:** Ministry of Agriculture and Forestry, Department of Planning, Statistics Division
- **Thailand:** Center for Agricultural Information. Ministry of Agriculture & Co-operatives
- **Vietnam:** General Statistics Office

The data retrieved from GLiPHA has been supplemented with information from research papers, technical reports, and expert opinion.

To improve the comparability across species all figures are presented in standardized livestock units (LU) as opposed to total stock numbers (head) unless otherwise stated (Table 2). It should be noted that the use of LU figures tends to undervalue poultry relative to other species.

Table 2. Livestock unit conversion factors (*FAO-AGAL 2005a*)

Livestock Unit (LU)	Conversion Factor
Cattle	0.65
Buffalo	0.70
Sheep and goats	0.10
Pigs	0.25
Poultry	0.01

Stock densities are provided in density per total land area and density per agricultural land area because this may impact the design of future interventions. The significance of livestock in terms of food security, household livelihood portfolios, and household coping strategies is often greatest in more remote areas with lower population densities. This will be demonstrated in the following sections.

A number of caveats and potential limitations of the analysis should be noted and are outlined in Annex 1.

2 CHARACTERIZATION OF LIVESTOCK SPECIES/SYSTEMS

The following section describes LMB livestock species and systems beginning with general trends in consumption and production, then general descriptions of animal husbandry systems utilized in the basin, followed by more specific system descriptions by country. Further detail on species and breeds is provided in Annex 2, the species inventory, and on specific systems in Annex 3, the species/systems database.

In the discussions below national boundaries may appear arbitrary in relation to natural systems but national policy, tradition, and level of economic development generally affect livestock system capacity and use. Further, much of the secondary information available is organized by country.

2.1 MAJOR TRENDS IN LIVESTOCK IN THE LMB

The most prominent species of livestock raised in the LMB are cattle, buffaloes, goats, pigs, and poultry. The methods and reasons for production vary significantly across the region.

Livestock production systems can be divided into two categories:

- **'Traditional' small-scale, low-intensity, low-input, low-output systems:** typically raising stock of local genetics and with limited market orientation. Stock fulfill multiple functions including supporting other household livelihood income-generation mechanisms, a form of savings, short-term cash through occasional sales, and a contributor to social status. In these systems livestock are important contributors to food security both directly, through consumption of products, and indirectly through income from occasional sales. Traditional systems are prominent in more remote locations with lower access to markets and greater access to communal and protected land. These systems dominate the higher-elevation and forested ecological zones in the LMB.
- **Commercial units:** exhibiting more intensive management and husbandry practices; investing significantly more in inputs; and in which animals are raised specifically for income generation, usually through sales of meat, milk, and/or eggs. Stocks are commonly of improved genetics. The scale of commercially oriented operations in the region ranges significantly for each species. Commercial units are usually located in better-connected areas with greater access to markets. These systems are becoming increasingly prominent in the region; they tend to be concentrated in the low-lying ecozones in Vietnam, in northeastern Thailand, and are becoming increasingly prevalent near Phnom Penh and Battambang in Cambodia.

Consumption of livestock-derived products is increasing rapidly throughout the region and this is predicted to continue through the medium to long term. Rising demand for livestock-derived products is largely associated with increasing household incomes, higher living standards, availability of products, and increasing urbanization of the region's population. Demand predictions show a strong bias toward urban areas, which are predicted to continue growing rapidly over the coming years (FAO 2011 and Jabbar et al. 2010).

Livestock production is expected to keep pace with rising demand for all major livestock products except milk and Thai beef and poultry. Increases in milk production are expected to be outstripped by rocketing demand. Thailand is currently a net importer of beef and a large net exporter of poultry and is expected to increase imports of beef and exports of poultry over the coming years.

The significance of both small and medium household-operated commercial systems and large corporate producers are expected to increase due to rising demand for livestock products, increasing urbanization of populations, evolving land regulations, and the increasing presence of large agribusinesses. Traditional systems will likely remain prominent in more remote areas. In some areas they may become more commercially oriented with the uptake of improved technologies and as access to input and output markets increases.

Infectious diseases will continue to be a major constraint to the livestock sector in the LMB. A number of key infectious diseases are endemic in the region and emerging infectious diseases are a major concern. Disease prevalence restricts access to potentially lucrative export markets due to current WTO Sanitary and Phytosanitary (SPS) measures. Diseases also present threats to public health in the form of zoonotic diseases and food-borne health hazards. Controlling infectious diseases and food-borne hazards are prominent on the livestock development agendas of both governments and donors.

Input and output price instability is problematic for commercially oriented small and medium-scale pig and poultry producers that typically operate at low margins. The reasons for price instability are complex and not fully understood. They are often associated with disease outbreaks, stock movement bans, legal and illegal cross-border trade, international commodity prices, weather patterns, local environmental issues, exchange rates, and interactions between these factors.

Increasing mechanization in agriculture is changing the way in which large livestock are used. The role of bovines in the provision of traction is declining in flatter, lower-elevation areas, while numbers are increasing in more remote, mountainous areas, in particular Lao PDR. Cattle numbers are expected to climb but their primary purpose will shift towards beef and milk production. Buffalo numbers will likely remain relatively static across the region as a whole with numbers predicted to slowly increase in Lao PDR while declining in Cambodia.

2.2 SELECTION OF KEY LIVESTOCK SPECIES/SYSTEMS

On the basis of secondary sources and expert opinion, livestock systems were assessed against the criteria outlined in Section 2.2. Table 3 presents the systems and species selected for vulnerability assessments and the development of adaptation strategies. The selected systems, outlined in detail in Annexes 2 and 3, encompass over 95 percent of livestock-raising farms in the LMB, and more than 75 percent of the region's total livestock production. Examples of each of these species are included in the species inventory provided in Annex 2. Examples of native, wild livestock species are also included in Annexes 2 and 3.

Table 3. Key livestock systems

Livestock Species	Livestock Systems	Uses	Comments
Large ruminants - bovines Cattle, buffalo	Smallholder cattle/buffalo 'keeping'	Draft	Cattle and buffalo are commonly raised under similar husbandry systems and are subject to similar constraints in terms of general management, feeding, and animal health. As a result, they are largely considered together. Cattle 'keeping' systems refers to traditional smallholder livestock systems employing limited market orientation; stock are typically raised as contributors to broader livelihoods and as a form of household savings, rather than as a steady source of income.
	Smallholder cattle 'keeping'	Beef	
	Dairy	Dairy	
Pigs	Small commercial pig	Fatteners/breeders	Small- and medium-scale commercial pig systems show significant variation but for the purposes of this assessment were defined as household-owned, commercially oriented, confined pig production units. Pig units of this nature use processed feeds and rear less than 200 fatteners and/or less than 30 sows.
	Smallholder low-input pig	Integrated	
Poultry Chickens	Scavenging chicken	Dual purpose	Small- and medium-scale commercial poultry systems show significant variation but for the purposes of this assessment were defined as household-owned, commercially oriented, confined poultry production units. Poultry units of this nature typically rear total head numbering less than 5,000; they buy in chicks or incubate mechanically and use processed feeds.
	Small commercial chicken	Broilers	
		Layers	
Ducks	Field running layer ducks	Layers	
Wild Species Banteng, saola, gaur, kouprey, eld's deer, *Sus scrofa*, wild poultry			

Though small ruminants, goats and sheep, and other poultry systems, such as quail, geese, and Muscovy were considered they were not selected for further impact assessment for the following reasons:

- Goats are almost exclusively raised in scavenging systems and are less significant contributors to the above criteria than other species in the region as a whole, despite their importance in some areas; information on goats is limited and rather unreliable;
- Sheep are of little significance in terms of the region's livestock and this is unlikely to change in the near future;
- Muscovy, quail, geese, pigeons and guinea fowl are raised in similar systems to chickens and ducks (impacts can to some extent be extrapolated to these species); they are less significant and the information found on these species was limited.

Large commercial pig and poultry systems are considered where their effects on other production are particularly important. These production systems generally exhibit greater vertical integration and are run by national or multinational corporations. They are important and growing in terms of regional production and competition. However, while important in terms of competition, employment, and consumer prices for products, they are not operated by poor and/or vulnerable households.

2.3 CHARACTERIZATION OF KEY LIVESTOCK SPECIES/SYSTEMS

2.3.1 LARGE RUMINANTS

Cattle

Trends in consumption and production

Beef consumption and production has increased significantly across the LMB countries over the past 30 years with the exception of Thailand. In Cambodia and Lao PDR this trend has been greatest where production and consumption has quadrupled between the years 1980 and 2000 (Knips 2004). This upward trend is predicted to continue. FAO (2011) predicts high growth in beef consumption throughout the LMB countries to 2030, particularly among urban consumers. Total beef consumption in Cambodia is predicted to increase by 180% of 2000 levels by 2030; Lao PDR, Vietnam, and Thailand are all expected to increase by approximately 160%. Thailand is the only country that is not self-sufficient in beef production and this will likely remain the case in the medium to long term; Cambodia and Vietnam are predicted to meet domestic demand; and Lao PDR is predicted to produce the only significant surplus by 2030 (FAO 2011).

Consumption and production for milk in all four countries will grow over the same period (2000-2030), although from a significantly lower base (FAO 2011). While total domestic production is predicted to increase dramatically, growing demand is expected to outstrip production and milk imports will rise accordingly (FAO 2011).

The total cattle population of the region is likely to grow considerably over the coming years with the gradual shift from draft to beef production, and possibly milk, in response to increasing demand. The role of cattle in the provision of traction is likely to reduce in low-lying areas where mechanization and intensification of landuse is predicted to continue. Cattle production systems are likely to gradually shift towards beef. There is some evidence of this in parts of Thailand and Vietnam, although this will probably be very slow in more remote areas.

Cattle system description

Cattle are predominantly raised for beef and to support other livelihood activities, through traction and manure. They also provide a means of generating private income from communal land through grazing. Draft is often the primary reason for raising cattle in the LMB, particularly in Cambodia and more remote areas. Cattle also contribute to household energy requirements with household and village biogas digesters becoming increasingly prevalent in the region, particularly in Vietnam and Cambodia. Cattle are also important for status and social standing in many areas.

Upland cattle raising is loosely integrated with rainfed cropping and agroforestry/forestry. **Upland cattle require high initial investment and are raised in low-input, extensive smallholder systems.** Cattle provide draft, a form of savings, manure, status, and eventual consumption and/or sale/gifting as beef (Simaraks 1998). They may also be sold as a coping strategy when short-term cash is needed. Typically cattle mate naturally while grazing, although artificial insemination and increased breeding management is occurring, notably in Vietnam.

In mountainous areas the most common breed is the local 'yellow' breed used primarily for beef (ASVELIS 2011, Cocks et al. 2004). Yellow cattle generally graze freely or supervised on communal ranges and fallow arable land particularly in Cambodia, Lao PDR, and upland areas in Vietnam where labor is often shared among households. Yellow cattle feed is occasionally supplemented with cultivated or wild forages including grasses and tree legumes in cut and carry systems, and on crop residues and byproducts of cultivation. They are infrequently vaccinated and dewormed. They rarely surpass 250-300 kg liveweight (LW) and are usually sold at weights below their genetic potential, primarily due to undernourishment (Maclean 2006). Stocks are generally managed as assets, sales are rarely planned – farmers seldom fatten intensively prior to sale. Traders in some areas will buy low body weight cattle and fatten intensively for several months before sale, notably Hmong cattle traders in Lao PDR and northern Vietnam (ASVELIS 2011; Cocks et al 2004; Luthi 2007).

Draft cattle are often zebu crossbreds; most commonly Sindh crosses in Vietnam and Lao PDR and Brahman crosses in Cambodia (ASVELIS 2011). **These animals are usually kept in the village and used to support cropping, vegetables, and other forms of household income generation through draft and manure.** They are often supplemented with cut and carry forages. Draft animals are more commonly vaccinated against hemorrhagic septicemia (HS) and foot and mouth disease (FMD). Draft cattle typically reach significantly higher liveweights than yellow cattle due to genetics and low offtake rates. Deworming is rare.

Dairy animals are predominantly of exotic genetics, primarily Holstein-Friesians and crosses, and are raised in more intensive, commercialized systems. Dairy consumption and production is growing rapidly in Thailand and Vietnam particularly, however, the national herds remain small relative to draft and beef animals. Most dairy products are currently imported.

Country-level trends

Cambodia

Cambodian cattle owners typically own two head. Some authors have associated cattle ownership with wealthier households, though other estimates suggest cattle ownership is much more widespread. Average carcass weights are estimated at 120 kg (FAO 2005). Cattle are closely associated with rice growing through draft and manure and as such are concentrated in rice cultivating areas (Knips 2004). Cambodian cattle are typically Brahman crosses, yellow cattle, or other zebu crosses.

Lao PDR

Cattle are widely distributed in Lao PDR but most common in the central region. They are commonly grazed on fallow cropping areas and on hill country slopes (FAO-AGAL 2005). Carcass weights were estimated to average approximately 130 kg in 2002, an increase of approximately 50% of weights in 1980. Cattle genotypes are typically yellow cattle and various zebu crosses. Formal and, more commonly, informal cross-border trade of cattle into and from Lao PDR is very significant. Cattle often arrive from Thailand (having originated in India and Myanmar) and return to Thailand or are traded to Vietnam. Many are also traded north to China (Cocks et al 2004; Knips 2004; Luthi 2007 and 2010).

Thailand

Cattle are prominent throughout rural Thailand and are notably common in the northeast. FAO-AGAL (2005) estimate Thai cattle average carcass weight at 200 kg, significantly higher than neighboring countries.

Dairy farming is growing rapidly in Thailand. Dairy herds were very small (less than 10 milkers) in the past but are increasing. Dairying is heavily concentrated in central Thailand and while there are small operations in the northeast they are of limited significance at present (FAO 2012c; Knips 2004).

Vietnam

Cattle are common throughout rural Vietnam and form a key part of most mixed irrigated and rainfed systems. Cattle are particularly prevalent in the central and northern regions where they are commonly raised for draft as well as beef (Knips 2004). Cattle are also raised extensively in the deltas and in peri-urban environments. Smallholder cattle are typically raised in herds of one to four head in Vietnam with the exception of some central highland areas where herd sizes are commonly 10 head or more. Crop residues and free grazing are the main feed sources. Cattle carcass weight is estimated at approximately 180 kg; this may be distorted by draft animals, which are usually the much larger Sindh crossbreds (Quirke et al. 2003; FAO-AGAL 2005).

Dairy in Vietnam has been concentrated around HCMC but is growing rapidly with rocketing national consumption. Numerous large farms have recently been established in central Vietnam and in the north. Wealthier interests dominate Vietnamese dairy production. Dairy production remains relatively small by comparison with beef and draft cattle in the project areas but will likely become increasingly important (Quirke et al 2003).

Buffaloes

Trends in buffalo rearing

In low-lying, more agriculturally productive areas of the LMB buffalo numbers are generally declining in line with increasing mechanization of agriculture, and reduced availability of grazing areas and accessible forages. However, buffalo remain an important low-maintenance cost, high-utility source of traction, and high-value asset in more sloping and remote areas. Buffalo are also important in terms of status in many parts of the LMB. This will likely remain the case in the foreseeable future.

System descriptions

Buffalo are primarily raised for draft and manure and as assets while also providing buffalo meat and hides. Buffalo are almost exclusively raised in small household herds, typically of one to four head, within defined crop-livestock systems where their role in land preparation is particularly significant.

Buffalo are usually raised in traditional, low-input systems; they are often free grazed under supervision or tethered on nearby communal lands and fallow cropping areas. Cut and carry supplementation is also common. Unlike cattle they are rarely grazed on more distant range lands largely because of the time-consuming nature of moving buffalo and their important roles in other household livelihood generation activities in and around villages.

Buffalo excrement also contributes to household energy requirements with increasing use of biogas digesters in many areas.

Country-level trends

Cambodia:

It is estimated that approximately 50% of rural households in Cambodia own buffalo. They are concentrated in rice-growing areas due to their use in land preparation and for manure. This figure is likely to decline with increasing mechanization (Knips 2004; Shepherd 2010). Buffalo carcass weights were estimated at 160 kg in Cambodia (FAO-AGAL 2005).

Lao PDR:

Buffalo in Lao PDR are most common in the central region and are managed in a similar manner to cattle, generally free grazing on communal/protected forested areas, highly sloping lands, and fallow arable lands, often unsupervised. They may be supplemented with cut and carry forages (cultivated or, more commonly, growing wild) and crop residues such as stover and bran. Buffalo are primarily used for draft, manure, and home consumption with occasional sales (FAO-AGAL 2005). Buffalo carcass weights in Lao PDR have been estimated at approximately 110 kg, but the reliability of this figure is doubtful given it is significantly lower than cattle carcass weights in the same region.

Thailand:

Thai buffalo carcass weights are the highest in the region and were estimated at 253 kg by FAO-AGAL (2005). Thai buffalo numbers are declining, again associated with increasing mechanization; however, the majority of Thai buffalo are located in the northeastern region of the country making them an important consideration in the context of this project (GLiPHA 2012).

Vietnam:

Buffalo are concentrated in the north of Vietnam outside of the USAID Mekong ARCC study area, though there are significant numbers in LMB mountainous areas of Vietnam and significant, though decreasing, numbers in the Mekong Delta. Buffalo in the delta are concentrated in the 'delta mangroves and saline water' ecozone. Like cattle in Vietnam, buffaloes are usually raised within mixed farming systems for draft and manure (FAO-AGAL 2005; Knips 2004). Buffalo carcass weights in Vietnam average 215 kg (FAO-AGAL 2005).

2.3.2 SWINE

Trends in consumption and production

Pig production and consumption is high in the LMB, particularly in Vietnam, and has risen sharply over the past 30 years. All four countries are currently self-sufficient in pork production (Knips 2004). Cambodia increased both production and consumption by a factor of 14 between 1980 and 2000 though beginning from a very low base. Increasing consumption will be focused in urban areas in all four LMB countries. Cambodian total (absolute) pork consumption is predicted to increase by approximately 230% from 2000 to 2030, Lao PDR by 180%, Vietnam by 160%, and Thailand will approximately double. Cambodia and Lao PDR production is predicted to keep pace with domestic consumption, while Thailand and Vietnam may produce a small surplus (FAO 2011).

Description of Systems

Pig production is, by and large, more commercialized than other species in Cambodia, Thailand, and Vietnam, though less so in Lao PDR. Some degree of specialization is common. An average sow farmer might maintain up to 10 sows and fatten a number of slaughterhogs, selling off excess weaners to other farmers dependent on available space, and short-term household capital needs. Fattener farmers typically raise between two and 50 slaughterhogs.

In lowland areas pigs are often raised in small- and medium-scale commercial units. In these systems they are fed on purchased processed feeds, vaccinated, and provided with animal healthcare well beyond the level of other species; these systems are particularly prevalent in Vietnam. Most pigs raised in these systems are crosses of exotic genotypes such as landrace, Yorkshire, large white, durocs and, less commonly, pietrans (typically F2+). Sows are often artificially inseminated, particularly in Vietnam where artificial insemination stations are particularly accessible even in more remote areas. Slaughterhogs commonly reach liveweights of 80-100 kg in six to seven months in well-managed systems. In these units pigs are clearly raised for income generation in relatively high-input, high-output systems (Simaraks 1998). This method of rearing is common in areas with reasonable access to markets. Disease outbreaks and price volatility make pig rearing in this manner high-risk but farmers can be well rewarded.

Traditional, low-input extensive systems in which pigs freely scavenge, are tethered or reared semi-confined are still common in much of Lao PDR and remote areas in Cambodia, Thailand and Vietnam. These systems are often linked to rice production through feeding of byproducts (Simaraks 1998). Pigs raised in this manner are usually of local 'black' genotypes reaching relatively low bodyweights, depending on breed, age, and system (50-70 kg liveweight in nine months+ would encompass most). In these systems pigs are treated as a form of savings with occasional sales, or are slaughtered for social events such as weddings. Inbreeding is a common concern. Vaccination levels are typically very low.

Country-level trends

Cambodia:

The majority of Cambodian farmers own pigs. **Pigs are predominantly raised in traditional systems** as described above. Households typically rear one or two head obtaining carcass weights estimated at 50 kg/head (FAO-AGAL 2005). However, pig raising appears to be shifting towards the Vietnamese-type of intensive small-scale production model particularly in better-connected areas. Larger-scale intensive systems are also establishing themselves, particularly near urban centers such as Phnom Penh and Battambang (Knips 2004; Indochina Research Ltd and Phil Psilos 2007). Pigs are commonly fed on agricultural byproducts, in particular rice bran and byproducts of fruit and vegetable cultivation. Quantity, quality, and price of rice bran may be the main factor affecting the profitability of pig production for smallholders (Maclean 1998). Disease outbreaks, in particular PRRS and CSF often introduced through illegal trade from Vietnam, are also important based on assessments and discussion with the USAID Cambodia MSME project swine team and the Department of Animal Health.

Lao PDR:

Upland households in Lao PDR commonly raise pigs in traditional systems. It has been estimated that over 60% of the population are engaged in pig rearing. A few small commercial units exist near the main urban centers (Knips 2004). The large majority, over 95% by some estimates, of pigs reared in Lao PDR are of local genetics. FAO-AGAL (2005) estimated pig carcass weight to be a mere 24.8 kg in 2002. Pig numbers per household are typically between one and four (Knips 2004).

Thailand:

The Thai pig industry is now dominated by large-scale commercial operations. This shift has largely been attributed to the increasing costs of production and limited access to credit which has forced smallholders out (Knips 2004; Quirke et al. 2003). Smallholder pig production is still common in northeast Thailand. Average carcass weight for the whole country is estimated at around 65 kg but is probably lower in traditional systems in more remote areas (FAO-AGAL 2005).

Vietnam:

Pig farms in Vietnam typically have between five and 100 in the herd, though usually at the lower end. Pig farming is most significant in the north of Vietnam in areas outside the study region. According to Quirke et al. (2003), pig production in Vietnam generally centers on areas with high levels of cassava, rice, and soybean cultivation, however, production has probably spread in recent years with increasing ease of transport of feed and stock.

Roughly 80-95% of Vietnamese pigs are raised on family farms. Average carcass weights are high, estimated at 81 kg, however there is significant variation in this figure. Much of the national pig population now consists of crossbreds raised in confined systems on processed feeds (FAO-AGAL 2005; Knips 2004).

2.3.3 POULTRY

Trends in poultry related consumption and production

Poultry production and consumption is estimated to have increased by a factor of approximately three between 1980 and 2000 in all four LMB countries (Knips 2004). **Demand is predicted to continue to increase throughout the region, largely driven by increasing urban consumption.** By 2030, Cambodian and Vietnamese poultry meat consumption is expected to increase by almost 240% of 2000 levels, in Lao PDR by approximately 195%, and in Thailand by approximately 130%. Cambodia, Lao PDR and Vietnam will approximately match domestic demand with production. Thailand, with an existing large export industry for poultry meat, is expected to increase exports from approximately 400,000 MT in 2000 to an estimated 600,000 MT by 2030 (FAO 2011).

Egg consumption in Cambodia and Lao PDR is predicted to increase by 250% of 2000 figures by 2030, in Vietnam by 150%, and in Thailand by 70%. All countries are expected to satisfy domestic egg consumption with minor surpluses (FAO 2011).

Description of systems

Commercial poultry production remains small relative to total numbers of farms and total bird numbers in the region with the exception of Thailand, which has a strong commercial sector.

The following subsections provide more descriptions of important poultry management systems in the LMB.

Chickens:

Broiler chickens

Broiler chicken production can be divided into three categories: i) 'backyard, subsistence systems' generally raising naturally bred, local, and slow-growth breeds in extensive, low-input systems with minimal biosecurity measures and minimal vaccination; commonly roosting under homes or in nearby trees or provided with low-cost shelters; ii) 'small- and medium-scale commercial' units, raising batches of local or crossbred birds in confined systems, purchased as day-old-chicks from hatcheries or traders, using processed complete feeds, and commonly vaccinated against fowl pox, fowl cholera, gumboro, and Newcastle disease; and iii) 'large commercial' units resembling intensive poultry units in developed nations, raising rapidly maturing white or colored birds of exotic genotypes, fully vaccinated and in more biosecure systems.

Products: meat, offal, manure, feathers

Layer chickens:

Layer chickens are typically raised in commercial units, are predominantly of colored exotic genetics, are fed on complete feeds, and are generally well vaccinated. Spent hens contribute a significant proportion of chicken meat consumed in the region.

Products: eggs, meat, manure, feathers

Ducks

Broiler ducks

Meat ducks are commonly raised in traditional systems resembling (and often mixing with) scavenging chickens and other poultry. In some areas, notably in the Mekong Delta and Tonle Sap, small to medium scale commercial units operate semi-confined systems. They are commonly supplemented with commercial processed feeds and are sometimes vaccinated against duck plague.

Products: meat, manure, feathers

Layer ducks:

'Field-running layer ducks' are specific to the Mekong Delta region, particularly Vietnam, and are discussed in the Vietnam description below.

Products: eggs, meat, manure, feathers

Other Poultry:

Quail are relatively common in Vietnam, and to a lesser extent in Thailand and Cambodia. Quail are raised in intensive systems for meat and eggs (both 'fresh' and half-hatched). They are sometimes vaccinated[5].

Muscovy, geese, turkeys, and guinea fowl are raised extensively in backyard systems with minimal supplementation; they are sold occasionally or more often consumed by the household or gifted. Some more commercially oriented operations have developed, largely in Vietnam and with some presence also in Thailand.

Products: meat/eggs, manure, feathers

Country-level trends

Cambodia:

Approximately 90-95% of farming households in Cambodia have chickens (Knips 2004). The great majority of Cambodian chickens are of local genotypes raised primarily for meat in scavenging, low-input, low-biosecurity backyard systems. Chickens may occasionally be supplemented with crop byproducts. Poultry carcass weights estimated by FAO-AGAL (2005) are 1.1 kg in Cambodia, however, chicken carcass weights are probably closer to 0.6-0.8 kg/head based on experience conducting assessments in markets in Cambodia. A number of large commercial broiler and layer units raising exotic, high-productivity breeds have recently been established near Phnom Penh – notably by CP Cambodia Co. and a number of other Cambodian companies– the number and significance of these units will likely increase quickly.

Lao PDR:

Most farmers in Lao PDR raise local chickens in traditional, very low-input, scavenging, backyard, low-biosecurity systems (FAO-AGAL 2005). FAO-AGAL (2005) estimate poultry carcass weights to be 0.8 kg. Backyard chickens are thought to be an important source of cash income for subsistence farmers (Knips 2004). Cottage commercial poultry farms exist particularly in the environs of Vientiane. Commercial production costs are high as Lao PDR has little or no commercial domestic feed supply meaning these systems rely on imported feeds from Thailand and Vietnam.

Thailand:

Backyard poultry are common throughout rural Thailand, particularly in more remote areas such as the northeast; however, large commercial interests now dominate poultry production in Thailand. Average poultry carcass weights in Thailand are estimated at 1.3 kg (FAO-AGAL 2005); however, the commercial poultry sector raising exotic high growth/high lay rate industrial breeds is likely skewing this estimate. Smallholder average chicken carcass weights are more likely 0.6-0.9 kg based on experience working with local and crossbred genetics in Thailand.

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[5] Discussions with quail producers indicated that quail vaccine availability and quality is poor.

Vietnam:

An estimated 75% of Vietnam's poultry are raised by smallholders (Knips 2004). However, small commercial units raising between 500 and a few thousand head in batch systems are more prevalent than in regional neighbors. Most large farms are located near major urban centers.

Chickens and ducks dominate the national poultry flock and are raised for both meat and eggs. Quail are also significant and are unique among Vietnamese poultry in that they are almost exclusively raised intensively in commercial units, though many of these would be considered small. Muscovy, geese and guinea fowl are also raised, largely in backyard scavenging systems. Muscovy is the most import of these species.

The delta is one of the world's largest duck production regions with ducks integrally linked to rice production. 'Field running ducks' are raised extensively in relatively large flocks typically of 1,000-5,000 head, they also fertilize the rice fields, and are effective at removing pests and cleaning up paddy losses. The flocks can travel tens of kilometers crossing provincial and national borders (i.e., into Cambodia). The system is extremely efficient, which is something of a conundrum for those seeking to combat disease threats given the likelihood these ducks act as a reservoir for the highly pathogenic avian influenza HPAI (ducks are largely asymptomatic) and given the management system leads to high risk of pathogen spread.

Local breeds are most prevalent contributing an estimated 70% of the national flock, with 30% consisting of crossbreds and exotic genotypes. Larger commercial enterprises have developed in recent years and are increasing quickly in significance; generally raising high growth/lay rate exotic genetics. Carcass weights are estimated to average 1.4 kg (FAO-AGAL 2005). The outbreak of HPAI has seen dramatic changes in the sector makeup, particularly in the delta areas. For example An Giang Province was a large chicken producing province prior to 2003 but no longer produces chickens due to the prevalence of HPAI.

2.4 KEY LIVESTOCK LINKAGES WITH OTHER SECTORS

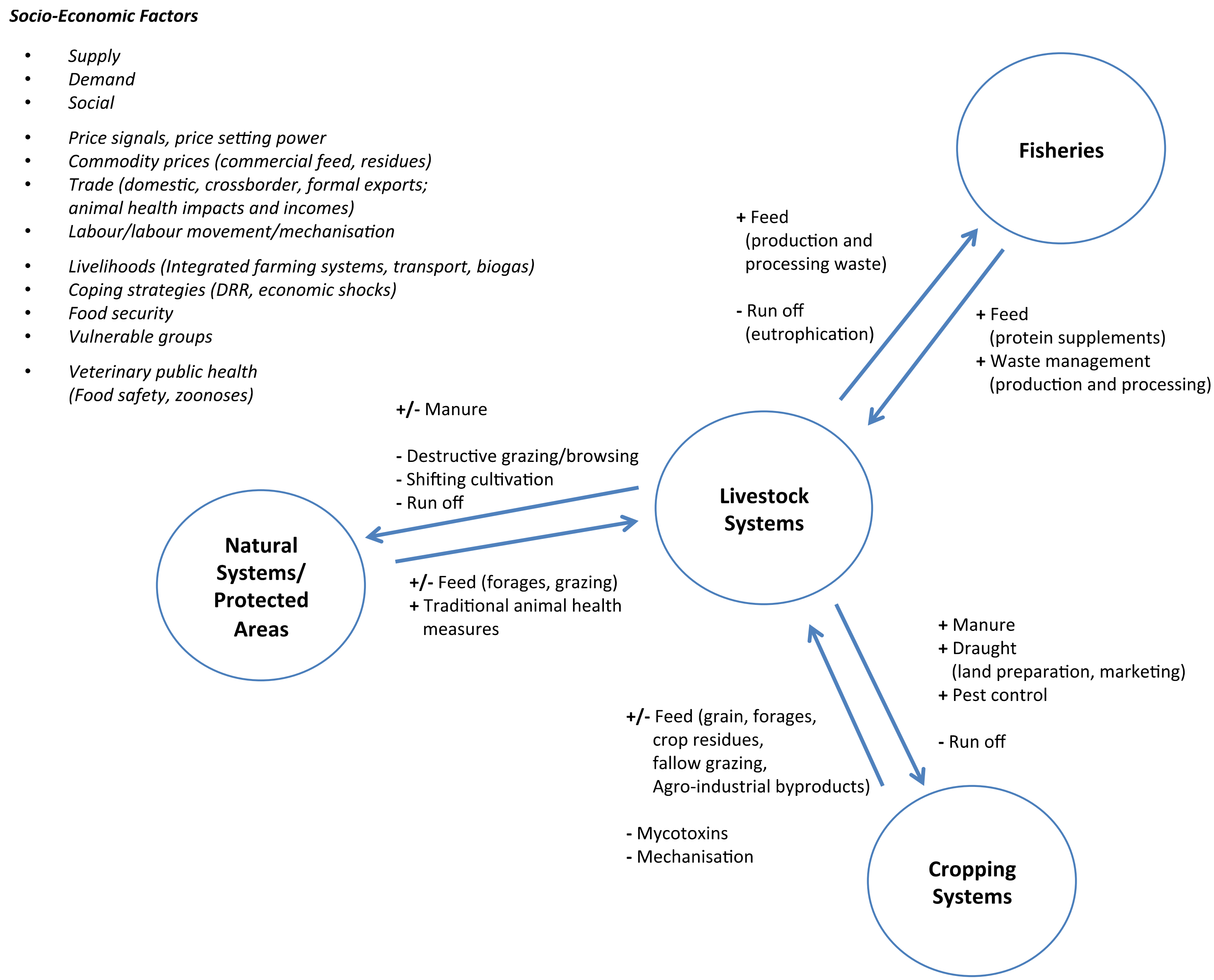
Most livestock raised in the LMB are closely integrated with other farming and livelihood systems, particularly smallholder livestock production. The large majority of households operate diversified livelihood systems that typically include livestock, crops, vegetables, fruit, fish, timber and NTFPs, as well as off-farm labor and trading. Each aspect is directly linked through finite household labor resources and most aspects will also be linked biophysically. For example:

- Agriculture: livestock are commonly used in land preparation for the cultivation of crops, for manure, and in transporting produce to markets. Stock is often supplemented with crop residues, agricultural byproducts, and through grazing of fallow areas.
- Natural systems: stock may range, graze, and browse natural and protected areas while dunging.
- Fisheries: fish are commonly utilized in waste management at slaughtering facilities and may be used as protein supplements for monogastrics, in particular.
- Socio-economic systems: livestock are also integrally linked to socio-economic systems by contributing to household livelihoods and resilience through physical, financial, human, natural, and social capital.

There are also potential negative linkages and feedback loops between livestock and household livelihoods including risk of losses, occupational hazards, veterinary public health risks, and local environmental damage and pollution.

Figure 2 presents some linkages between the key themes considered by this study. It should be noted that the figure provides examples and is not exhaustive. The influences of socio-economic factors are wide-ranging hence the representation of these factors encompassing the other four sectors under consideration. As this baseline focuses on livestock, this theme is placed at the center. However, there are also numerous, complex interactions between the other sectors. The **+** and **–** symbols suggest potentially positive and/or negative interactions between livestock and other systems. However, they are indicative and no attempt has been made to quantify interactions.

Figure 2. Linkages between the key sectors considered by this project



3 CLIMATE TOLERANCES OF LIVESTOCK SYSTEMS

3.1 GENERAL POTENTIAL IMPACTS

'When combined performance level and environmental influences create a low level of vulnerability, there is little risk. As performance levels (e.g., rate of gain, milk production per day, eggs/day) increase, the vulnerability of the animal increases and, when coupled with an adverse environment, the animal is at greater risk. Combining an adverse environment with high performance pushes the level of vulnerability and consequent risk to even higher levels. Inherent genetic characteristics or management scenarios that limit the animal's ability to adapt to or cope with environmental factors also puts the animal at risk. At very high performance levels, any environment other than near-optimal may increase animal vulnerability and risk.' [6]

Possible climate change impacts on livestock systems include:

Productivity

- Temperature must be considered for all species in relation to housing, in particular bedding and air circulation, but also humidity, thermal history, feeding rates, stocking rates, weight, age, sex, and genotype. Poorly housed exotic or crossbred stocks are most likely to experience losses in productivity.
- Critical temperatures vary by species but once reached will impact productivity and increase behavioral problems with some stock, particularly poultry and pigs housed with higher stocking density in more commercial systems.
- Lethal effects of temperature would be unlikely in most of the region. However, cattle and buffalo losses in northern mountainous areas have been associated with very cold snaps in 2008 and 2011 and likely had greater impacts on total numbers of poultry and pigs, though this was not publicized.

Animal Health

- The quantity and quality of disease vector breeding sites will change in relation to changes in the environment. Specific disease vectors of significance in the region include arthropods (mosquitoes, flies, ticks, etc.), and rodents (Forman et al. 2008).
- The likelihood of pathogen transmission through fomites is likely to be affected. For example, wetter weather increases the likelihood of disease transmission through mud. This will increase the importance of biosecurity measures such as cleaning, disinfection and control, quarantining, disposal of dead animals, and of controlling on- and off-farm traffic.
- Wetter wet seasons are likely, overall, to exacerbate current parasitic problems, both internal and external.

[6] Quote from Dr. J.L. Hatfield of the U.S. Department of Agriculture (The Pig Site 2008)

Nutrition

- Climatic changes will likely affect the availability and price of feed sources and ingredients and will have significant impacts on all producers, particularly more commercially oriented farms.
- Drier, and in some locations longer, dry seasons will likely increase the length and severity of low-feed periods for grazing stock and those fed predominantly on local raw feeds. The need for good feed preservation systems will increase and issues such as aflatoxins, already a significant constraint to many production systems, will likely increase.
- Aside from direct impacts on growth rates and reproductive performance, undernourishment also reduces livestock resilience to stress and disease challenges.

Extreme events: flooding, drought, storms

- Both slow and rapid-onset extreme events can affect livestock directly and indirectly. Livestock may be killed in flash flooding, for example, or through malnutrition during droughts and post flooding. Associated stock movement resulting in greater mixing will increase the risk of disease, which will be exacerbated by stress from transportation, change of diet, unfamiliar environmental conditions, and by stock condition.
- There are numerous examples of stock losses through extreme events in the region. A selection of examples is provided in the following section.

3.1.1 IMPACTS OF EXTREME EVENTS IN THE LMB

Provided here are select examples of the impacts of extreme climatic events on livestock in the LMB. The examples provided are not exhaustive.

Cold snaps in Northern Vietnam and Lao PDR: 60,000 cattle deaths in early 2008 were attributed to a prolonged cold snap, though many of these losses occurred outside the LMB proper (MRC 2010). In reference to the cold snap in 2011, The Huffington Post (2011) estimated 10,000 cattle and buffalo had been lost while Tuoitre News (2011) stated: 'The record low temperature this year had frozen over 7,000 buffaloes and cows to death in more than 12 northern mountainous provinces, said Deputy Head of the Livestock Breeding Department Nguyen Thanh Son on Friday.'

Flooding in Cambodia: The heavy floods in Cambodia in September-October 2011 caused severe losses among all livestock. While exact numbers are not known, there a number of indications that they were significant:

- According to a post-flood survey of 2,500 households in 11 flood-affected provinces in January 2012, two-thirds of households with livestock reported losing animals as a result of the flood (FAO-WFP 2012).
- CARE et al. (2012) surveyed 390 flood-affected households after the 2011 floods. Stock losses due to the flood where significant, estimating poultry losses of 70%, pig losses of 23%, and cattle losses of 5%.
- FAO (2012b) reported flooding in Cambodia in 1995 killed 301 pigs in 10 surveyed districts, though the likelihood of underreporting is high.

Flooding in Thailand: The MRC (2010) estimated over 55,000 head of livestock were lost during the 2009 floods in Thailand, though much of these losses occurred outside the LMB.

Flooding in Lao PDR: In Lao PDR during the 1996 floods WFP (2012d) found that households lost, on average and across wealth categories, half their cows and/or buffaloes.

Market impacts of extreme events: Livestock are often a key form of household savings and may be sold as a coping mechanism in response to shocks, such as extreme events, to fulfill immediate cash needs. Given the seasonal nature of flooding, at the time of flooding stock are generally not at optimal value having endured low feeding during the late dry season and early wet season. Further, rapid sales can lead to localized oversupply issues forcing prices down, with traders well aware of the immediate household need to sell. This situation is reversed during the rebuilding phase when households want to restock, increasing demand with fewer stock available leading to higher prices for replacement.

Furthermore, greater stock movement and mixing occurs during the event, aftermath, and rebuilding phases as stock are initially moved to alleviate direct threats and then through sales in coping with financial needs. Mixing and movement increase the risk of animal health problems by inducing stress and reducing immune system responses and increasing the risk of animal to animal disease transmission.

Flooding, flash flooding, landslides, and other extreme events can affect market access in more remote areas, both in terms of obtaining inputs and for the sale of livestock-derived products.

3.2 SPECIES/SYSTEM SPECIFIC TOLERANCES

3.2.1 TEMPERATURE

Bovines

Ruminants are generally relatively thermotolerant (see Box 1 for a description of climate stress terminology), **capable of effectively adapting to experience of longer-term temperature changes and regulating their body temperatures, primarily through the employment of evaporative heat loss (oral).** *Bos indicus* sp. or zebu cattle are particularly thermotolerant, significantly more so than European *Bos taurus* breeds. For example, Rocha et al. (1998) found that certain aspects of reproductive performance affected by temperature and humidity increases in *Bos taurus* sp. did not affect performance in *Bos indicus* sp. Hansen (2004) found that zebu cattle have a superior ability to dissipate heat and that their lower metabolic rates reduce the impact of higher temperatures in terms of heat stress and effects on performance.

BOX 1: NOTE ON CLIMATE STRESS TERMINOLOGY

Thermocomfort zone: the animal is comfortable; stock are neither huddling nor separating**.**

Thermoneutral zone: no danger and little or no extra metabolic demands are placed on the animal; the animal can still perform optimally but behavioral changes are noticeable (huddling, panting, postural changes, etc.) may lead to vices in more densely stocked management – such as densely housed systems.

Lower and upper critical zones: notable performance impacts, animals will adjust feeding to compensate; generally little impact on ruminant productivity on low-cost feeds (though may affect draft animal ability to work), but will affect more intensive pig and poultry systems.

Lethal temperatures: temperatures at which the animal may/will go down and potentially succumb if conditions are not addressed quickly. Environmental stress is high, negatively affecting intake and the animal's ability to respond to disease challenges through suppressed immunity.

Bos indicus sp. breeds are the dominant cattle in the region. ***Bos indicus* sp. cattle are comfortable in high temperatures, as high as 38°C before any notable effects on production.** Temperatures above 38°C may lead to heightened stress, reducing immunity and feed intake, and likely exacerbated by work. Use of external evaporative cooling systems would be economically untenable for most LMB cattle production systems (with the possible exception of dairy herds) so ensuring adequate water and shade is essential.

Bos taurus sp. thermoneutral (see Box 1) zone is typically 0-20°C. Individuals exhibit significant decline in milk yields at around 21-25°C. In the LMB this is important for the burgeoning dairy industry which largely employs Holstein-Friesians. However, relatively wide variation exists between breeds. For example, Brown Swiss milk production is not affected until 30-32°C, and again will depend on the animal's past experience.

There has been even less research conducted on buffaloes but it is likely their responses to heat are similar to that of zebu cattle, if anything they may be more resilient and given how they are managed the impacts of increased temperatures will be low and difficult to measure.

The likelihood of disease transmission will be affected by changes in temperature affecting pathogen ecology.

Given the capacity of bovines to adapt to different temperatures, minor temperature changes across the region will have impacts at scale but will be difficult to notice/measure in individual animals/herds.

Pigs

Feed conversion efficiency will tend to be reduced with cooler temperatures and voluntary food intake reduced at higher temps though stock suffer little discomfort within reasonably wide temperature ranges, with the exception of young piglets. **Thresholds vary dependent on systems of management and breed but typically optimal production can be achieved between 20 and 30 degrees centigrade.**

Young pigs in their first few days are most susceptible to low temperatures. Bigger piglets are better able to cope; hence improved sow condition management is a possible means of building resilience to temperature changes.

Grower and fattener performance, both growth rates and feed efficiency, is highly affected by temperature, particularly above the optimum. This is most relevant for more intensive units raising crossbreds, where optimum temperatures vary but are generally in the low 20s and, at most, 30°C. Effects will be much less measurable in scavenging systems. Renaudeau et al. (2006) found in a comparative experiment on acclimation to heat stress comparing Large White and Creole barrows (loosely comparable with local Asian breeds) that the Creoles were significantly better at dealing with chronic temperature stress. Unfortunately a similar study on crossbred pigs in Asia has not been found but one might reasonably assume they demonstrate higher tolerance than pure exotics although less than local breeds.

In high-performance breeds estimates have been made which suggest for every one degree rise above optimal temperatures a five percent reduction in voluntary feed intake can be expected with consequential impacts on growth rates and reproductive performance (Forman et al 2008).

The likelihood of disease transmission will be affected by changes in temperature as with all species.

Poultry

Young birds generally need to be well warmed either by the mother (in scavenging systems) or by external heat sources in the case of commercial units; optimal temperatures are approximately 25-30°C at all times until a week or so of age.

Commercial broilers optimal temperature range is generally 18-21°C. Above 21°C reduced voluntary feed intake, and hence growth rates, will be apparent in exotic broilers. However, this is strictly in terms of biological performance, birds will be quite comfortable outside that range, but economic considerations related to reduced productivity will become an important factor.

Commercial producers in lower-lying areas in the LMB are likely to suffer in terms of production and/or bottom-line due to higher utility costs for environmental control. In small-scale operations relying on natural cooling, higher temperatures will likely reduce productivity both in terms of intake and stress, reducing disease resilience and increasing behavioral problems such as cannibalism.

For poultry the biggest production losses occur with sudden temperature changes; they are better able to cope with temperature extremes if the change is gradual. Hence sudden temperature shocks can be disastrous, particularly in intensive units.

The likelihood of disease transmission will be affected by changes in temperature through changing pathogen viability and risk of transmission.

3.2.2 RAINFALL

Changes in rainfall will affect livestock units through feed and animal health issues. This is the case across species, but varies.

Changes in the availability, quality, and price of feeds are fundamental to all livestock production systems. For intensive monogastric units, feed costs typically account for 65 to 80 percent of production costs, while a key current constraint to most extensive smallholder systems in the region is under-nutrition.

Pathogens will likely be affected in terms of viability outside hosts and rates of proliferation by humidity levels and, importantly, the quality and quantity of vector breeding sites. Further, wetter periods typically increase the likelihood of disease transmission through fomites, increasing the importance of employing effective biosecurity measures.

3.2.3 ANIMAL HEALTH AND FOOD SAFETY

Pathogens may be affected by climate change in a variety of ways. For example, their viability outside hosts, their proliferation, and the likelihood of transmission will be affected by changes in environmental conditions. It is difficult to generalize and communication with specialists would be recommended if more specifics are required.

The tolerances of bacteria and parasites are difficult to generalize as conditions vary widely with type and strain. Broadly, viruses tend to be deactivated, and the likelihood of their causing disease reduced, in hotter, drier, sunnier conditions. Some pathogens, such as anthrax spores and oocysts are highly resilient to environmental changes, and increased risk of spread through fomites may be likely. Environmental resilience is further complicated by shifts, mutations, and the emergence of new pathogens.

Changes in the ecology of disease vectors will have important influences on disease risks and spread. Interesting examples from human health, such as changes in dengue prevalence in humans, shifts in tsetse in East Africa, and Japanese encephalitis recognized in other regions have been well documented (Patza et al. 2000). Key vectors to consider are arthropods (such as flies, mosquitoes, ticks, etc.), and rodents. How the lifecycles and numbers of these vectors are affected will impact disease prevalence and impact.

Climate changes will also affect the resilience of livestock to disease challenges, affecting the prevalence and relative incidence of diseases. Stock condition and stress levels can have significant impacts on livestock resilience so employment of good husbandry practices will be a vital protection measure.

Flooding often leads to changes in stock movement and mixing which can exacerbate disease issues. Use of safe-hills, for example, increases the likelihood of disease transmission due to more crowded conditions and mixing of herds/flocks. Drought and flooding can lead to low feed availability with negative impacts on stock condition, reducing resilience to disease. Further, extreme events can force stock sales as an element of household coping strategies. Changes in volume and direction of stock sales will affect disease prevalence, usually in a directly proportional manner.

Mycotoxins (aflatoxins in particular) are a key constraint to many livestock producers in the region. Poor storage of grains, particularly maize, is often the main source. **Wetter conditions, longer time in storage, and poor management of stored feed may increase the presence of mycotoxins**, increasing the risk of intoxication with negative effects on productivity and increased feed waste.

The effects of climate change on foodborne hazards deserve consideration, though will likely prove difficult to isolate and measure. Food safety issues are increasingly prominent on the agendas of government and some donor institutions in the region. Livestock value chains in the LMB are often fragmented and cold chain management is very variable. It is possible higher temperatures will increase the need for good hygiene in slaughtering, processing and storing, better cold chain management, and the need for traceability and transparency in livestock supply chains.

3.2.4 SUMMARY OF POSSIBLE EFFECTS OF CLIMATE CHANGE ON LIVESTOCK PRODUCTION

Traditional smallholders may be favored under climate change conditions as they use local genotypes, which are likely to be more resilient to changes in conditions than higher-performance exotic breeds.

However at scale, marginal productivity losses will become significant. Industrially farmed chicken broilers and layers will incur higher heat stress-related behavioral problems and related performance losses. This will necessitate increasing use of utilities as temperatures rise, increasing costs of production possibly beyond the means of many smaller producers. The enterprises where this might become a consideration are largely located in northeastern Thailand, near urban centers in Cambodia and the few remaining chicken producers in the Vietnamese delta zones. Lower temperatures would more likely reduce costs and improve productive performances in these units, though any changes would, again, be marginal.

Temperature changes will affect pathogens, particularly in terms of survival time outside the host animal and wetter conditions will mean more mud thus increasing livestock exposure. Warmer, damper conditions tend to suit some pathogens and would increase the likelihood of disease spread through fomites. Pathogens to consider include a variety of viruses, bacteria, and parasites, each of which will be affected differently and affect different species and production systems in differing ways.

The impacts of climate change on broader agricultural systems, such as cropping and the availability of grazing land, crop residues for feed, and the need for traction, will perhaps be the most important impact on livestock production in the region. **The large bulk of livestock raised in the region, in terms of total numbers and numbers of farms, are managed in mixed crop-livestock systems so changes in cropping will affect the value, uses, and management of livestock.** Further, changing cropping patterns and the quality of communal and protected grazing, browsing, and scavenging areas will affect livestock viability and performance. Given large stock are commonly supplemented with crop residues and cut and carry forages (both wild and cultivated) there will likely be changes in diet potentially leading to positive and/or negative impacts on certain species and production systems in specific regions. Scavenging stock will be less obviously affected.

Commercial units will be affected by changes in the availability, quality, and price of feed ingredients. How feed sources are affected will have major impacts on the competitiveness of these businesses given feed costs typically account for around 70% of variable costs. With increasing competition from outside the region, margins will be further squeezed.

Slow-onset flooding, flash flooding and drought will exacerbate ongoing production constraints and create additional problems for livestock systems. For example, drought and flooding reduce feed availability and negatively impact stock condition, and therefore value and resilience. While commercial units are generally better located and able to supply feed from further afield, smallholders can be badly affected. Flooding, notably in areas such as the Tonle Sap and delta, may force producers to move stock to 'safe hills', which are a significant biosecurity hazard. Flooding, and hence the use of safe hills, often entails stock from a wide area being collected and with low vaccination rates the likelihood of disease outbreaks is high. Disease risks are further compounded by other factors, for example flooding tends to occur soon after a low-feed period in Cambodia when stock condition is relatively poor. Further flood-related pressures include change of diet, movement, and new conditions that induce stress (particularly among young animals), all contributing to heightened risk of infection.

Extreme events may also affect markets, both for inputs such as feed and stock and in sale of animals. Markets may be affected by physical access, but often more important is an increase in stock sales to cope with the extreme event impacts. Destocking tends to reduce the selling price in the affected area through oversupply and poor-condition stock. Prices for young stock tend to increase in the recovery period as farmers look to replenish their herds and oversupply is replaced by heightened demand. Further, destocking and restocking periods increase stock movement and further heighten the risk of disease.

4 HOTSPOT PROVINCE LIVESTOCK BASELINE PROFILES

Hotspot provinces have been selected on the basis of projected climate changes; this process is described in detail in the Main Report. This section provides brief hotspot province profiles that overview key livestock species and production systems in each province. For further details on the key species/systems of the LMB please refer to specific entries in Annex 3: Systems Database.

4.1 MONDULKIRI, CAMBODIA

Key species/systems:

1) Smallholder cattle 'keeping' (draft); buffalo
2) Scavenging chicken
3) Banteng (*Bos javanicus*) and other wild species

WFP (2012b) indicates relatively high numbers of poultry, buffalo, and cattle per household in Mondulkiri Province in comparison with national averages, though total density by area is low (GLiPHA 2012). Livestock production is almost exclusively small-scale, extensive, and low-input. Livestock are largely maintained as assets, contributing significantly to household coping strategies while supporting mixed farming systems through manure and draft.

Cattle are almost exclusively *Bos indicus* varieties, predominantly crosses with Haryana and, to a lesser extent, Brahman breeds. Poultry are predominantly of local genetics with some crossbreds locally known as 'three-bloods'.

Market access is poor and well below the national averages (WFP 2012b). **Limited market orientation, poor quality and quantity of feed, low vaccination rates, and minimal employment of biosecurity measures contribute to high morbidity and mortality and low overall productivity.** Key infectious diseases include *pasteurellosis* among all stock and Newcastle disease among chickens. Though households typically derive little cash income from stock they do invest labor resources in tending to animals through feeding and supervision of grazing (IOM 2009). Extreme events such as flash flooding, slow-onset floods, and drought exacerbate constraints to livestock production.

Mondulkiri Province has a large network of protected areas inhabited by important wild flora and fauna. Mondulkiri contains the largest remaining banteng population globally, a wild species related to domesticated cattle. There are also populations of other significant wild flora and fauna such as Eld's deer, *Sus scrofa*, wild poultry, and potentially the critically endangered, possibly extinct, kouprey (*Bos sauveli*). Hunting, disease, and loss of habitat are the key threats to these species and systems. Climate change may stress current livelihoods and force greater incursions into these habitats and exacerbate current threats (IUCN 2012, AWCSG 2012).

4.2 CHIANG RAI, THAILAND

Key species/systems:

1) Small commercial chicken (also high numbers of scavenging chickens)
2) Smallholder cattle 'keeping' (draft); buffalo
3) Small commercial pig

Poultry production is very significant in Chiang Rai although lower than cattle and pig production in terms of overall density. Large, vertically integrated production, much of which is destined for export, likely accounts for an estimated poultry density of 11 LU per sq km of agricultural land (GLiPHA 2012). However, while accounting for a large proportion of total production, these units only make up roughly one to two percent, or less, of total farms. The vast majority of farms raising poultry are smallholders utilizing scavenging or, less commonly, semi-commercial production methods. Smallholders are at high risk from infectious diseases such as Newcastle disease, fowl cholera, and fowl pox, which constitute key production constraints.

Cattle are widespread in Chiang Rai though lower density than other parts of the region (MRC 2000). Cattle density in Chiang Rai is estimated at 18.5 LU per sq km of agricultural land. Stock is predominantly kept in small herds (1-10) in low-input extensive systems, though more intensive beef production systems may be emerging. Dairy production is increasing with an estimated 9000 milkers in neighboring Chiang Mai Province in 2003 (Srikitjakarn et al. 2003).

Pig production is prominent within the Kok River Basin. Systems broadly range from extensive, low-intensity scavenging or tethered systems to small semi-intensive landless units; there may also be larger operations in the area operating high-intensity, industrial breeding and fattening units. Smallholders operating confined systems typically feed locally available feeds, and/or supplemented with purchased processed concentrates or complete feeds. Both local breeds and crossbreds are common. Pig density in Chiang Rai is an estimated 11 LU per sq km of agricultural land (GLiPHA 2012).

4.3 KHAMMOUAN, LAO PDR

Key species/systems:

1) Smallholder cattle 'keeping' (draft); buffalo
2) Smallholder low-input pig

Livestock are significant contributors to household livelihood portfolios in Khammouan Province. They are typically raised in diverse mixed systems involving rice, maize, vegetables, and tree crops. It is estimated that 80% of households own large livestock although there are notable differences in types and numbers of livestock by ethnic group, for example **the Hmong have the largest cattle herds while Khmu are the most prominent pig raisers** (ADB 2005).

The most significant livestock are bovines, which support mixed systems through draft and manure and are held as assets. Cattle are almost exclusively *Bos indicus* breeds. Pigs are also significant, in some cases raised in small commercial systems utilizing crossbreds, though predominantly they are of local genotypes raised in scavenging or semi-confined systems (Phengsavanh et al. 2011). Buffaloes may have become less prevalent in lowland areas with increasing use of hand tractors, as has occurred in neighboring provinces (ADB 2005).

Stocking densities are low by total land area but high by agricultural land, most recent estimates for cattle, buffalo, and pigs are 51.3, 94.4 and 17.4 LU per sq km of agricultural land respectively (GLiPHA 2012). Stock density per agricultural land area in highland areas are typically overestimated by the grazing of areas not included in agricultural land area figures (GLiPHA 2012).

Low feed quantity and quality negatively affects reproductive performance and growth rates. Feeding is generally low in protein for all species and pig diets suffer from specific essential amino acid deficiencies (personal correspondence). Minimal supplementation with forages and/or concentrates occurs and most stock are considered undernourished. Malnourishment is most severe at the end of the dry season when feed resources are at their lowest. Given the existing stock management systems, feed quality is not a high priority for most producers at present.

Disease issues are considered a key constraint to production (ADB 2005). Unidentified pig and bovine diseases have circulated for many years; the most significant are likely to include CSF, HS and FMD.

4.4 GIA LAI, VIETNAM

Key species/systems:

1) Small commercial pig
2) Smallholder cattle ‘keeping’ (draft); buffalo

Pigs are prevalent in Gia Lai and predominantly raised in small-scale, semi-commercial, or commercial production systems. Pig density by agricultural land is estimated at around 27 LU per sq km (GLiPHA 2012). Breeds vary but are largely crossbreds in better-connected areas where farmers typically employ more market-oriented systems. Market access can form a constraint to producers in remote areas of the province. Recent PRRS outbreaks have had major impacts on pig production, both directly and through movement bans. CSF outbreaks are also common.

Cattle are very important in Gia Lai with an estimated stocking density of 56 LU per sq km of agricultural land (GLiPHA 2012). Most cattle in Gia Lai are local breeds or Sindh crosses raised in low-output extensive systems as a form of savings and in support of other household livelihood activities through the provision of draft, manure, and eventually beef. There has been some recent movement towards more intensive, stall-fed beef production in this area of the highlands, notably in neighboring Dak Lak Province through the support of a CIAT-led project, which sought to promote the use of forage-based feeding systems and the use of improved breeds (Khanh et al. 2010).

Cattle production is increasing in the province overall though this varies by district. Cattle producers are increasingly employing, or taking advantage of, agroforestry-based production systems. Access to improved breeds is a key constraint to beef production (Khanh et al. 2010). HS and FMD likely remain prevalent along with parasite problems.

Gia Lai could prove a competitive province for beef production, and potentially dairy, given rapidly increasing national demand, relatively low land use at present, and parts of the province are relatively well-connected to several key urban centers such as Nha Trang, Da Nang, and Ho Chi Minh City.

The importance of livestock to food security and income generation may have increased in recent years with changes in waterways contributing to a decline in fishing (NGO 2005).

4.5 KIEN GIANG, VIETNAM

Key species/systems:

1) Small commercial pig
2) Field-running layer ducks

Kien Giang exhibits broadly similar characteristics to other low-lying Southern Vietnamese provinces in terms of livestock production systems. **There is significant informal crossborder trade in livestock with Cambodia.**

Pigs are the most significant species with density in Kien Giang estimated at 24 LU per sq km of agricultural land. They are typically raised in small- to medium-scale intensive landless systems with relatively high investment in feed and animal health services (GLiPHA 2012; Kamakawa et al. 2002). Pigs are generally exotic crossbreds (F2-Fn) and sows are often artificially inseminated. Internal parasites are generally managed through medicated feeds and deworming protocols. Disease concerns focus on CSF, PRRS, and FMD, which have stifled recent growth in pig numbers; frequent outbreaks of these diseases have high impacts on pig producers both directly and through outbreak responses, such as culling and movement bans (VV Online 2011). Kien Giang pig production has also been negatively affected by recent feed price volatility.

Though poultry density is relatively low in terms of LU per sq km, which is estimated as less than 1, these figures are quite unreliable and likely under represent poultry numbers. Field-running layer ducks play a significant role in rice production systems by controlling pests, fertilizing fields, and collecting in-field paddy losses while producing fertilized eggs. Duck plague outbreaks (e.g., duck virus enteritis and duck herpesvirus 1) are the major animal health concern for producers. Since 2003 HPAI outbreaks and responses have had significant impacts on the poultry sector, particularly chicken production, with the virus likely circulating in duck flocks and wild birds. Initiatives to date have had limited success in controlling the disease so chicken raising in Kien Giang remains high risk.

Cattle and buffalo numbers are low but some sources suggest they are growing. However, increasingly intensive land use and mechanization of rice production in the region will likely see numbers stagnate or systems move towards meat production in coming years (personal communication with DLP).

SECTION 2: LIVESTOCK SYSTEM VULNERABILITY ASSESSMENTS

1 VULNERABILITY ASSESSMENTS

1.1 CLIMATE CHANGE VULNERABILITY ASSESSMENTS

1.1.1 HOTSPOT PROVINCES

Detailed livestock system vulnerability assessment results for the hotspot provinces are provided in Annex 4. The following section provides a description of the main threats and impacts for key livestock systems in each of the hotspot provinces and upscales these results for a basin-wide summary of livestock system vulnerability.

Mondulkiri

Smallholder cattle/buffalo were identified as the most vulnerable livestock system in Mondulkiri Province (Table 4). They are very highly vulnerable to drought due to the reduction in fodder and increase in disease risk. They were also identified as highly vulnerable to temperature and precipitation increases and flash floods/storms.

Scavenging chicken systems are most vulnerable to flash floods/storms because they can be carried away by flood waters. They were also identified with medium vulnerability to increases in temperature and precipitation.

Banteng (and other wild species) were identified with only medium vulnerability. This is because wild species typically have strong internal adaptive capacity. Changes in other systems will likely have the greatest secondary impacts on wild species.

Table 4. Main threats and vulnerability for livestock systems in Mondulkiri Province

Vulnerable livestock system	Main threat	Impact summary	Vulnerability
Smallholder cattle/buffalo 'keeping': Bos indicus, draft cattle, buffalo	Drought	*Reduced fodder availability on already undernourished stock increases risk of disease, reducing value and reproductive performance*	Very High
Scavenging chicken: dual purpose	Flash floods/storms	*Stock directly exposed to flash flooding may be lost. Exposure rates will be low but sensitivity of exposed stock is high.*	High
Banteng (and other wild species)	Temperature, precipitation, water availability, drought, flash floods and storms	*Wild species typically have strong internal adaptive capacity. Changes in other systems will likely have the greatest impact as secondary effects on wild species.*	Medium

Chiang Rai

In Chiang Rai small commercial chicken and pig systems were found to be very highly vulnerable to temperature (Table 5). Due to the confined, relatively stressed conditions, the animals are already normally outside of their thermoneutral zone, which leads to reduced voluntary feed intake (VFI), reduced immunity, and increased incidence of behavioral problems.

Table 5. Main threats and vulnerability for livestock systems in Chiang Rai Province

Vulnerable livestock system	Main threat	Impact summary	Vulnerability
Small commercial chicken (broilers; few layers)	Temperature	*Confined, relatively stressed systems that are generally already outside the birds thermoneutral zone; high likelihood of reduced VFI and therefore reduced growth rates; reduced immunity due to increased prevalence of heat stress and increased incidence of behavioral problems such as cannibalism and stereotypies.*	Very High
Small commercial pig	Temperature	*Confined, relatively stressed systems that are already outside their thermoneutral zone; high exposure, high sensitivity. High likelihood of reduced VFI and therefore reduced growth rates, lower reproductive performance, reduced immunity through increased stress (increasing disease problems) and behavioral problems. May make some systems economically unviable. Systems do have greater internal adaptive capacity than commercial poultry.*	Very High
Smallholder cattle/buffalo 'keeping': Bos indicus, draft cattle, buffalo	Flash floods/storms	*Stock directly exposed to flash flooding may be lost. Exposure rates anticipated to be low but sensitivity of exposed stock high.*	High

Khammouan

In Khammouan Province, smallholder cattle/buffalo systems are most vulnerable to temperature. The effects of a gradual increase will be limited as stock are already accustomed to high temperatures. But extreme temperatures ('snaps') may have direct impacts on animal value, productivity, and resilience to disease.

Table 6. Main threats and vulnerability for livestock systems in Khammouan Province

Vulnerable livestock system	Main threat	Impact summary	Vulnerability
Smallholder cattle/buffalo 'keeping': Bos indicus, draft cattle, buffalo	Temperature	*Temperature increases will have a negative impact on productivity, limited in the individual but significant over the population.*	High

Kien Giang

In Kien Giang, confined relatively stressed small commercial pig systems will be very highly vulnerable to climate change (Table 7). Increasing heat stress will lead to reduced voluntary food intake and reduced growth rates, lower reproductive performance, reduced immunity (increasing disease problems) and behavioral problems. Climate change may make some small commercial pig systems economically unviable.

Temperature increases may have effects on rice cultivation and reduce availability of scavenging areas for ducks that scavenge fallow rice fields. Intake may be somewhat reduced but of little consequence to field-running layer duck systems, resulting in a predicted medium vulnerability to climate change.

Table 7. Main threats and vulnerability for livestock systems in Kien Giang Province

Vulnerable livestock system	Main threat	Impact summary	Vulnerability
Small commercial pig	Temperature	*Confined, relatively stressed systems already outside their thermoneutral zone; high exposure, high sensitivity. High likelihood of reduced VFI and therefore reduced growth rates, lower reproductive performance, reduced immunity through increased stress (increasing disease problems) and behavioral problems.*	Very High
Field-running layer ducks	Temperature	*Effects on rice production will have significant impacts on availability of running areas for scavenging. Could force changes in management, which may also be endorsed by Department of Animal Health (DAH)-Government of Vietnam policy.*	Medium

Gia Lai

Small commercial pig systems in Gia Lai will be highly vulnerable to increases in temperature. Temperatures are already well outside comfort zones (low to mid 20s Celsius) reducing productivity, so further increases may have considerable impacts on economic viability.

Increases in maximum daily precipitation and heightened risk of flash flooding may lead to increases in direct loss of livestock making smallholder cattle/buffalo systems highly vulnerable to these events.

Table 8. Main threats and vulnerability for livestock systems in Gia Lai Province

Vulnerable livestock system	Main threat	Impact summary	Vulnerability
Small commercial pig	Temperature	*Confined, relatively stressed systems already outside their thermoneutral zone; high exposure, high sensitivity. High likelihood of reduced VFI and therefore reduced growth rates, lower reproductive performance, reduced immunity through increased stress (increasing disease problems) and behavioral problems. May make some systems economically unviable.*	High
Smallholder cattle/buffalo 'keeping': Bos indicus, draft cattle, buffalo	Flash floods/storms	*Stock directly exposed to flash flooding may be lost. Exposure rates anticipated to be low but sensitivity of exposed stock high.*	High

1.1.2 BASIN-WIDE SUMMARY

Small- and medium-scale commercial operations are most vulnerable and have limited capacity to adapt (Table 9**).** The presence of commercial livestock production units has increased dramatically in recent decades, a trend highly likely to continue, with an associated increase in the use of higher performance genetics and higher productivity management practices such as heightened stocking rates. High-performance breeds managed in high-density systems will be negatively affected by expected climate changes. Ambient temperature increases of up to five degrees Celsius, predicted for parts of the LMB, will reduce productive performance and increase behavioral problems, morbidity, and mortality in the majority of small- to medium-scale commercial units without investment in cooling systems (Forman et al. 2008); investments that are typically beyond the reach of these producers. Productivity losses and increased mortality rates, particularly among young and immuno-compromised stock will negatively affect farmer incomes and may increase prices of livestock-derived products, or drive increasing demand for imported products.

Higher temperatures will have little measureable effect on individual animals in 'traditional' systems but multiplied across villages to the regional level the impacts may be significant (Table 9 and Table 10**).** Traditional systems typically rear hardier local breeds and crossbreds with greater thermal tolerance, for example, *Bos indicus* cattle breeds are raised throughout the region primarily for draft (Hansen 2004; Maclean 2006). Though loss of productivity due to temperature increases is unlikely to be noticed on an individual basis, and no specific study has been found, it is probable that draft animal fatigue (due to thermal stress/reduced feed intake) will reduce household incomes directly, by limiting ability to work for hire and reduced working life; and indirectly through impacts on other livelihood-generating mechanisms. Among other species, reduced lay rates and gain may occur but low offtake rates will make estimation of losses difficult.

Table 9. Climate vulnerability of livestock systems in the Lower Mekong Basin

Livestock system	Impact	Adaptive capacity	Vulnerabilit y
Smallholder cattle/buffalo	Low	Low	*Medium*
Dairy/large commercial	Very high	High	*High*
Small commercial pig	High	Medium	*High*
Smallholder low-input pig	Low	Low	*Medium*
Small commercial chicken	Very high	Low	*Very high*
Scavenging chicken	Low	Low	*Medium*
Field-running layer duck	Very low	Low	*Low*

Table 10. Climate vulnerability of wild livestock systems in the Lower Mekong Basin

Wild Species	Impact	Adaptive capacity	Vulnerability
Banteng (esp. Mondulkiri)	Low	Very low	*Medium*
Eld's deer (esp. Mondulkiri)	Low	Very low	*Medium*
Sus scrofa	Very low	Low	*Low*
Wild poultry	Very low	Low	*Low*

Though it is not possible to quantify changes in competitiveness and productive outputs associated with predicted climate changes to 2030 and 2050 it is reasonable to describe trends and suggest likely impacts on the subsector.

General productivity

Temperatures beyond the upper critical value for specific animals once reached will impact productivity and increase behavioral problems in intensely stocked systems: this effect will be most notable among poultry and pigs housed in higher-stocking densities in more commercially oriented systems, most prominent in low-lying areas of the LMB (PigSite 2008). Stock will reduce their feed intake with higher temperatures, reducing liveweight gain and increasing time to slaughter weight. For example, in intensive pig systems studies have shown for each degree increase above approximately 30 degrees centigrade a five percent reduction in voluntary feed intake can be expected, sudden changes will have even greater impacts on stock health and productivity. More densely stocked commercial poultry will experience comparable reductions in weight gain, egg weights, and eggs/hen/year. As stated, high stocking rate pig and poultry systems will likely experience more behavioral problems, negatively affecting productivity, making management more difficult and increasing risks of infection through reduced immune responses. However, with all species temperature must be considered in relation to housing, in particular bedding and drafts but also humidity, the animal's previous experience of temperature and humidity (or thermal history), feeding rate, stocking rates, weight, age, sex and genotype.

Nutrition

Climatic changes will likely affect the availability and price of local feed sources and ingredients, which will have significant impacts on smallholders: drier dry seasons will likely increase the length and severity of low-feed periods for grazing stock and those fed predominantly on local raw feeds; systems which are already stressed with stock typically already scoring low on body condition. The need for good feed preservation systems will increase. Greater use of preserved feeds, however, risks exacerbating the negative effects of mycotoxins (aflatoxins in particular), already a significant constraint to many production systems. Aside from direct impacts on growth rates and reproductive performance, undernourishment also reduces livestock resilience to stress and disease challenges. Larger producers more closely tied to global commodity prices will be affected differently.

Animal health

Negative impacts on feed availability caused by drought and flooding will reduce stock condition and resilience to disease challenges: immunity is reduced by poor body condition and the risk of physical injury is also increased, potentially leading to infections among other health and production-related issues. Further, drought and floods often lead to rapid stock sales as a household coping mechanism, increasing stock movement and mixing in the affected areas and increasing the risk of disease outbreaks. Disease challenges will be further increased by stress from transportation, change of diet, unfamiliar environmental conditions, and by stock condition.

The quantity and quality of disease vector breeding sites will be altered by changes in the environment, particularly water availability: for example greater climatic variability may include unseasonable rainfall in some areas, increasing stagnant water and the availability of breeding grounds for mosquitoes; and the need for greater feed preservation and storage may encourage rodent problems. While pathogens vary widely in their temperature tolerances, spatial and temporal shifts in disease patterns have been well documented in the past and can be expected to increase with predicted climate changes and associated seasonal variation. Important disease vectors in the region include: arthropods (mosquitoes, flies, ticks) and rodents.

Changing weather systems will influence the likelihood of pathogen transmission through fomites: wetter weather will increase the likelihood of disease transmission through mud, for example, increasing the importance of fundamental biosecurity measures such as cleaning and disinfection, quarantining, disposal of dead animals, and control of on- and off-farm traffic.

Wetter wet seasons are likely, overall, to exacerbate current internal and external parasite problems: nematode infections are a common constraint to livestock production in the LMB. Parasitic infestation is typically seasonal and associated with the wetter conditions, which are expected to increase.

Extreme events – flooding, drought, storms

Increased numbers of, and strength of, extreme events will have negative impacts on livestock raising: livestock affected directly by extreme weather events may be lost, flash flooding, for example, claims significant numbers in the region annually. Indirect impacts through malnutrition during and after droughts, and slow-onset flooding affect huge numbers of livestock producers. FAO-WFP (2012) estimated two-thirds of affected livestock owners lost stock as a direct result of the September-

October 2011 floods in Cambodia (on the basis of 2,500 household surveys post flood). Further, as referred to above, increased stock movement and mixing associated with extreme events will increase the risk of disease outbreaks.

Lethal effects of temperature extremes will be unlikely in most of the region, however, 60,000 cattle and buffalo were estimated to have been lost in northern mountainous areas during the 2008 cold snap (MRC 2010): though estimates have not been made public, recent cold snaps in 2008 and 2011 likely caused significant losses of poultry and pigs, particularly young stock. Climate change is expected to increase weather extremes, for example, sudden extremes in temperature may become more common, which will result in increased thermal stress on stock in naturally ventilated buildings and will exacerbate stress-related health and welfare issues and result in losses in productivity.

2 ADDITIONAL EFFECTS OF DEVELOPMENT ON VULNERABILITY

Alongside expected climate changes the LMB is undergoing significant socio-economic and biophysical changes affecting current and probable future livestock production and consumption and livelihoods derived from livestock in the region.

2.1 DEVELOPMENT EFFECTS ON LIVESTOCK SYSTEMS

2.1.1 INCREASING DEMAND AND CONSUMPTION OF LIVESTOCK PRODUCTS, COMPETITION AND CHANGES IN CONSUMER BEHAVIOR

The LMB countries have experienced high GDP per capita growth for the past 20 years. Associated with this growth has been an **overall increase in household incomes and standards of living, which is associated with increasing domestic demand for livestock-derived products**.

Investment in infrastructure, such as roads and ICT networks, has contributed to rapid improvements in access to markets and market information in much of the LMB, and with it increasing competition for producers. Globalization and increasing links to global markets, such as Vietnam's accession to the WTO in 2006, is placing downward pressure on prices and subsequent pressure on domestic production. Further, increasing links to global commodity markets effect input prices with particular significance for more commercial production systems, most notably pigs and poultry at present. Recent grain price instability has had important, largely negative, effects on more market-oriented livestock production. The emergence and increasing importance of national and multi-national supermarkets in more accessible parts of the LMB is changing consumer behavior, food safety risks, and the nature of livestock value chains (Wong 2007).

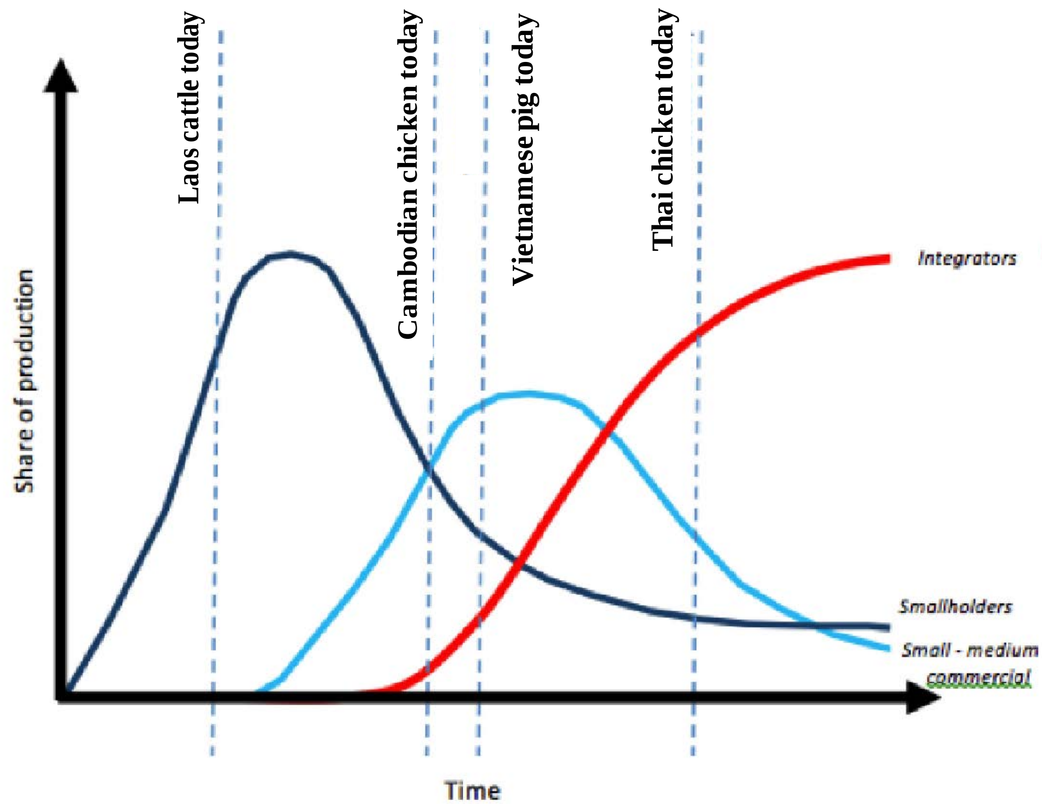
2.1.2 CONCENTRATION OF LIVESTOCK PRODUCTION

Livestock production is concentrating in line with increasing demand, urbanization, economic growth, and market and trade liberalization, a trend strongly expected to continue to 2050 (FAO 2011; FAO-AGAL 2005). While small, low-input systems continue to dominate total farms and stock numbers in much of the LMB, commercial units are rapidly increasing in both number and in terms of total production. In Vietnam and Cambodia small- and medium-scale commercial pig and poultry units are very significant suppliers of urban markets, particularly in Vietnam. Further large-scale 'industrial' vertically integrated corporate systems are rapidly increasing in terms of numbers, production volumes, and market share, particularly in urban areas.

The Thai chicken sector offers a view of the probable future of livestock production in the region - total chicken production is now dominated by large-scale vertically integrated enterprises. Small- and medium-scale commercial poultry production, unable to compete on price, has dwindled leaving a polarized system of low-input diversified 'subsistence' producers and large volume integrators.

Figure 3 provides a graphical representation of trends in share of livestock production in the LMB by broad livestock system. Over time livestock systems tend to move away from smallholders and small to medium commercial systems to larger integrator systems. Dashed lines show example estimates of the current situation for specific national systems.

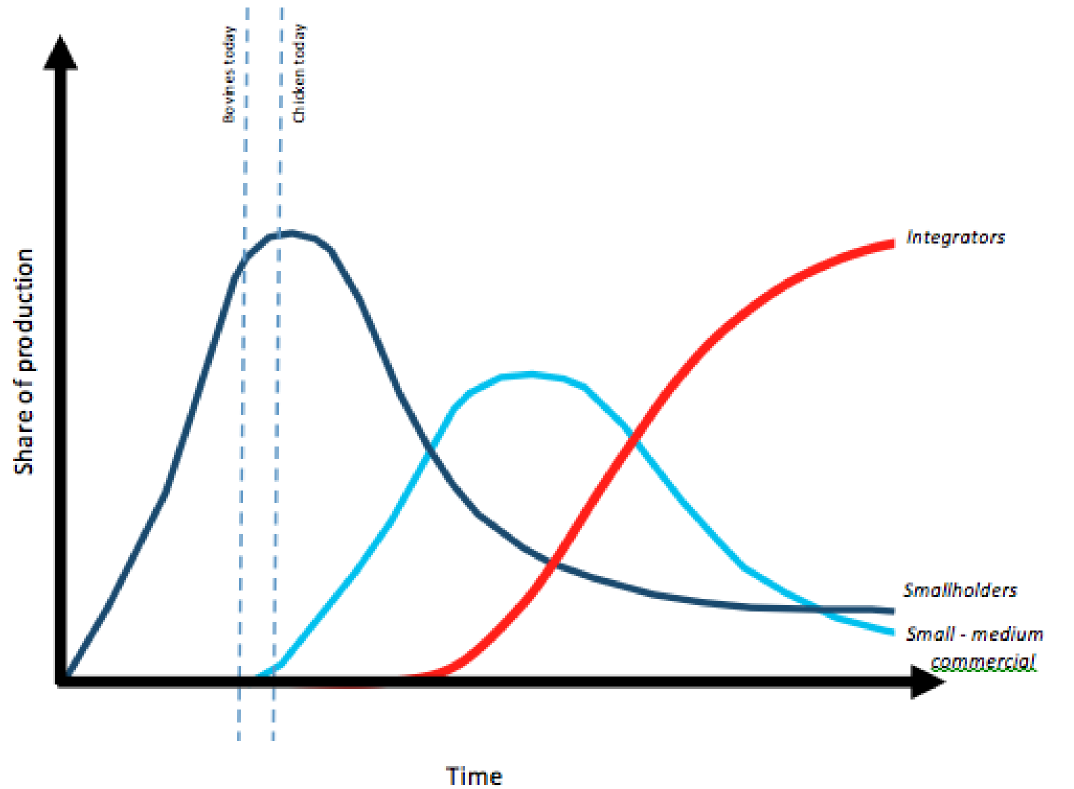
Figure 3: Regional trends in livestock production over time



Current trends in the LMB strongly suggest the following developments in the livestock sector, by country:

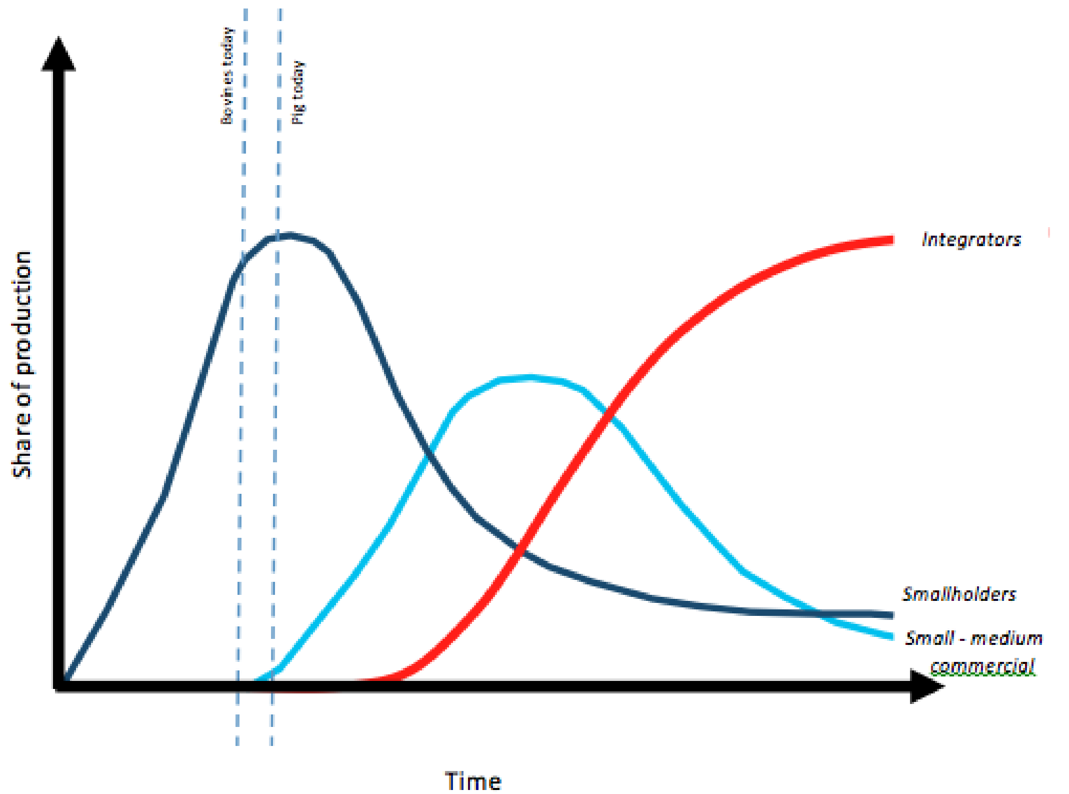
Cambodia: Small- and medium-scale commercial pig and poultry production will continue to grow rapidly in the short-term, however, large-scale commercial poultry, and to a lesser extent pig, production is also growing rapidly and already commands a significant share of urban markets. Beef production is polarized, dominated by low-value local produce and high-value imported products. Market concentration in beef production is unlikely in the immediately foreseeable future. For example, in Mondulkiri both bovine and chicken production is dominated by smallholder systems but the introduction of small to medium commercial systems has begun (Figure 4).

Figure 4: Mondulkiri trends in livestock over time



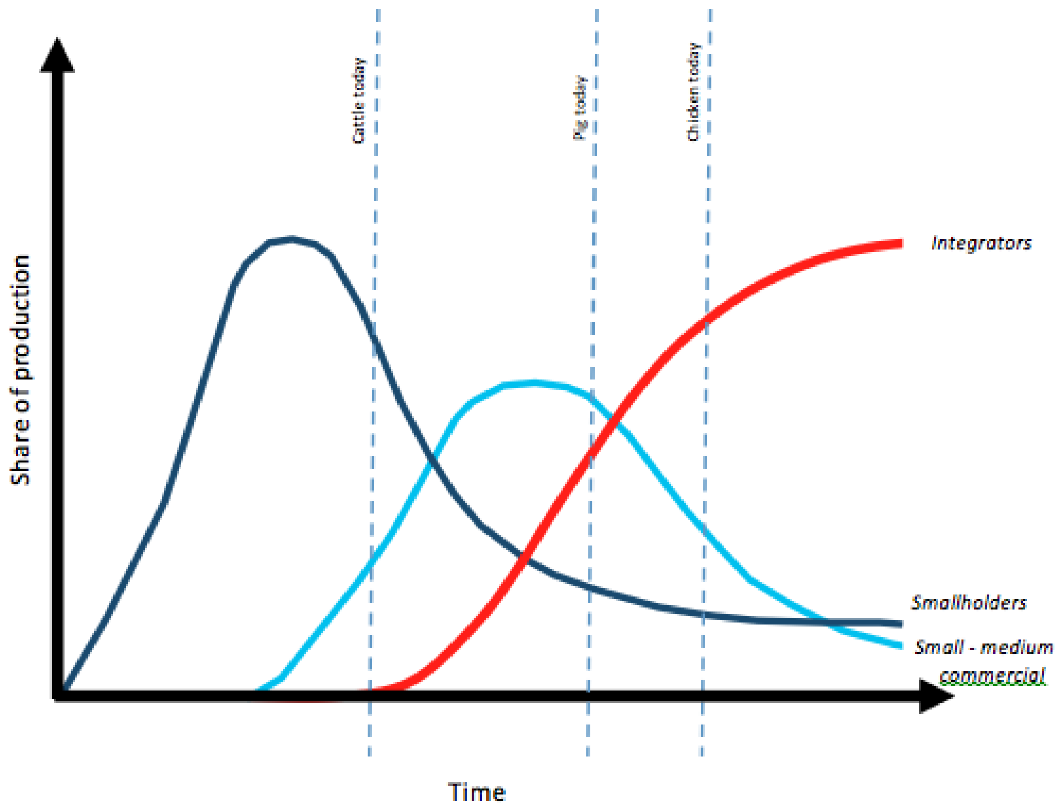
Lao PDR: There is currently very little commercial production, though small-scale commercial pig and poultry production supplying Vientiane is emerging in surrounding areas. Beef production is heavily dominated by low-input, low-value production systems, which is unlikely to change in the near future. A small high-value market exists and is supplied almost exclusively by imported beef. For example, in Khammouan both bovine and pig production is dominated by smallholder systems but the introduction of small to medium commercial systems has begun (Figure 5).

Figure 5: Khammouan trends in livestock over time



Thailand: Poultry is dominated by large-scale integrated production, which is expected to remain the case. Pig production is rapidly concentrating; small-scale commercial units are declining, which will almost certainly continue. Small commercial beef and dairy production is increasing, and expected to become increasingly concentrated in the medium term. For example, in Chiang Rai pig and chicken production has seen the rapid introduction of integrator systems while cattle systems are still mainly smallholder (Figure 6).

Figure 6. Chiang Rai trends in livestock over time



Vietnam: Poultry is rapidly concentrating; small- and medium-scale commercial units are likely to come under increasing pressure from larger producers and imported products. Small- and medium-commercial systems are expected to peak and decline in the medium term. Pig production is also concentrating; small commercial units have likely peaked and are expected to concentrate and decline with greater competition from large domestic producers, and possibly imported products. Small-scale commercial beef production is emerging slowly and likely to grow in the medium term. Dairy has emerged as highly commercialized, vertically integrated enterprises; production is rapidly increasing. For example, in Gia Lai bovine production is still dominated by smallholder systems with some introduction of small to medium commercial systems (Figure 7). Pig production in Gia Lai is currently dominated by smallholder and small to medium commercial systems but larger commercial systems are beginning to operate.

Pig production in Kien Giang is a mix of smallholders, small to medium commercial, and large integrator systems (Figure 8).

Field-running layer duck husbandry systems employed in Kien Giang, and throughout the Vietnamese Delta, are extremely cost efficient. This is likely to remain the dominant system of duck management in Kien Giang in the foreseeable future. The main development threat to these systems is possible changes in national and subnational policy due to associated problems for control of disease, such as HPAI; however, it is not possible to predict the likely nature or impacts of future policy changes at this time.

Figure 7: Gia Lai trends in livestock over time

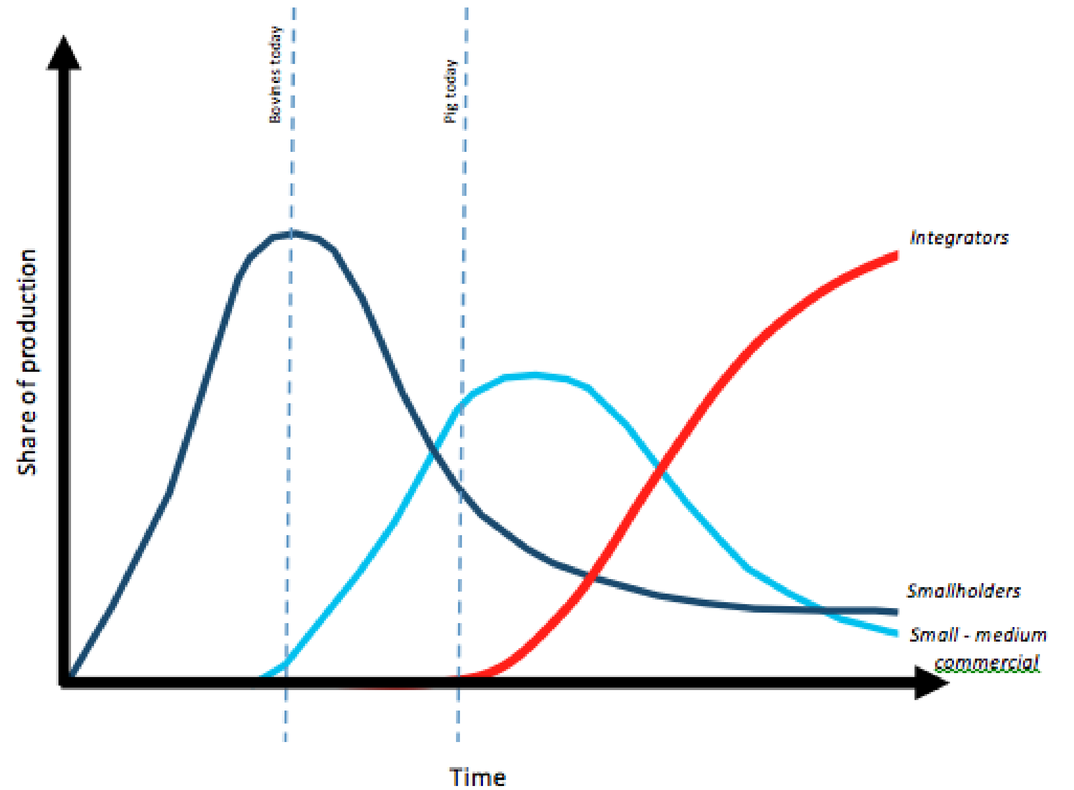
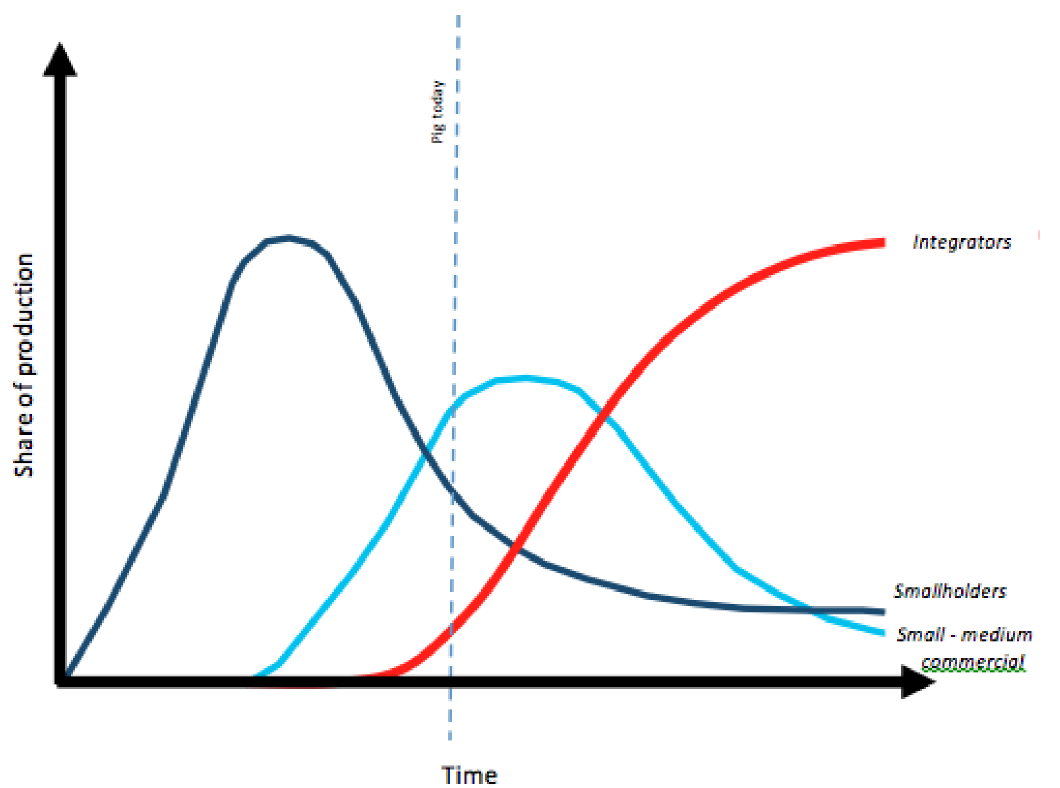


Figure 8: Kien Giang trends in livestock over time



2.1.3 SPREAD OF ANIMAL AND HUMAN DISEASE

Animal disease and increasingly livestock-related human health issues (zoonoses and food quality and safety) are key livestock production issues. **The high human and livestock populations, number of livestock-raising households, and nature of production in the LMB contribute to emerging infectious disease risks, outbreaks, and endemic diseases.**

The increasing market share held by integrators, both national and international, has meant an increasing share of total production is now produced under contract and has led to changes in genotypes, production methods, and input use. The rate and extent of change has varied with Thailand having a longer history of integrated export-oriented production, Vietnam and Cambodia moving quickly in that direction, while change in Lao PDR is less apparent.

Regulatory changes both regionally and at national levels are being driven by increasing concern over and investment in food safety and quality assurance; stability and quality of supply; and increasing domestic consumer demand for safe, high-quality produce. ASEANGAP and national guidelines and standards have been enacted, and numerous programs targeting whole chain and nodal safety and certification are affecting costs of production and access to markets for producers and associated value chain actors.

2.1.4 INCREASING CONNECTIVITY, MECHANIZATION, AND TECHNOLOGICAL INNOVATION

Significant national and international investment in roads, water treatment and supply, and electricity and ICT networks has rapidly increased connectivity in previously remote areas. **Parts of the LMB, formerly isolated from markets beyond their immediate vicinity, are now presented with opportunities to supply potentially higher value and/or more stable markets; but local production is increasingly challenged by lower cost produce from more commercialized production.** Increased access to markets is notable throughout the LMB. Cambodia and Lao PDR have seen the most recent and rapid increases, though at present large segments of the populace still remain poorly connected.

Increasing access to and use of communication technologies is changing the methods by which producers gather information on markets, both up and downstream, and is altering service access and delivery. New communication tools offer the potential for new approaches to information transfer.

Increasing mechanization in many areas, such as the employment of hand tractors and harvesters, is increasing key crop yields and reducing on-farm labor requirements and the need for livestock as a source of traction (Shephard 2010). Rapid mechanization has occurred in the better-connected, more commercially oriented areas of the LMB, such as the Vietnamese Delta, and is slowly changing production methods in more remote areas.

Introduction of higher-productivity genotypes has had varied levels of success impacting yields, costs of production, and disease risks for individual producers and livestock product supply. Recognition of disease concerns has led to numerous programs addressing animal health issues, notably through vaccination programs and access to animal health services, disease surveillance, response capacity building, and improved animal husbandry practices.

2.1.5 ENVIRONMENTAL CONCERNS AS A POLICY DRIVER

Increasing concern over local environmental degradation and climate change are important factors governing policy and altering production methods. Vietnamese national and provincial policy in relation to the delta region provides a good example due to the particularly high population density and the threat posed by expected sea level rises. Agricultural policy and policymaking processes vary widely at sub-national, national and regional levels but increasingly planning and screening tools and procedures are giving environmental concerns more weight, especially in the design and operation of intensive livelihood enterprises. Technocratic policy informing and making channels are gaining strength across the LMB; however transparency and associated issues of 'good governance' remain a challenge.

2.2 CLIMATE VERSUS NON-CLIMATE VULNERABILITIES OF LIVESTOCK SYSTEMS

Overall livestock system vulnerability to both climate change and non-climate related changes, in effect development changes, vary on a species by species basis in the LMB (Figure 9) and between provinces (Annex 5). Small commercial poultry and pig systems tend to be more vulnerable to non-climate drivers while large commercial systems tend to be more vulnerable to climate change. The rational for weighting of non-climate related vulnerabilities is presented in Table 11.

Figure 9. Livestock system vulnerability at the basin level

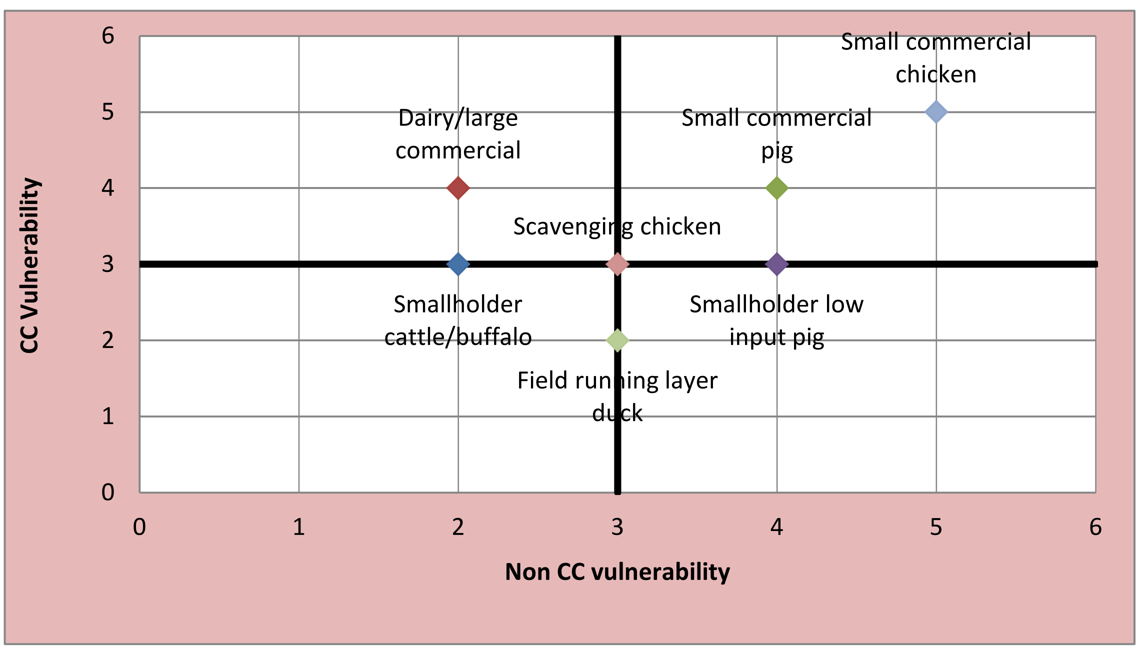


Table 11. Rationale for non-climate vulnerability scores

Livestock System	Non-CC vulnerability	Summary rationale for non-CC vulnerability score	CC vulnerability
Smallholder cattle/buffalo	2	Limited competition in current and likely markets in the medium term, vital to other household livelihood sources through integration with farming systems.	3
Dairy/large commercial	2	High capital investment, rapidly increasing demand, expected to continue rapid growth (from a low base). However, disease issues and long–term competitiveness are a possible future concern.	4
Small commercial pig	4	Increasing competition from large-scale more vertically integrated producers. Viability of these enterprises will be challenged by reduced margins. High-stress systems, high vulnerability to disease and disease responses, limited capacity to invest further in husbandry.	4
Smallholder low-input pig	4	Increasing competition from medium- and large-scale producers, less integrated with farming systems by comparison with bovines. Likely to remain popular in more remote areas in the short term.	3
Small commercial chicken	5	Increasing competition from large-scale more vertically integrated producers. Viability of these enterprises will be challenged by reduced margins. High-stress systems, high vulnerability to disease and disease responses, limited capacity to invest further in husbandry.	5
Scavenging chicken	3	Very low cost systems, significant consumer preference (though changing). Likely to remain prominent in rural and peri-urban areas in the short to medium term.	3
Field-running layer duck	3	Very low cost systems, highly competitive with other production methods. Policy changes relating to disease control are not predictable but could change quickly.	2

SECTION 3: LIVESTOCK ADAPTATION

Due to the diversity of livestock production in the LMB and the wide range of specific constraints and opportunities at the local level, the potential adaptation strategies to increase climate change resilience and strengthen household livelihoods described here are intentionally broad and flexible. The approach presented offers a means of considering livestock systems strategically, which can then be built upon for the identification and design of specific interventions at the local level.

Examples are provided of potential adaptation options, which will be broadly appropriate throughout the region. The options presented are not exhaustive and are intentionally generic; the specific situation in, for example, pilot locations would need to be assessed and considered carefully before intervention. It is intended that the strategies presented become a starting point for adaptation and use at the local, provincial, livelihood zone or even basin level, but local assessments would also need to be conducted before proceeding with specific adaptation activities.

The potential adaptation strategies presented in this section are based on specific experiences within the LMB and a range of secondary sources. The strategies would likely be applicable to the systems identified throughout this report in most situations in which these systems are found in the LMB.

1 GENERAL ADAPTATION STRATEGIES

Improving livestock nutrition, health, and market access - both up and downstream - will improve household and stock resilience to climate change in the majority of the LMB. This approach will also promote local and national economic development and reduce food insecurity, poverty, and vulnerability. Building on these broad principles at the local level will require prioritization, phasing, and specific adaptation interventions.

Five key aspects of livestock production in the LMB have been identified for future intervention design to build livestock development and increased resilience to climate change:

- Nutrition
- Disease resistance: reduced challenges and increased resistance to disease
- Housing
- Production planning and offtake
- Access to markets: both up and down stream

The five aspects are closely interrelated but have been separated to promote consideration of livestock production constraints from a range of perspectives. They may be considered under the two broad categories of ‘production’ and ‘market’ factors. Progress in improving these aspects of livestock production will most likely enhance both household and livestock resilience to climate changes; as well as support other household livelihood mechanisms and reduce local and broader environmental pressures, including threats to protected areas.

These key livestock production aspects are generally applicable to all major smallholder production systems currently operating in the LMB, and are particularly important for low-input smallholder systems and small commercial units. They do not target larger-scale operations though there would be significant indirect benefits to these businesses through trade, reduced disease threats, and the potential to access new and higher value markets domestically and internationally.

In the following sections where the term 'smallholders' is used it refers to both low-input scavenging and grazing poultry, pig and ruminant systems and more commercially orientated small- and medium-scale pig and poultry units.

1.1 NUTRITION

Reduce undernourishment by increasing the quality and quantity of feed production, storage, and the nutritional balance of diets.

Adaptation rationale: increasing internal adaptive capacity.

Adaptation options should first consider smallholder access to feed and feed quality on an annual basis, noting seasonal peaks and troughs. Smallholder stock in the LMB, particularly ruminants, are generally in poor condition during the late dry and early wet seasons. During these periods stock of all species typically lose value and productivity, have reduced ability to work, lose weight, and produce less non-meat products. Climate change will increase seasonal extremes in much of the LMB and increase the length and severity of feed-deficit periods. Increasing household ability to feed stock adequately during these periods will have significant positive effects on household resilience.

Improved use of current feed resources, such as crop residues and wild feed sources, and introduction or improvement of forage cultivation will help reduce periods of nutritional deficiency. Available protein is typically the key nutritional component to address, while some areas also endure chronic mineral deficiencies, such as phosphorous deficiencies in parts of Lao PDR, which may be alleviated easily through supplementation but requires knowledge transfer and access to appropriate feed additives. The appropriate forage varieties will depend on local availability, growing conditions, and typical land use such as major crop systems. Introduction of feed preservation techniques, such as small-scale silaging, can reduce pressure on stock during lean periods.

Improving feeding systems will also reduce pressure on the local environment and protected areas commonly used for grazing large ruminants. Reducing the need to graze these areas will decrease contact between wild species, such as banteng of which the largest population globally inhabits Eastern Cambodia, and domesticated species thereby reducing the risk of disease transmission between species. Limiting the need for grazing in protected areas will also reduce contact between people tending stock and wild animals, reducing hunting pressure.

1.2 DISEASE RESISTANCE

Reduce threat of disease by i) increasing internal resistance through improvement of nutritional status and body condition and vaccination levels, and ii) reducing disease challenges by improving biosecurity levels to reduce the risk of pathogens entering the herd or flock.

Adaptation rationale: increasing adaptive capacity (internal and external)

Disease issues present a significant threat to all stock in the LMB. Morbidity and mortality are major constraints to livestock productivity and value. Further, disease responses frequently include market-related restrictions, such as movement bans implemented during outbreaks that limit access to potential markets. Climate change will alter disease patterns and prevalence; there is strong empirical evidence of shifts in disease patterns in Southeast Asia and the emergence of new infectious diseases is inevitable. Increasing human and livestock populations and increasing movement and contact in even the most remote areas of the LMB suggest emerging and endemic disease risks will increase. Further, drier dry seasons and heightened risk of flooding are likely to exacerbate current nutritional problems, while wetter wet seasons increase key infectious disease risks by allowing key pathogens, particularly bacteria, to survive longer outside hosts, increasing the risk of transmission through mud by fomites and vectors.

Reduced productivity and mortality due to infectious disease are a problem for stock in all systems, though the specific disease threats vary with production system. **The highest risk systems are small- and medium-commercial enterprises, which typically make substantial investments in buildings, stock, and feed.** Higher investment, stocking rates, the use of more productive but less resistant improved genetic lines, suboptimal employment of biosecurity measures, and variable vaccination quality and coverage particularly in more remote areas make risk associated with disease particularly high for these producers.

The disease risk varies between species. Outbreaks of Newcastle Disease, fowl pox and fowl cholera are ongoing problems for smallholder chicken production. Hemorrhagic septicemia, foot and mouth disease, blackleg, brucellosis, and sporadic cases of anthrax are particularly important for cattle and buffalo owners. Pigs are most severely affected by classical swine fever, swine cholera and Porcine Reproductive and Respiratory Syndrome (PRRS). Notably regular PRRS outbreaks cause significant productivity losses among pig breeders and movement bans in response to outbreaks have important economic ramifications for producers.

Low-input systems that generally use minimal vaccination and employ limited biosecurity measures are frequently affected by disease outbreaks. The threat of disease will be heightened by poor nutrition and rapid sales post flooding, events which are likely to occur more frequently and with greater intensity. Smallholders in areas affected by seasonal changes and heightened risk of flooding and drought are likely to experience greater prevalence of key diseases in the future.

Disease risks also threaten wild species such as banteng. The risk of transmission both to and from wild, feral, and domesticated animals is likely increased by climate change through changing feed availability, which will lead to increased grazing in protected areas and therefore contact between species. **Changes in disease patterns and the health status of domesticated stock are therefore highly likely to affect wild populations**, and vice versa.

Adaptation strategies need to consider improving livestock internal resistance to disease through improved nutritional status and vaccinations while also reducing disease challenges through improved biosecurity measures to lower the risk of pathogens entering the herd or flock. Building animal health service capacity in delivery of services and technology transfer is a priority in most areas of the LMB.

1.3 HOUSING

Improve housing location and design to maximize natural ventilation and minimize exposure to extreme events.

Adaptation rationale: reducing exposure of sensitive systems

Housing and confinement systems are an important first step in reducing the risk of disease as they provide a physical barrier to traffic and mixing, reducing the risk of pathogens entering the herd or flock. Further, with expected increases in average temperatures and periods of temperature extremes stock housing should be located and designed to maximize natural ventilation; utilize perflation, convention, and stacking effects; reduce current and future heat stress issues.

Mondulkiri is a primary concern for heat stress issues given predicted five degree centigrade increases in maximum temperature during the wet season. However, there are few commercial units in the province. **Improving housing is a greater priority in provinces in northeast Thailand, central and southeast Cambodia and the Vietnamese Delta areas where commercial pig and poultry units are more common**. The hotspot provinces Chiang Rai and Kien Giang show less extreme temperature increases, but the number and importance of small commercial pig and poultry enterprises, the increasing competition from larger-scale corporate producers, and the high human and livestock population density make improved housing and confinement a key adaptation strategy in these areas. **Often the key limit to improving housing is access to capital to invest, for this reason access to rural credit may be a key starting point for increased adaptation.**

1.4 PRODUCTION PLANNING AND OFFTAKE

Improve production planning and reproduction management in breeder herds/flock by reducing inbreeding, improving recognition of estrus, and promoting earlier weaning.

Increase offtake rates, where beneficial, by promoting controlled destocking to reduce pressure on stock, land, and/or nucleus herds and flocks with the additional benefit of increasing household incomes.

Adaptation rationale: reducing exposure and sensitivity, increasing internal adaptive capacity

Low-input system resilience to climate change is currently low because of limited production planning, particularly among cattle raisers. Current supply and demand peaks may be smoothed by increasing efficiency in reproduction management and increasing planned sales, which will also increase household incomes and reduce pressure on feed resources. If managed well, greater efficiency in stock management and sales can increase household access to, and income from, draft and manure. Increasing planning and offtake also provides a potential incentive for households to invest more in animal health, primarily vaccination and biosecurity measures, benefiting all producers by reducing disease risk.

Increasing offtake rates for cattle will be most beneficial in areas prone to extreme events such as drought and flooding. Increasingly flood-prone areas such as Mondulkiri, Khammouan, and Gia Lai have large populations owning small herds of cattle and buffalo raised in low-input, low-productivity systems. Low feed periods and poor stock condition caused by drought are particular problems in Mondulkiri and Khammouan.

Low-input scavenging poultry and pig systems will also benefit from greater planning in reproduction and reduced time to sale. Scavenging poultry are often kept beyond six months, pigs above 12 months, by which point weight gain is negligible and maintaining stock increases the risk of loss to disease, and predators in the case of poultry.

As animal health practices develop, the gradual improvement of genetics through the introduction of more productive lines might be considered. However, modern genetics are usually less able to cope with the high disease challenges present in the LMB. They require better quality diets to thrive and are generally less resilient when threatened with temperature extremes. Upgrading genetics is usually high risk and should be considered with caution**.** **Breeding programs utilizing local genetics would be lower risk and potentially very valuable given the many advantages of local breeds in terms of reproduction, heat tolerance, and disease resistance.**

1.5 ACCESS TO MARKETS

Increase access to input and output markets and producer organization to reduce input costs, increase prices received, and reduce price volatility.

Adaptation rationale: increasing adaptive capacity, reducing sensitivity

By increasing access to markets, upstream input costs can be reduced and stabilized. If managed accountably, access to markets will crowd business, leading to greater competition to supply and improved quality. Greater access to feed suppliers, genetics, and animal health products and services will increase productivity and resilience to climate change. Isolated areas will particularly benefit from increasing access to markets. Greater ties to other markets reduce the threat of localized events by allowing access to necessary inputs and smoothing input price volatility.

Improving access to output markets will increase producer price setting power and the transparency and accountability of middlemen and traders. Higher-value urban markets are increasing in size with rapid urbanization. Unlocking these markets for smallholders presents enormous potential for income generation through greater margins and price stability. Further, greater competition can incentivize better practices such as use of vaccinations and employment of biosecurity measures, reducing disease risks. Allowing smallholder access to new markets requires improving access infrastructure, increased linkages between producers, middlemen and traders, and greater producer organization to improve stability of supply and food safety awareness and assurance, for example slaughtering hygiene and cold chain development.

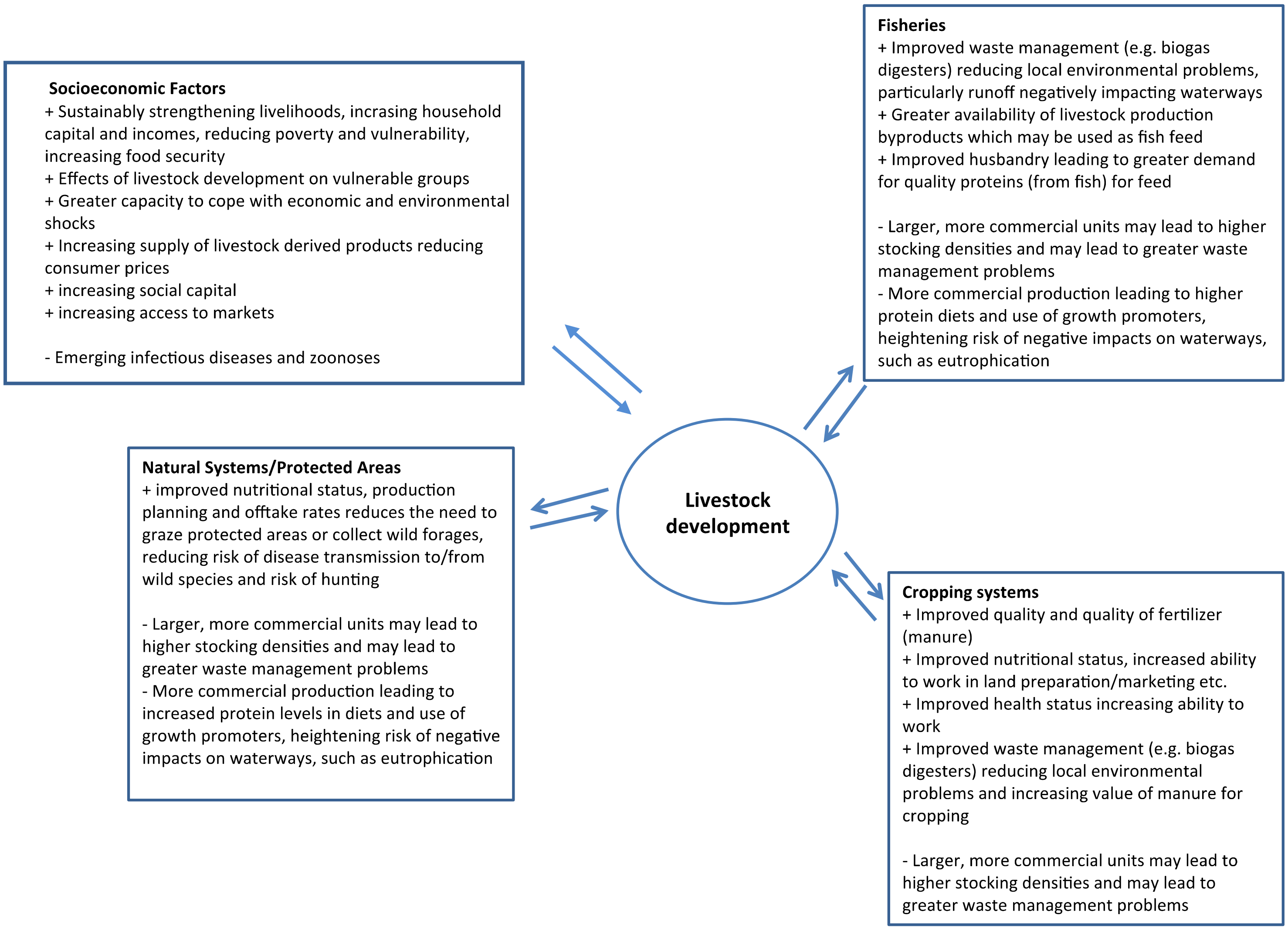
Access to usable market information and increasing linkages between value chain actors further increase transparency and accountability in negotiations. Second generation market information systems are most applicable because they are based on network development and strengthening which is typically more sustainable, dynamic, and adaptive. They also allow information exchange in real time unlike more passive first generation models. The extensive mobile phone coverage in the region has allowed ICT related formal and informal systems to become established. Continuing this development is likely to increase producer resilience to climate change threats in the longer term.

Market access is most limited in remote areas such as Khammouan, Mondulkiri and, to a lesser extent, areas of Gia Lai and Chiang Rai. These areas can remain competitive in a more open market due to the relatively high availability of land for grazing and forage cultivation, relatively low costs of production, and current market preferences for local, slow-growth breeds. Unlocking markets and increasing linkages between actors in these areas have the potential to strengthen household livelihoods and resilience to climate change considerably.

1.6 ADAPTATION LINKAGES

Figure 10 identifies key potential positive (+) and negative (-) feedback of livestock adaptation strategies on other livelihood incomes. The identified interactions are not exhaustive but illustrate the complex connections at play and the need to avoid negative impacts on other areas:

Figure 10. Adaptation linkages



2 LIVESTOCK SYSTEM ADAPTATION PLANNING APPROACHES

The following section outlines potential adaptation planning interventions for livestock systems. When working at the local level the broadly described adaptation options contained here will have to be revised for the local context through prioritization, phasing, and additional specific adaptation interventions.

For all of the described livestock systems the following general considerations should be taken into account when planning for adaptation:

- **Evaluate current value of livestock** relative to other livelihood mechanisms and linkages within and between livelihood components, potentially using participatory or quantitative methods
- **Assess local strengths, weaknesses, opportunities, and threats** (SWOT) employing a climate change lens. Consider:
    - **history of extreme events** in the location through media search and discussion with local stakeholders, e.g., semi-structured interviews, animal histories, timelines, etc.
    - **production level issues** including access to inputs and service markets; animal nutrition; animal health; and veterinary public health
    - **postharvest issues** including slaughtering, processing and cold chains; market related issues, e.g., price setting power, market access, etc.; and veterinary public health

Examples of interventions suggested in the following section include but are not limited to:

- Farmer-to-farmer information exchange
- Farmer field schools
- Action research trials – farming systems research approaches, e.g., with and without, before and after trials
- Cross visits (although this is a potential biosecurity hazard)
- Participatory marketing activities (e.g., see SDC SADU Lao PDR)
- Capacity building village animal health worker (VAHW), extension service, private service provider (e.g., refresher courses, business planning)
- Farmer group development – increasing social capital, formal/informal micro-credit/micro-insurance
- Promote access to existing social protection mechanisms, e.g., access to credit

2.1 SMALLHOLDER CATTLE/BUFFALO 'KEEPING': *BOS INDICUS*, DRAFT CATTLE, BUFFALO

Potential adaptation options to address the key climate change threats on smallholder cattle and buffalo systems are outlined in Table 12.

Table 12. Key climate change threats and associated adaptation options for smallholder cattle/buffalo systems

Key threat	Impact	Adaptation options
Drought	Reduced fodder availability affecting already undernourished stock; increased risk of disease, reduced productivity and value.	Planned destocking, forage development, improve access and quality of animal health services.
Increased temperature	Temperature increases will have a negative impact on productivity (draft, beef, reproduction); though limited on the individual level, the effects are likely to be significant when multiplied to the larger population.	Planned destocking, forage development, improve access and quality of animal health services.
Storms/flash flooding	Stock directly exposed to flash flooding may be lost. The likelihood is exposure rates will be low but sensitivity of exposed stock high.	Locate stalls/stock/ forage plots away from high risk areas, e.g., consider low lying areas, valleys, near rivers/streams; local history/experiences needs to be considered.

2.1.1 GENERAL MANAGEMENT

General management for smallholder cattle and buffalo systems can be improved through the following specific adaptation interventions:

- **Improving infrastructure**
  - o Stall-feeding; animal handling equipment, e.g., basic crush, etc.
  - o Locating any infrastructure away from areas exposed to storms and/or flash flooding is clearly advisable.
  - o Quarantine pens (see animal health).
- **Improving reproduction management**
  - o Observation during calving is recommended. Preferably calve in a clean area to reduce the risk of infection.
  - o Assess seasonality. Plan calving late dry season/early wet season (to maximize available fodder during peak lactation).
  - o Consider early weaning at 5-6 months to reduce stress on cows, increase land carrying capacity (reducing pressure on cattle and other natural resources) and reduce inter-calving interval.
  - o Consider bull exchanges (often there are inbreeding issues in remote areas).
- **Improving waste management**
  - o Improved manure utilization through collection and drying and/or biogas digesters.

2.1.2 ANIMAL NUTRITION

Adaptation measures designed to adapt to low feed/feed deficit periods caused or exacerbated by climate change include:

- **Feed development**: particularly better protein sources, which will increase stock value, reproductive performance, and boost immunity to disease challenges (e.g., HS, FMD, blackleg, anthrax).
  - Forage establishment: e.g., *Stylosanthes sp*., Napier (elephant grass), and mulato grass (consult ACIAR Tropical Forage Database for information on cultivation and use and for other possible forage species).
  - Crop byproduct use: e.g., cassava tops (cassava production suitability is projected to increase gradually); *Sesbania sp*. (commonly utilized as shade for coffee, coffee suitability is projected to increase in some areas of the LMB); use of legume cover crops under rubber (again, suitability of rubber is projected to increase significantly in some areas of the LMB), e.g., promotion of stylo under rubber stands may be possible.
  - Urea treatment of grain stover/straw: notably rice straw where rice is cultivated.
  - Consider increasing use of wild forages: e.g., paper mulberry, luceana, and other tree legumes.
  - Technology transfer to consider piloting: e.g., three strata forage systems (ACIAR, FAO, ILRI, CIAT), improved food-feed systems (ACIAR, FAO, ILRI, CIAT), and biogas digesters (National Biogas Project).
- **Feed preservation**
  - Silaging: introduction of bag and/or ring methods.
  - Controlled destocking: destocking early dry season to reduce pressure on available feed resources and reduce stress on breeding cows (improving stock condition). This may also reduce the risk of disease and help to maintain stock value and condition for the following season, improving reproduction and progeny viability/growth. Additional benefits include increased household incomes/financial capital and, potentially, flattening possible over-supply issues, e.g., gluts in the aftermath of natural and economic shocks.
- **Water**
  - Ensuring access to adequate quality and quantity of water is essential.

2.1.3 ANIMAL HEALTH

Adaptation activities to address disease risks exacerbated by climate change and poor stock condition include:

- **Increase vaccinations**
  - Group vaccination campaigns: hemorrhagic septicemia and foot and mouth disease (possibly blackleg) through village animal health workers (VAHW) networks. Reach of current national campaigns can be supported/facilitated. Quality of vaccines is essential (producer, expiration dates, and cold chains and administration technique need to be considered).
- **Increase deworming**
  - Early and late wet season to improve stock condition and increase resistance to other diseases.
- **Improve biosecurity**
  - Reduce stock mixing to reduce risk of outbreaks.
  - Introduce quarantining of new and sick stock (minimum 2 weeks).

2.1.4 MARKETS (OUTPUT) – DRAFT, MANURE, AND BEEF

Adaptation measures designed to improve producer organization include:

- **Destocking** (increased offtake rates) in early dry season, as above, to flatten supply, reduce stress on feedstock, and improve individual condition/disease resilience. Target demand peaks, e.g., Pchum Benn, Tet, and Songkran.
- **Increased draft production** through improved condition.
- **Facilitate access to markets,** e.g., market information systems, ICT, participatory marketing, group marketing/supply.

2.2 SMALL COMMERCIAL PIG

2.2.1 KEY THREATS

Potential adaptation options to address the key climate change threats on small commercial pig systems are outlined in Table 13.

Table 13. Key climate change threats and associated adaptation options for small commercial pig systems

Key threat	Impact	Adaptation options
Increasing temperature	Confined, relatively stressed systems generally already outside their thermoneutral zone; high exposure, high sensitivity. High likelihood of reduced VFI causing reduced growth rates, lower reproductive performance, and reduced immunity through increased stress (increasing disease problems) and behavioral problems such as stereotypies, bullying, and fighting. May make some systems economically unviable.	Improve quality of and access to water. Direct cooling, e.g., by spraying water on pigs. Ensure adequate vaccination protocols are in use. Improve biosecurity practices especially separation of sick or injured pigs. May force reductions in stocking density depending on management practices. Grow shade trees if shelters are exposed to direct sun. Improved shelter designs that maximize natural ventilation (stack effect, aspiration, perflation).
Storms/flash flooding	Stock directly exposed to flash flooding may be lost. The likelihood is exposure rates will be low but sensitivity of those exposed high. Possible damage to housing and loss of feed stores.	Locate housing and feed storage away from high-risk areas, e.g., consider low lying areas, valleys, near rivers/streams; local history/experiences needs to be considered.

2.2.2 GENERAL MANAGEMENT

General management for small commercial pig systems can be improved through the following adaptation actions:

- **Housing**
  - Improve housing location and design (for new buildings and/or upgrades): incorporating natural ventilation in design is relatively cheap (particularly in the case of new builds), reliable, and effective. Locating housing in areas exposed to air movement and

maximizing stack effect, aspiration, and perflation through housing dimensions and wall and roof design will have significant production benefits.
    - Incorporate water-based cooling systems: such as direct hosing of stock and roof drips are effective but will depend on accessibility and cost of water, and further infrastructure for lifting water (pumps, gravity feeds, and capillary action-based systems) would likely require economic assessment, e.g., cost-benefit analysis, and partial budgets.
    - Facilitate cleaning: sloping floors, smooth surfaces. Ensure manure is removed daily.
- **Water**
    - Ensure access to appropriate quality and quantity of water: this is fundamental and will become even more critical in areas enduring higher mean and maximum temperatures. Of course this is particularly true for lactating sows, when flow rates of approximately 2l/minute are needed.
- **Stocking density**
    - Reduce stocking densities to reduce ambient temperatures, behavioral problems, and risk of disease spread.
- **Nutrition**
    - Feeding higher quality diets may make economic sense due to reduced VFI, though this will need to be carefully assessed in the specific situation.
    - Improved feed storage: reduced waste and risk of intoxication of mycotoxins.
    - Consider use of vitamin supplements, particularly pre and during the hottest periods.
    - Monitoring of stock condition: particularly sows, e.g., fat-sow, thin-sow syndrome is a common problem.
- **Reproduction (piglet producers)**
    - Monitor stock condition and biosecurity (see nutrition and animal health).
    - Preferably housing should include nests for piglets.
    - Artificial heating for piglets to a few days of age, e.g., gas or protected charcoal fires.
    - Refresher courses in heat recognition. Potentially introduction of artificial insemination depending on availability and quality.
- **Waste**
    - Improve manure utilization through collection and drying. Potential installation of biogas digesters.
    - Slaughtering waste management: significant source of local environmental degradation, use of fish ponds can be effective.

2.2.3 ANIMAL HEALTH

Adaptation activities to address changing disease risks exacerbated by climate change include:

- **Vaccinations**
    - Quality of vaccines is essential. Ensure good products within expiration dates and managed in unbroken cold chains. Persons administering may need to be trained/attend refresher courses.
    - Minimum protocol: classical swine fever, preferably PRRS, FMD and Aujesky's disease, local recommendations should be considered.
- **Biosecurity**
    - Confinement.

- All-in, all-out systems for fatteners with 2-week (minimum) vacuum period including cleaning and disinfection.
- Improved general cleaning and disinfection, particularly of farrowing pens/areas.
- Frequent removal of manure: reducing disease risk and ammonia levels.
- Minimize on- and off-farm traffic, e.g., meet trader at the gate, rather than in the pen.
- Quarantine sick and/or injured pigs.
- Careful disposal of any losses: well away from the piggery, burning or deep burying with disinfectant. Dead pigs should not be sold or consumed.

2.2.4 MARKETS (OUTPUT) – MEAT AND/OR PIGLETS

Adaptation measures designed to improve small commercial pig producer organization include:

- Production planning targeting demand peaks, e.g., Tet and Pchum Benn. Sow owners should be targeting two parturitions per year and at least 20 weaned pigs/sow/year.
- Facilitate access to markets, e.g., market information systems, ICT, participatory marketing, group marketing/supply.

2.3 SMALLHOLDER LOW-INPUT PIG

2.3.1 KEY THREATS

There are limited direct impacts from climate change on smallholder pig systems aside from flash flooding in exposed areas that may lead to stock and/or infrastructure loss.

The changing ecology of pathogens may affect disease prevalence, which is a major constraint to most current systems. This could be exacerbated by climate change.

2.3.2 ADAPTATION OPTIONS

Gradual progression to confined, more market-oriented systems, where pigs are regarded as income generators as opposed to a form of savings would normally be recommended. This reduces the risk of disease by reducing contact and allowing increased use of biosecurity measures. Greater market orientation can increase the incentive to vaccinate. Greater commercialization can increase incomes but care needs to be taken as stock move from scavenging to reliance on owners to meet their nutritional requirements.

If confined systems are a stated objective, many of the principles/interventions described in greater detail for other systems will be applicable. In particular:

- **Feeding:** Usually the optimal entry-point, e.g., developing forages prior to confinement. Adequate feeding is of course fundamental to success of confined systems.
- **Animal health:** Including biosecurity measures and vaccinations.
- **Access to markets:** Ensure demand exists, or can be developed before changing animal husbandry systems. Improving productivity in this manner inevitably increases costs (monetary and non-monetary such as labor); it is essential that pigs can be sold.

2.4 SMALL COMMERCIAL CHICKEN (BROILERS; LAYERS)

2.4.1 KEY THREATS

Potential adaptation options to address the key climate change threats on small commercial chicken systems are outlined in Table 13.

Table 14. Key climate change threats and associated adaptation options for small commercial chicken systems

Key threat	Impact	Adaptation options
Increasing temperature	Confined, relatively stressed systems that are generally already outside the birds thermoneutral zone; high likelihood of reduced VFI and therefore reduced growth rates, reduced immunity due to increased prevalence of heat stress (increasing disease problems), and increased incidence of behavioral problems such as cannibalism and stereotypies.	Improve biosecurity practices especially separation of sick and/or injured birds. May force a reduction in stocking density depending on management practices. Ensure adequate vaccination protocol. Grow shade trees if using run system and to shelter buildings. New housing designs, which incorporate maximum natural ventilation (stack effect, aspiration, perflation). Possibly invest in fans, promote the use of supplementary vitamins in drinking water.
Flash floods and storms	Stock directly exposed to flash flooding may be lost. The likelihood is exposure rates will be low but sensitivity of those exposed high. Possible damage to housing and loss of feed stores.	Locate housing, run, and feed storage away from high-risk areas, e.g., consider low lying areas, valleys, near rivers/streams; local history/experiences needs to be considered.

2.4.2 GENERAL MANAGEMENT

General management for small commercial chicken systems can be improved through the following interventions:

- **Housing**
  - **Improve housing location and design** (for new buildings and/or upgrades): maximizing natural ventilation effects in building design is relatively cheap (particularly in the case of new builds), reliable, and effective. Locate housing in areas with good air movement and maximize stack effect, aspiration, and perflation through housing dimensions and wall and roof design. Housing and feed storage should be located in areas with low exposure to storms and/or flash flooding if possible.
  - **Water-based cooling systems**: e.g., roof drip systems are effective but will depend on accessibility and cost of water and infrastructure for lifting water (pumps, gravity feeds, and capillary action-based systems). This would need to be priced and balanced against benefits, which will primarily depend on scale of production.
  - **Artificial heating:** in brooding units, e.g., gas burner and protected charcoal fires.
  - **Ease of cleaning**: smooth surfaces.

- **Water**
  - Ensuring access to adequate quality and quantity of water is fundamental and will become even more critical in areas enduring higher mean and maximum temperatures.
- **Stocking density**
  - Reduce stocking densities: may become necessary to reduce ambient temperatures, behavioral problems, and risk of disease spread. This might be achieved through establishing run areas (which should be confined to limit the risk of predation and disease challenges), increasing housing size, and/or reducing stock numbers per batch.
- **Nutrition**
  - Feeding higher quality diets may make economic sense due to heat-reduced VFI, though this will need to be carefully assessed in the specific situation.
  - Consider use of vitamin supplements during the hottest periods (multivitamin supplements in drinking water).
- **Genotype**
  - Local breeds and crossbred broilers are usually more thermotolerant than exotic equivalents. Despite lower performance they typically receive a significant price premium due to strong consumer preference in the region. Crossbred broilers are growing in popularity among these systems and availability of good chicks is increasing, these breeds can be encouraged. Unfortunately layer alternatives are not yet readily available and the performance losses are likely too high for commercial units with negligible associated price premium for products.
- **Waste**
  - Used litter can be used as fertilizer and being high biomass may be utilized in energy production if the appropriate infrastructure exists in the area. Locally specific markets or uses would need to be investigated.

2.4.3 ANIMAL HEALTH

Adaptation activities to address changing small commercial chicken system disease risks exacerbated by climate change include:

- **Vaccinations**
  - Quality of vaccines is essential; ensure good products within expiration dates and unbroken cold chains. Persons administering may need to be trained/attend refresher course.
  - Minimum: Newcastle disease (one or preferably two boosters), fowl pox, and fowl cholera. Local recommendations should be consulted.
- **Biosecurity**
  - Confinement: both housed and in run (if used).
  - All-in, all-out systems, change litter between batches, 2 week (minimum) vacuum period (cleaning and preferably disinfection).
  - Minimize on- and off-farm traffic, e.g., fencing and gates, signs, meet trader at the gate rather than in the pen.
  - Quarantine sick and/or injured birds.
  - Careful disposal of dead birds: well away from other birds using burning or deep burying with disinfectant. Dead birds should not be sold or consumed.

2.4.4 MARKETS (OUTPUT) – MEAT AND/OR EGGS

Adaptation measures designed to improve small commercial chicken producer organization include:

- Production planning: target demand peaks if they exist, e.g., Tet and Pchum Ben.
- Facilitate access to markets and social capital, e.g., using participatory methods, group marketing/supply (i.e. inputs and/or products).
- Facilitate access to markets, e.g., market information systems, ICT, participatory marketing, group marketing/supply.

2.5 SCAVENGING CHICKEN: MEAT/DUAL PURPOSE

Similar to smallholder low-input pig systems, direct effects are likely to be limited, though stock directly exposed to flash flooding may be lost. Changing ecology of pathogens may affect disease prevalence, which is a major constraint to current systems. This could be exacerbated by climate change.

A move towards confined systems and increased use of vaccinations would typically be recommended, though it is usually difficult to achieve as birds raised in this manner are not generally regarded as a source of income and little to no capital is invested in their management.

Specific adaptation options may include:

- Locate stalls/housing and develop forage plots away from high risk areas, e.g., low-lying areas, valleys, near rivers/streams and consider past events.
- Please refer to general adaption considerations for confinement systems described under 'smallholder low-input pig' and smallholder commercial poultry operations.

2.6 FIELD RUNNING LAYER DUCKS

2.6.1 KEY THREATS

Potential adaptation options to address the key climate change threats on field-running layer ducks are outlined in Table 13.

Table 15. Key climate change threats and associated adaptation options for field-running layer ducks

Key threat	Impact	Adaptation options
Changes to rice production	The effects of climate change on rice production will have significant impacts on the availability of running areas for scavenging. Changes to rice production could force changes in management systems.	Little option but to dramatically change production system or rely more on other livelihood mechanisms. Increased public and private sector collaboration with smallholders is needed to minimize the disease threat posed by these systems, in particular for the benefit of other poultry producers.
Flash floods and storms	Stock directly exposed to flooding may be lost. Possible damage to housing.	Locate any housing and confined areas away from high-risk places and consider past events.

2.6.2 ANIMAL HEALTH

Adaptation activities to address changing field-running layer duck systems and disease risks exacerbated by climate change include:

- **Vaccinations**
  - Quality of vaccines is essential; ensure good products, within expiration dates and unbroken cold chains. Persons administering may need to be trained/attend refresher course.
  - Duck plague; local recommendations should be consulted.
- **Biosecurity**
  - Confined systems would significantly reduce disease risk to the flock and other producers and people, however, there is, at present, little incentive for producers to change their systems.

2.6.3 OUTPUTS (MARKETS) – MEAT AND/OR EGGS

Adaptation measures designed to improve field-running layer ducks producer organization include: facilitating access to markets, social capital, group marketing/supply, and products.

2.7 BANTENG AND OTHER WILD SPECIES

Direct effects of projected climate changes will be less significant on banteng and other wild species, however, the likely increase in pressure on household livelihoods may increase pressure on wild areas and with it the likelihood of contact between people (increased risk of hunting losses) and domestic stock (risk of disease, loss of habitat).

Adaptation options for wild species include:

- Increase the capacity of protected area management
- Awareness raising at all levels
- Strengthening other livelihood aspects (see above adaptation options for livestock) to reduce pressure on wild species habitat. For example, forage development for ruminants may reduce the need to graze stock in natural areas
- Breeding programs
- Relocation of herds

3 PROMOTING INTEGRATED FARMING SYSTEMS

This study has found that integrated systems raising livestock as positive contributors to other household livelihood generation activities, while performing roles as productive income generators and as a means of household wealth storage, is sustainable and can strengthen livelihoods while increasing resilience to climate change among livestock-rearing households in the LMB.

As the livestock sector rapidly develops in the basin the competitiveness of small- and medium-scale commercial production diminishes, largely due to competition from larger-scale producers, and will be further threatened by climate change. Commercial units are more likely to produce negative externalities, such as local pollution, potentially weakening other livelihood mechanisms in the local area. Wealthier households typically operate commercial units and have greater ability to alter their livelihood strategies if needed.

Smallholder, low-input systems can remain both viable and locally valuable due to their broader contributions to household livelihoods and use of hardier, more climate-tolerant breeds. Furthermore, smallholder livestock raising is often conducted by poor and vulnerable households and individuals who don't have the ability to develop into commercial production.

Livestock products of slower-growth local or crossed genetics remain strongly preferred by many consumers in much of the LMB. Further, the low costs of production and high livelihood value of non-meat products, such as manure and traction, make continued smallholder livestock raising economically rational. Increasing the efficiency of these production systems and ensuring these systems can, or continue to, contribute optimally to broader farming and livelihood systems will increase resilience to climate change while reducing household poverty and vulnerability.

Smallholder rural livelihoods are currently centered on integrated farming systems in many areas of the LMB. These systems are broadly resilient due to the diversity of income and food streams contributing to the household livelihood. Further, mutually supportive systems, most obviously livestock and cropping systems, increase the productivity of each other while increasing household nutrition, income, savings and social standing and at the same time dispersing risk. Managing livestock as elements of diversified 'ecological farming systems' can increase the availability of manure and draft for land preparation, provide tillage and rent, while also increase crop and horticultural productivity through the benefits of intercropping forage cultivars, particularly legumes benefiting animal nutrition and increasing crop yields. Building on the current smallholder 'ecological farming systems' through introduction of more effective management practices, such as three strata forage systems and other food-feed related systems, can build upon beneficial linkages and increase stock value and household incomes more broadly.

The use of nitrogen fixing forages in intercropping or rotational systems can also reduce the use of fertilizer and pesticides, reducing the risk of runoff that can harm local waterways and other natural systems. Further, by increasing the availability of feed, the need to graze bovines in protected areas will be reduced, reducing pressure in terms of livelihoods and threats to endangered species.

Building on already integrated crop-livestock production at the smallholder level has the potential for long-term benefits for livelihoods and to increase resilience to climate change, while reducing the burden of current production on other systems. Diversified approaches to rural development in the LMB will directly benefit many of the poorest, most vulnerable, and most food insecure households and individuals while increasing long-term resilience and minimizing negative externalities.

REFERENCES

Asian Development Bank (ADB) (2005) 'Final Report: Participatory Livestock Development Project' ADB PPTA No. 4287 LAO: Socioeconomic Assessment

ADB (unknown) Climate Change Vulnerability, Adaptation and Mitigation in the Greater Mekong Subregion Core Environment Program

Asian Veterinary and Livestock Services (ASVELIS) (2011) 'Documentation and Impact Analysis of Interventions in the Cattle Sub-Sector in Tuong Duong and Ky Son Districts, Nghe An Province' for Oxfam Hong Kong, Hanoi, Vietnam

Agrifood Consulting International (2005) 'Final Report for the Cambodian Agrarian Structure Study'

Asian Wild Cattle Specialist Group (AWCSG) (2012) http://www.asianwildcattle.org/

Barrett, J. (1992) 'The Economic Role of Cattle in Communal Farming Systems in Zimbabwe' Pastoral Development Network, Overseas Development Institute (ODI), Paper 32b.

Chantong, W. and Kaneene, J.B. (2011) 'Poultry Raising Systems and Highly Pathogenic Avian Influenza Outbreaks in Thailand: The Situation, Associations, and Impacts' http://www.tm.mahidol.ac.th/seameo/2011-42-3/14-5089.pdf

Cocks, P., Abila, R., Bouchot, A., Benigno, C., Morzaria, S., Inthavong, P., Long, N.V., Luthi, N.B., Scoizet, A., and Sieng, S. (2009) 'FAO ADB and OIE SEAFMD Study on Cross Border movement and market chains of large ruminants and pigs in the Greater Mekong Sub Region'

Connell, J., Stur, W., and Horne, P. (2010). 'Forages and Farmers: Case Studies from South- East Asia. ACIAR, Canberra and CIAT Vientiane. ACIAR Monograph No. 142

Convention on Biological Diversity (CBD) (1993) http://www.cbd.int/

Crotty, R. (1980) 'The Indian Case: Cattle Grazed Communally; Milk has Value' Cattle Economics and Development, Cabi Publishing, pgs. 163-192

CARE, Catholic Relief Services, Oxfam and PACT (2012) 'Drowning in Debt: The Impact of the 2011 Cambodia Floods on Household Debt: A Survey of Poor Households in Three Affected Provinces'

DIPECHO (2011) 'Reducing Multi Hazard Induced Risks and Building Community Resilience to Disaster in Cambodia: Disaster Resilient Livestock to Support the Poorest Households – Livestock Consultant's Report' Unpublished

FAO (2012a) 'Global Livestock Production and Health Atlas (GLiPHA)' http://kids.fao.org/glipha/ Accessed 25 August 2012

FAO (2012b) 'Technical Session I: Introduction to Flood Management', FAO Corporate Document Repository, Rome, Italy http://www.fao.org/docrep/004/ac146e/AC146E01.htm

FAO (2012c) 'The Livestock Industries of Thailand: The Dairy Industry' http://www.fao.org/docrep/004/ac797e/ac797e05.htm Accessed 27 August 2012

FAO (2011a) 'Mapping Supply and Demand for Animal-Source Foods to 2030' FAO, Rome, Italy

FAO (2011b) 'Atlas of Poultry Production in Pilot Provinces', FAO Vietnam, Hanoi, Vietnam

FAO-AGAL (2005a) 'Livestock Sector Brief: Cambodia', FAO, Rome, Italy

FAO-AGAL (2005b) 'Livestock Sector Brief: Vietnam', FAO, Rome, Italy

FAO-AGAL (2005c) 'Livestock Sector Brief: Lao PDR', FAO, Rome, Italy

FAO-AGAL (2005d) 'Livestock Sector Brief: Thailand', FAO, Rome, Italy

FAO/WFP (2012) 'Crop and Food Security Update Mission to Cambodia: Report', Rome

Farooq, H., Samad, H.A., Shehzad, F. and Qayyum, A. (2010)' Physiological Responses of Cattle to Heat Stress' World Applied Sciences Journal 8 (Special Issue of Biotechnology & Genetic Engineering): 38-43, 2010

Forman, S., Hungerford, N., Yamakawa, M., Yanase, T., Tsai, HJ., Joo, Y.S., Yang, D.K. and Nha, J.J. (2008) 'Climate change impacts and risks for animal health in Asia' Rev. sci. tech. Off. int. Epiz., 2008, 27 (2), 581-597

Gallen, M. (2004) 'Rural Development Project Dak Lak (RDDL) Vietnam: Concept for Sustainable Upland Farming in Dak Lak Province' GTZ

Hansen, P.J. (2004) 'Physiological and cellular adaptations of zebu cattle to thermal stress' Animal Reproduction Science 82–83 (2004) 349–360

Hatfield, J.L. (2008) 'The Effects of Climate Change on Livestock Production' The Pig Site, http://www.thepigsite.com/articles/2296/the-effects-of-climate-change-on-livestock-production

Huffington Post (2011) '10,000 Cattle Dead in Vietnam: Cows, Buffalo Part of Mass Die-Off' http://www.huffingtonpost.com/2011/01/21/10000-cattle-dead-vietnam_n_812224.html

Huyen, L.T.T., Herold, P. and Valle Zárate, A (In Press 2009) 'Farm types for beef production and their economic success in a mountainous province of northern Vietnam', Agricultural Systems, Vietnam. Agr. Syst. (2009), doi:10.1016/j.agsy.2009.11.004

Huyen, L.T.T., Herold, P. Markmann, A. and Valle Zárate, A (2011) 'Resource use, cattle performance and output patterns on different farm types in a mountainous province of northern Vietnam' Animal Production Science, 2011, 51, 650–661

ICEM (2012) Memo

ILRI (2012) 'Mapping of Poverty and Likely Zoonoses Hotspots'

Indochina Research Ltd and Psilos, P. (2007) 'The Cambodian Swine Value Chain: Market Function and Dysfunction' for DAI for the USAID Cambodia MSME Project, Phnom Penh, Cambodia

Informa Agra (Agra-net) (2012) 'Food Supply Future: Famine of Plenty?' https://www.agra-net.com/portal2/

IOM (2009) 'Mapping Vulnerability to Natural Hazards in Mondulkiri – Final Report' IOM, Cambodia

IUCN (2012) 'Red List', http://www.iucnredlist.org/details/2888/0

Jabbar, M.A., Baker, D. and Fadiga, M.L. (2010) 'Demand for livestock products in developing countries with a focus on quality and safety attributes: Evidence from case studies' International Livestock Research Institute (ILRI), Nairobi, Kenya

Johnston, R. M., Hoanh, C. T., Lacombe, G., Noble, A. N., Smakhtin, V., Suhardiman, D., Kam, S. P., Choo, P. S. (2010) 'Rethinking agriculture in the Greater Mekong Subregion: how to sustainably meet food needs, enhance ecosystem services and cope with climate change' Colombo, Sri Lanka: International Water Management Institute. 26p. doi:10.3910/2010.207

Kamakawa, A., Ho Thi Viet Thu, Ly Thi Lien Khai, Le Thi Thu, Yamada, R., Yamane, I., and Taniguchi, T. (2002) 'Pig management in Tan Phu Thanh village and characterisation of the losses' Proceedings of the 2002 annual workshop of JIRCAS Mekong Delta Project, JIRCAS-CTU-CLRRI-SOFRI, Can Th, Vietnam, 2002

Khanh T. T., Stur, W., Dzung, V. T. and Ha, N. V. (2010) 'Assessment of cattle marketing in Ea Kar district, Daklak, Vietnam in 2008' Fodder Adoption Project Working Paper Series

Khounsey, S., Nampanya, S., Inthavong, P., Yang, M., Khamboungheung, B., Avery, M., Bush, R., Rast, L., and Windsor, P.A. (2011) 'Significant mortality of large ruminants due to hypothermia in northern and central Lao PDR' Tropical Animal Health Production.

Knips, V. (2004) 'Review of the Livestock Sector in the Mekong Countries' FAO-AGAL, FAO, Rome, Italy

Lapitan, T. M., Del Barrio, A. N., Katsube, O., Tokuda, T., Orden, E. A., Robles, A. Y., Fujihara, T., Cruz, L. C., and Kanai, Y. (2004) 'Comparison of feed intake, digestibility and fattening performance of Brahman grade cattle (Bos indicus) and crossbred water buffalo (Bubalus bubalis)' Animal Science Journal (2004) 75, 549–555

Lüthi, N. (2010) 'Beef cattle and buffalo trade patterns from Xieng Khouang province, Lao PDR to Vietnam'

Lüthi, N (2007) 'National trends in supply and demand of beef (red meat) in Vietnam with special reference to Xieng Khouang province Lao PDR'

Lüthi, N, et al (2007). 'Rapid market appraisal on cattle and buffaloes in M'drak district, Dak Lak province'

Luthi, N. (2010) 'Beef Cattle and Buffalo Trade Patterns from Xieng Khouang Province, Lao PDR to Vietnam'

Maclean, M (2006) 'Cattle Finishing - Technical Implementation Procedure' ACIAR

Mekong Wetlands Biodiversity Conservation and Sustainable Use Program (MWBC) (2005) 'Vulnerability Assessment of Climate Risks in Stung Treng Province, Cambodia' UNDP, IUCN, MRC

Mekong Wetlands Biodiversity Conservation and Sustainable Use Programme (MWBC) (2012) http://www.mekongwetlands.org/Demonstration/Thailand/livelihoods.htm

MRC (2000) 'Kok River Basin - Pilot Study for Water Resources and Environment Management (Basinwide): Final Report' 7.1.25/97/UKM

MRC (2010) 'Proceedings of the 8th Annual Mekong Flood Forum Vientiane, Lao PDR, 26 – 27 May 2010

NGO Forum on Cambodia (2005) 'Down River: The Consequences of Vietnam's Se San River Dams on Life in Cambodia and Their Meaning in International Law'

Nguyen Quang Dung (2011) 'Biogas User Survey 2010-2011: Biogas Development Program for Livestock Sector in Vietnam 2007-2012' Hanoi, Vietnam

OIE (2012) 'SEACFMD News' OIE, Bangkok, Thailand

Patza, J. A., Graczykb, T. K., Gellera, N., and Vittorc, A. Y. (2000) 'Effects of environmental change on emerging parasitic diseases' International Journal for Parasitology (2000) 1±11

Pen, M., Savage, D., Stür, W. and Senga, M. (2009) 'Constraints to Cattle Production of Small-scale Farmers in Kampong Cham Province, Cambodia' University of Hamburg

Phengsavanh, P., Ogle, B., Stur, W., Frankow-Lindberg, B. E. and Lindberg, J. E. (2011) 'Smallholder Pig Rearing Systems in Northern Lao PDR' Asian-Australian Journal of Animal Science, Vol. 24, No. 6:867-874

Pig Site, The (2008) 'The Effects of Climate Change on Livestock Production' http://www.thepigsite.com/articles/2296/the-effects-of-climate-change-on0livestock-production

Quirke, D., Jarding, M., Vincent, D. and Garrett, D. (2003) 'Effects of Globalisation and Economic Development on the Asian Livestock Sector', ACIAR, Canberra, Australia

Renaudeau, D., Huc, E., Kerdoncuff, M. and Gourdine, J.L. (2006) 'Acclimation To High Ambient Temperature In Growing Pigs: Effects Of Breed And Temperature Level' Symposium COA/INRA Scientific Cooperation in Agriculture, Tainan (Taiwan, R.O.C.)

Rocha, A., Randel, R.D., Broussard, J.R., Lim, J.M., Blair, R.M., Roussel, J.D., Godke, R.A., Hansel, W.(1998) 'High environmental temperature and humidity decrease oocyte quality in bos taurus but not in bos indicus cows' Theriogenology. Feb;49(3):657-65.

Shephard, A. W. (2010) 'Rice Market Information in Cambodia' IRRI, unpublished

Simaraks, S. (1998) 'Roles and Limitations of Animals in the Farming Systems in Southeast Asia: Field Observations and Experiences' in 'Upland Farming Systems in the Lao PDR: Problems and Opportunities for Livestock' ACIAR, Canberra, Australia

Srikitjakarn L, Sirimalaisuwan A, Khattiya R, Krueasukhon K, and Mekaprateep M.(2002) 'Seroprevalence of melioidosis in dairy cattle in Chiang Mai Province, northern Thailand' Southeast Asian Journal of Tropical Medicine and Public Health. Dec 33(4):739-41.

Teufel, N., Markemann, A., Kaufmann, B., Valle Zárate, A. and Otte, J. (2010) 'Livestock Production Systems in South Asia and the Greater Mekong Sub-Region: A Quantitative Description of Livestock Production in Bangladesh, Cambodia, India, Lao PDR, Nepal, Pakistan, Sri Lanka, Thailand, and Viet Nam' FAO-PPLPI, Working Paper No. 48

Thornton, P.K., Kruska, R.L., Henninger, N., Kristjanson, P.M., Reid, R.S., Atieno, F., Odero, A.N. and Ndegwa, T. (2002) 'Mapping poverty and livestock in the developing world' ILRI, Nairobi, Kenya

Truong Tan Khanh, Stür, W, Nguyen Van Ha and Duncan, A (2009). 'Developing Innovation capacity through effective partnerships: moving from subsistence cattle raising to market-oriented beef production in Dak lak, Vietnam'

Truong Tan Khanh, Stür, W., Van Tien Dzung, and Nguyen Van Ha (2010) 'Assessment of cattle marketing in Ea Kar district, Daklak, Vietnam in 2008' CIAT, Fodder Adoption Project Working Paper Series

Tuoitre News (2011) '7,000 Buffalo and Cows Freeze to Death in Vietnam' http://www.sott.net/articles/show/221627-7-000-Buffalo-and-Cows-Freeze-To-Death-in-Vietnam

Unattributed 'Field Study: Lao PDR: Nam Et and Phou Loei National Biodiversity Conservation Areas'

VV Online (2010) 'Blue-ear Pig Disease spreads to 24 provinces and cities' http://english.vov.vn/Home/Blueear-pig-disease-spreads-to-24-provinces-and- cities/20108/118749.vov

World Food Program (WFP) (2012a) 'Kampong Cham Provincial Food Security Profile' http://www.foodsecurityatlas.org/khm/country/provincial-Profile/Kampong-Cham

WFP (2012b) 'Mondulkiri Provincial Food Security Profile' http://www.foodsecurityatlas.org/khm/country/provincial-Profile/Mondulkiri

WFP (2012c) 'Stung Treng Provincial Food Security Profile' http://www.foodsecurityatlas.org/khm/country/provincial-Profile/Stung-Treng

WFP (2012d) 'Risk and Vulnerability Analysis: Lao PDR' http://www.foodsecurityatlas.org/lao/country/vulnerability/risk-analysis

Wong, L. C. Y. (2007) 'The Role of Supply Chains and International Networks in Enhancing the Agricultural Sector's Competitiveness of Cambodia, Laos, Myanmar and Vietnam (CLMV)' Asian Journal of Agricultural Development, Vol. 3, No. 1

ANNEXES

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ANNEX 1: CAVEATS ON LIVESTOCK DATA AND ANALYSIS

A number of caveats and potential limitations of the analysis should be noted and are outlined below.

Available data fails to differentiate between the products and 'level of commercialization' of livestock systems. For example, it is not possible to determine if cattle in a specific area are raised for beef or primarily for draft. Likewise, poultry may be raised in commercial units in the thousands or as scavengers in the household backyard. These parameters are notoriously difficult and time consuming to assess reliably, particularly on a large-scale, therefore any figures presented should be viewed with caution and used primarily to discern trends.

Significant supplementary information and discussion is presented within the livestock baseline section to this report. This information is taken largely from research papers and reports relating to specific methods and aspects and areas of livestock production in the region; discussions with a wide variety of experts; and on the basis of expert experience. Some of this information is extrapolated where this was deemed reasonable. This additional information aided the project in identifying possible, if not probable, impacts of climate change on current livestock systems in the LMB, however, caution and further information gathering is recommended prior to active intervention.

Other caveats and potential limitations of the analysis include:

- At the local level, systems may vary significantly from the descriptions presented in this report. Specific future interventions should collect locally specific information before proceeding with adaptation interventions.
- The size and diversity of the region defined by the project makes it necessary to take a broad view of the region's livestock systems. While this report attempts to describe the most prominent livestock systems in the region, it is impossible to provide detailed information on all technical aspects (e.g., specific production indicators and management practices) for the breadth of the subject matter of this report. Some estimated figures are provided for context but should be treated with caution.
- The national data for each of the four LMB countries has a number of limitations including: i) some errors in the GLiPHA data were spotted but that by no means ensures others were not missed; ii) the information is somewhat dated in certain cases and livestock systems can be extremely dynamic, particularly in the case of small stock; iii) livestock are notoriously difficult to assess, particularly in remote areas where extensive systems are used, for example there may be reasons for farmers to conceal animal numbers; iv) stock numbers can vary significantly depending on time of year, often exhibiting seasonal peaks in offtake and/or breeding; v) the available data is general and at the provincial level; vi) inevitably with such large-scale data collection the quality of data collectors, data storage, and analysis may have been compromised (this was evident on a number of occasions while writing the baseline). The information should be viewed as trends/relative values rather than actual values.

- The secondary sources collected may have been based, at least in part, on the same primary data used in this report. In this case possible errors may appear to be validated. Some of the secondary sources used are also somewhat dated. It is not always easy to verify information in sources, and so subjectivity in assessing the reliability of the information and analysis provided was often unavoidable. Triangulation between sources has improved reliability.
- GLiPHA is disaggregated only to the provincial level. Provinces are not homogenous in terms of livestock production systems, it could well be that stock density is significantly higher in one or other part of the province skewing the provincial average.
- There is no data available in GLiPHA for Hau Giang, Dak Nong, and Dien Bien Provinces, Vietnam and no other sources were found to compensate for these omissions. There were also a number of occasions where data for particular countries was not available; this has been clearly signposted.

ANNEX 2: INVENTORY OF SELECT SPECIES

Species			Notable breeds (and crosses)	Latin name	Main Purpose	Origin	Conservation status
Ruminants	Bovines	Cattle	'Yellow'	*Bos indicus*	Beef	Asia	
			Sindh	*B. indicus*	Draft	Asia	
			Haryana	*B. indicus*	Draft	Asia	
			Brahman	*B. indicus*	Draft	Asia	
			Holstein-Friesian	*B. taurus*	Dairy	Exotic	
			Banteng	*B. javanicus birmanicus*	Wild	Indigenous	Endangered
			Gaur	*B. gaurus*	Wild	Indigenous	Vulnerable
			Kouprey	*B. sauveli*	Wild	Indigenous	Critically endangered (possibly extinct)
			Saola	*Pseudoryx nghetinhensis*	Wild	Indigenous	Critically endangered
		Buffalo	Buffalo	*Bubalus bubalis*	Draft		
			Water buffalo	*Bubalus arnee*	Wild	Indigenous	Endangered
	Ovins	Goats	Barbari	*Capra aegagrus hircus*	Meat	Asia	
			Beetal	*C. a. hircus*	Meat	Asia	
			Damani	*C. a. hircus*	Meat	Asia	
			Jamnapuri	*C. a. hircus*	Meat	Asia	
			Kamori	*C. a. hircus*	Meat	Asia	
			Malabar	*C. a. hircus*	Meat	Asia	
			Katjang	*C. a. hircus*	Meat	Asia	
			Ma'tou	*C. a. hircus*	Meat	Asia	
		Sheep	Dorper	*Ovis aries*	Meat	Exotic	
			Saint Ines	*O. aries*	Meat	Exotic	
			Katahdin	*O. aries*	Meat	Exotic	
	Cervidae	Deer	Eld's Deer	*Rucervus eldii*	Wild	Indigenous	Endangered
Monogastrics	Suidae	Pigs	Landrace	*Sus domesticus*	Meat	Exotic	
			Large white	*S. domesticus*	Meat	Exotic	
			Yorkshire	*S. domesticus*	Meat	Exotic	
			Duroc	*S. domesticus*	Meat	Exotic	
			Pietran	*S. domesticus*	Meat	Exotic	
			Mong cai	*S. domesticus*	Meat	Indigenous	
			I	*S. domesticus*	Meat	Indigenous	
			Muong khoung	*S. domesticus*	Meat	Indigenous	
			Soc	*S. domesticus*	Meat	Indigenous	
			Meo	*S. domesticus*	Meat	Indigenous	
			Ban	*S. domesticus*	Meat	Indigenous	
			Co	*S. domesticus*	Meat	Indigenous	
			Moo chid	*S. domesticus*	Meat	Indigenous	
			Moo laat	*S. domesticus*	Meat	Indigenous	
			Moo daeng	*S. domesticus*	Meat	Indigenous	
			Moo nonghaet	*S. domesticus*	Meat	Indigenous	
			Meishan	*S. domesticus*	Meat	Asia	

Species			Notable breeds	Latin name	Main Purpose	Origin	Conservation status
Monogastrics	Poultry	Chickens	Commercial broilers (e.g. Cobb, Hubbard etc)	*Gallus gallus domesticus*	Meat	Exotic	
			Commercial layers (e.g. ISA, Leghorn, Goldline 54)	*G. g. domesticus*	Eggs	Exotic	
			ISA coloureds	*G. g. domesticus*	Eggs	Exotic	
			Thai fighting cock	*G. g. domesticus*	Meat	Indigenous	
			Ri	*G. g. domesticus*	Meat	Indigenous	
			Ac	*G. g. domesticus*	Meat (med.)	Indigenous	
			Hmong	*G. g. domesticus*	Meat (med.)	Indigenous	
			Dong tao	*G. g. domesticus*	Meat	Indigenous	
			Te	*G. g. domesticus*	Meat	Indigenous	Endangered
			Tre	*G. g. domesticus*	Meat	Indigenous	
			Choi	*G. g. domesticus*	Cock fighting	Indigenous	
			Tau vang	*G. g. domesticus*	Dual	Indigenous	
			Luong Phuong	*G. g. domesticus*	Meat	Asia	
			Kabir	*G. g. domesticus*	Exotic	Exotic	
			Sasso	*G. g. domesticus*	Exotic	Exotic	
		Ducks	Commercial broilers (e.g. Super M 1, 2 and 3)	*Anas platyrhynchos domesticus*	Meat	Exotic	
			Co	*A. p. domesticus*	Meat	Indigenous	
			Bau	*A. p. domesticus*	Meat	Indigenous	
			Commercial layers (e.g. Kakhi Campbell, CV2000)	*A. p. domesticus*	Eggs	Exotic	
			TrietGiang	*A. p. domesticus*	Eggs	Asia	
		Muscovy	White	*A. cairina moschata*	Meat	Indigenous	
			Spotted	*A. c. moschata*	Meat	Indigenous	
			Black	*A. c. moschata*	Meat	Indigenous	
			R 51 and 31	*A. c. moschata*	Meat	Exotic	
		Geese	R 31, 51 and 71	*A. anser domesticus*	Meat	Exotic	
		Turkeys		*Meleagris gallopavo*	Meat	Exotic	
		Quail			Meat/ eggs	Exotic/Asia	
		Pigeons			Meat	Exotic/Asia	
		Guinea fowl			Meat	Exotic	

ANNEX 3: SYSTEMS DATABASE

3.1.1 LARGE RUMINANTS

System overview	**Smallholder cattle 'keeping' (draft)**
Species	Cattle (*Bos indicus*)
Common phenotype(s)/characteristics	Large white/gray or brown/black draft (350-500+kg)
Key breeds	Sindh, Haryana, Brahman crosses
Breed origin	Exotic (Asiatic), indigenous/crossbreds
Distribution (prominence)	
ECOZONEs	Particularly prominent in high elevation, remote areas and the Floodplain areas.
National	Ubiquitous
Economic importance (GDP), current	Medium: direct contribution of beef and important support to other agricultural production systems.
Livelihood contribution	High: financial and social in particular; high value savings, coping mechanism. Support other livelihood mechanisms.
Food security contribution	High: indirect through other livelihood mechanisms
Global genetic diversity	Medium: indigenous/Asian breeds
Trends	Reducing prevalence in low land areas. Remain important and growing in some remote areas.
Drivers	Mechanization in lowland areas and reduced availability of grazing areas (increasing land demands of cropping systems). Population growth and urbanization. Increasing demand for beef.
Production	
Productivity indicators	
Primary output(s)	Draft, manure, wealth storage, beef
Key production figures	
Reproduction rates	First parturition ~4 years, calving intervals 2+ years.
Typical husbandry system	
Herd/flock numbers	~1-5 head per household
Feed	Free grazing, tethered/supervised grazing, fallow arable land and ranges, cut and carry forages, crop residues.
Vaccination level	Low. Occasional hemorrhagic septicemia (HS), foot and mouth disease (FMD) and deworming.
Biosecurity level	Low
Reproduction management	Natural mating and AI
Key animal health concerns	HS, FMD, blackleg, anthrax, internal and external parasites. Animals are commonly undernourished, diets are typically low in protein.
Market integration, level	Low
System vulnerability to climate change	
Temperature change	
Temperature increases	*Bos indicus* are tolerant to higher temperatures, no noticeable affect up to ~38 degrees, exhibiting strong tolerances developed by past experience. However, may lead to minor reductions in ability to work. May cause changes in availability of fodder. May alter pathogen viability. May alter quality and quantity of breeding

	sites for vectors. Changes in cropping will likely alter the value and use of these animals.
Temperature extremes	Increase the risk of heat stress, weakening immune responses, sudden cold or hot snaps may lead to temperature induced or related losses.
Rainfall	Effects on cropping will indirectly impact value of draft animals and availability of feed.
Humidity	Changing humidity will affect pathogen and vector viability.
Extreme events	
Drought	High impact on availability of feed resources
Flash flood	Direct losses, losses of infrastructure (stalls, forage plots). Stock are commonly sold as a coping strategy.
Slow onset flood	May affect access to grazing areas and supplementary feeds, though can also improve future grazing. Forced movement of stock increasing risk of disease outbreaks.
Storm	Stock are commonly sold as a coping strategy.

System overview	**Smallholder cattle 'keeping' (wealth storage, beef)**
Species	Cattle (*Bos indicus*)
Common phenotype(s)/characteristics	Small yellow/brown (~250-300kg)
Key breeds	Local 'yellow' cattle
Breed origin	Indigenous (Asiatic), indigenous/crossbreds
Distribution (prominence)	
ECOZONEs	Particularly prominent in mountainous, remote areas
National	Ubiquitous
Economic importance (GDP), current	Limited direct, are kept for manure and as assets
Livelihood contribution	Medium-high: financial and social in particular; savings, coping mechanism. Support other livelihood mechanisms.
Food security contribution	Medium: beef, indirect through other livelihood mechanisms, manure in particular.
Global genetic diversity (biodiversity index)	Medium: indigenous
Trends	Reducing prevalence in low land areas. Remain important and growing in some remote areas.
Drivers	Low productivity but very hardy. Increasing land demands of cropping systems reducing the availability of grazing land.
Production	
Productivity indicators	
Primary output(s)	Wealth storage, manure, beef, draft
Key production figures	
Reproduction rates	First parturition: ~3-4 years; calving intervals ~2 years
Typical husbandry system	
Herd/flock numbers	1-15 head per household
Feed	Free grazing, fallow arable land and ranges, crop residues, occasional tethered/supervised grazing, occasional cut and carry forages.
Vaccination level	Low
Biosecurity level	Low
Reproduction management	Natural mating
Key animal health concerns	HS, FMD, blackleg, anthrax, internal and external parasites
Market integration, level	Low
System vulnerability to climate change	

Temperature change	
Temperature increases	*Bos indicus* sp are tolerant to higher temperatures and have strong tolerances developed by past experience, yellow cattle are very hardy and raised in very low productivity systems. May alter disease risks. Changes in cropping will likely alter the availability of grazing areas.
Temperature extremes	Increase the risk of temperature-induced stress, weakening immune responses. Sudden cold or hot snaps may lead to temperature induced or related losses.
Rainfall	Effects on cropping will indirectly impact value of animals and availability of feed.
Humidity	Changing humidity will affect pathogen and vector viability.
Extreme events	
Drought	High impact on availability and quality of grazing.
Flash flood	Direct losses, losses of infrastructure (stalls, forage plots if they exist). May affect access to grazing areas, though can also improve future grazing. Stock are often sold as a coping strategy.
Slow onset flood	May affect access to grazing areas, though can also improve future grazing. Forced movement of stock may increase the risk of disease outbreaks.
Storm	Stock are commonly sold as a coping strategy.

System overview	**Buffalo**
Species	Buffalo (*Bubalus bubalis*)
Common phenotype(s)/characteristics	Thickset, grey, short- or long-haired, docile
Key breeds	Domestic Asian water buffalo
Breed origin	Indigenous (Asiatic)
Distribution (prominence)	
ECOZONEs	Higher prevalence in mountainous and remote areas
National	Ubiquitous
Economic importance (GDP), current	Medium: support other agricultural production, buffalo meat.
Livelihood contribution	Medium- high: financial and social in particular; high value savings, coping mechanism. Support other livelihood mechanisms.
Food security contribution	Medium: largely indirect through support of other agricultural production, buffalo meat.
Global genetic diversity (biodiversity index)	Medium: indigenous
Trends	Reducing prevalence in low land areas. Remain important and growing in some remote areas.
Drivers	Mechanization and reduced availability of grazing areas (increasing land demands of cropping systems). Population growth and urbanization. Increasing demand for beef.
Production	
Productivity indicators	
Primary output(s)	Draft, manure, wealth storage, meat
Key production figures	
Reproduction rates	First parturition ~4+ years, calving intervals 2+ years.
Typical husbandry system	
Herd/flock numbers	1-5 head per household
Feed	Free-grazing, tethered/supervised grazing, fallow arable land and ranges, cut and carry forages, crop residues.
Vaccination level	Low, occasional HS and FMD, deworming.
Biosecurity level	Low

Reproduction management	Natural mating.
Key animal health concerns	HS, FMD, blackleg, anthrax, internal and external parasites.
Market integration, level	Low
System vulnerability to climate change	
Temperature change	
Temperature increases	Buffalo likely have similar resilience to that of zebu cattle breeds though empirical evidence is available. May lead to minor reductions in ability to work. Typical management systems do not overstrain the animals for extended periods. May cause changes in availability of fodder. May alter disease risks. Changes in cropping will likely alter their value and use.
Temperature extremes	Increase the risk of heat stress, weakening immune responses, sudden cold or hot snaps may lead to temperature induced or related losses.
Rainfall	Effects on cropping will indirectly impact value of draft animals and availability of feed.
Humidity	Changing humidity will affect pathogen and vector viability.
Extreme events	
Drought	High impact on availability of feed resources
Flash flood	Direct losses, losses of infrastructure (stalls, forage plots). Stock are commonly sold as a coping strategy.
Slow onset flood	Loss of feedstock, though may increase future feed availability and quality. Forced movement of stock increasing risk of disease outbreaks.
Storm	Stock are commonly sold as a coping strategy.

System overview	**Dairy**
Species	Cattle (*Bos taurus*)
Common phenotype(s)/characteristics	Black and white, high performance dairy breeds
Key breeds	Holstein-Friesian
Breed origin	Exotic (Europe, North America, Australia, New Zealand)
Distribution (prominence)	
ECOZONEs	
National	Small numbers in Northeast Thailand and parts of Vietnam.
Economic importance (GDP), current	Small but growing.
Livelihood contribution	Low: typically very commercialized systems, stock are very high value and not raised by the poor or vulnerable.
Food security contribution	Dairy products are becoming is increasingly significant in household diets.
Global genetic diversity (biodiversity index)	Low
Trends	Rapidly increasing production in Vietnam, increasing in Thailand. Almost non-existent in Cambodia and Lao PDR.
Drivers	Rapidly growing consumption of dairy products throughout the Basin. Population growth and urbanization.
Production	
Productivity indicators	
Primary output(s)	Milk, beef
Key production figures	
Reproduction rates	First parturition ~2-2.5 years; calving interval 1-1.5 years
Typical husbandry system	
Herd/flock numbers	20-20,000 head per farm
Feed	High quality supplemented grazing

Vaccination level	High
Biosecurity level	Medium-high
Reproduction management	AI, JIVET and natural mating
Key animal health concerns	Mastitis, internal and external parasites, potentially HS, FMD, brucellosis, blackleg, anthrax but well vaccinated.
Market integration, level	High
System vulnerability to climate change	
Temperature change	
Temperature increases	Have a significant impact on production. Thermoneutral zone is typically 0-20°C, tough past experience will increase adaptability, exhibiting significant decline in milk yields, for example, at around 21-25°C. However, exhibit relatively wide ranges among breeds, for example Brown Swiss milk production is not affected until 30-32°C, and again will also depend on the animals thermal history.
Temperature extremes	Have a significant impact on production, reduction in immune response to pathogens risk of high production losses and potentially stock losses if not addressed.
Rainfall	Will likely adversely affect grazing and supplementary feed availability.
Humidity	May affect disease risk.
Extreme events	
Drought	Will likely adversely affect grazing and supplement availability.
Flash flood	Farms are currently not located in high risk areas
Slow onset flood	Farms are currently not located in high risk areas
Storm	Low impact due to locations and management systems

3.1.2 PIGS

System overview	**Smallholder commercial pig**
Species	Pig (*Sus domesticus*)
Common phenotype(s)/characteristics	White, productive crossbreds (typically F2 or further crosses)
Key breeds	Landrace, large white, Yorkshire, duroc, pietran, Mong Cai
Breed origin	Exotic (Europe, North America), indigenous crossbreds
Distribution (prominence)	
ECOZONEs	Most prevalent in lower lying and more accessible areas.
National	Ubiquitous, but most prevalent in Vietnam, common in Thailand and increasingly in Cambodia and low land Lao PDR
Economic importance (GDP), current	High: in Vietnam, in particular.
Livelihood contribution	High, for household's employing this system it typically accounts for at least 50% of household cash income, and often more. High risk due to: disease, price volatility.
Food security contribution	Medium: typically this system is not employed by the poorest, but pork is the highest contributor to animal protein in the Vietnamese diet, and high throughout the Basin, and these systems are relatively efficient lowering consumer pork prices.
Global genetic diversity (biodiversity index)	Low
Trends	Growing throughout the region, particularly in Cambodia and Lao PDR
Drivers	Increasing consumption of pork. Population growth and urbanization (system has low land requirements).
Production	
Productivity indicators	
Primary output(s)	Meat, piglets
Key production figures	80+kgCW in ~6 months; FCR ~4
Reproduction rates	First farrowing ~12 months; 2 litters per year averaging 20+ pig/sow/year
Typical husbandry system	
Herd/flock numbers	10-50 fatteners; 2-20 sows
Feed	Complete
Vaccination level	Medium-high
Biosecurity level	Medium
Reproduction management	AI, natural mating
Key animal health concerns	Classical Swine Fever (CSF), Porcine Reproductive and Respiratory Syndrome (PRRS), FMD, Aujesky's disease, Internal and external parasites (more commonly vaccinated and dewormed, processed feeds typically include antibiotics and coccidiostats)
Market integration, level	High
System vulnerability to climate change	
Temperature change	
Temperature increases	Feed efficiency (FCR) likely will reduce with cooler temperatures and intake (VFI) reduce at higher temperatures though they suffer little discomfort within reasonably wide temperature ranges with the exception of young piglets. Growers and fattener performance, both VFI, growth rates (ADG) and FCR, is highly affected by temperature, particularly above the optimum. Optimum temperatures recorded vary but

	are generally between 20 and, at most, 30°C. In high performance breeds estimates have been made which suggest for every one degree rise above optimal temperatures a five percent reduction in VFI can be expected with consequential impacts on ADG and reproductive performance (Forman et al 2008). Higher temperatures are also thought to reduce protein deposition while increasing adipose deposition – higher carcass backfat.
Temperature extremes	Periods of extreme temperatures will affect animals as above but will also cause higher stress with consequential reduction in resilience to disease challenges. Heightened losses in both productivity and through mortality would be expected. Increased pre-wean losses.
Rainfall	Limited impact on these systems.
Humidity	May affect disease incidence, most significantly respiratory problems.
Extreme events	
Drought	Limited effect on these systems as long as adequate drinking water remains available.
Flash flood	Direct losses and loss of infrastructure in vulnerable locations.
Slow onset flood	May force movement of stock in affected areas. Heightened risk of disease outbreaks
Storm	Possibility of direct losses in vulnerable areas.

System overview	**Smallholder low-input pig**
Species	Pig (*Sus domesticus*)
Common phenotype(s)/characteristics	Small, black/colored, sway-backed
Example breeds	Mong Cai, Ban, I, Meo, Soc, Co, Muong Khoung, Moo Chid, Moo Laat, Meishan, crossbreds
Breed origin	Indigenous, exotic crossbreds
Distribution (prominence)	
ECOZONEs	Prominent in high elevation and remote areas.
National	Lao PDR, Cambodia, mountainous areas in Vietnam and remote Thai areas.
Economic importance (GDP), current	Limited
Livelihood contribution	High: savings, coping strategy, use in social events, manure supporting other livelihood mechanisms, occasional sales. Often raised by vulnerable members of the household/vulnerable households.
Food security contribution	Medium: occasional consumption and sales.
Global genetic diversity (biodiversity index)	High: for indigenous genetics
Trends	Remain significant in mountainous and remote areas. General, though varied, trend towards more commercial management and crossbreds reared in confined systems.
Drivers	Market access, increasing demand for pork, population growth and urbanization.
Production	
Productivity indicators	
Primary output(s)	Meat, piglets
Key production figures	40-70kg LW in 8-12+ months; FCR 6+
Reproduction rates	1-2 litters/sow/year; 10-15 piglets per litter; 15-25

	pigs/sow/year
Typical husbandry system	
Herd/flock numbers	2-5 fatteners; 1-2 sows
Feed	Scavenging, raw feeds predominantly crop residues and byproducts (e.g. rice bran, brokens, stover), forages, swill.
Vaccination level	Low
Biosecurity level	Low
Reproduction management	Natural mating (inbreeding problems are common)
Key animal health concerns	CSF, PRRS, FMD, Aujesky's disease, internal and external parasites
Market integration, level	Low
System vulnerability to climate change	
Temperature change	
Temperature increases	Limited impact given management systems and productivity levels.
Temperature extremes	May increase temperature-induced stress with consequential reduction in resilience to disease challenges. Heightened losses in both productivity and through mortality would be expected. Increased pre-wean losses.
Rainfall	May affect availability of feed
Humidity	May increase disease risks
Extreme events	
Drought	Will negatively affect availability of feed.
Flash flood	Direct losses, loss of infrastructure, and possible loss of forage plots, available feed.
Slow onset flood	May force movement of stock in affected areas. Heightened risk of disease outbreaks. Loss of feed supplies.
Storm	Direct losses, loss of infrastructure, possible loss of forage plots and other feed sources.

3.1.3 POULTRY

System overview	Smallholder commercial chicken
Species	Chickens (*Gallus gallus domesticus*)
Common phenotype(s)/characteristics	Medium bodyweights, colored, exotics and crossbreds
Example breeds	ISA coloreds, 'three bloods', various crosses
Breed origin	Exotic (Europe, North America), crossbreds
Distribution (prominence)	
ECOZONEs	Low lying, less remote areas
National	Vietnam, less in Thailand, increasing in Cambodia and to a lesser extent Lao PDR
Economic importance (GDP), current	Medium
Livelihood contribution	High: for household's employing this system chickens are typically an important contributor to household cash income. Important social functions, such as gifting. High risk due to: disease and ability to market produce.
Food security contribution	This system is not typically employed by the poorest. Contribute to household nutrition through eggs and/or meat. Increase availability of products in local markets and affect price of products in the local area.
Global genetic diversity (biodiversity index)	Low: typically crossbreds or exotics.
Trends	Growth slowed post-2003, now increasing in most areas, with the possible exception of Thailand.
Drivers	Increasing demand, population growth and urbanization. Low demand on land. Badly affected by HPAI outbreaks and responses since 2003, particularly in the Delta areas and northeast Thailand.
Production	
Productivity indicators	
Primary output(s)	Meat, eggs
Key production figures	Typically 1-2.5kgCW in 60-90 days, FCR ~2.5-3; 150-280 eggs/hen/year
Reproduction rates	N/A
Typical husbandry system	
Herd/flock numbers	100-5000
Feed	Complete
Vaccination level	Medium
Biosecurity level	Medium-low
Reproduction management	DOCs
Key animal health concerns	Newcastle disease, avian influenza viruses (highly pathogenic avian influenza, low pathogenic avian influenza), fowl cholera, fowl pox, gumboro (infectious bursal disease), infectious bronchitis, Marek's disease, internal and external parasites
Market integration, level	High
System vulnerability to climate change	
Temperature change	
Temperature increases	Young birds generally need to be well warmed with external heat sources for first 7-14 days; optimal temperatures are approximately 25-30°C until a week or so of age. Commercial broilers optimal temperature range is generally 18-21°C. However, birds comfortable outside that range. Above 21°C reduced VFI, and hence ADG, will be apparent in exotic broilers. Intensive layers optimal around 21°C (economic). A reduction of

	0.5eggs/hen-housed/year for each 0.5°C below 21°C can be expected. Increasing temperatures estimated loss of egg weight 1g/egg/3 degrees C above 15°C. Generally commercial producers in lower-lying areas in the LMB are likely to suffer in terms of production and/or bottom-line due to higher utility costs for environmental control, or, in small-scale operations that do not control climate reduced productivity both in terms of VFI and stress, reducing disease resilience and increasing behavioral problems.
Temperature extremes	Sudden environmental changes can cause morbidity and mortality, better able to cope with temperature extremes if the change is gradual.
Rainfall	Limited impact on these systems.
Humidity	Will increase disease risks, particularly respiratory, and stress related problems.
Extreme events	
Drought	Limited effect on these systems.
Flash flood	Direct losses and loss of infrastructure in vulnerable locations.
Slow onset flood	Direct losses and disease concerns in vulnerable areas, may force movement of stock, increasing stress and risk of disease.
Storm	Direct losses and loss of infrastructure in vulnerable locations, possibly increased stress related problems.

System overview	**Scavenging chicken**
species	Chicken (*Gallus gallus domesticus*)
Common phenotype(s)/characteristics	Small, sharper breast bone, small breast size, longer legged, colored, yellow (or black) skin, fat (partly diet related).
Example breeds	Ri, Ac, Luong Phuong, Mia, Tau Vang, Hmong
Breed origin	Indigenous, indigenous crosses
Distribution (prominence)	
ECOZONEs	High elevation, more remote areas
National	Ubiquitous
Economic importance (GDP), current	Low
Livelihood contribution	Medium-high: often the only form of livestock raised by the poorest households. Contribute to household income through occasional sales and as coping strategy against shocks. Often gifted for important social functions. Often raised by vulnerable members of the household/vulnerable households.
Food security contribution	Medium-high: contribute to household nutrition through meat and eggs and cash through occasional sales.
Global genetic diversity (biodiversity index)	High: indigenous genetics.
Trends	Stable
Drivers	Constitute the cheapest (including demand on household labor) livestock production system.
Production	
Productivity indicators	
Primary output(s)	Meat, eggs
Key production figures	0.7-1.5kgCW in 120+days; low FCR
Reproduction rates	Mature at 22+ weeks, clutches vary widely between breeds and individuals, high losses in young birds through disease and predation.
Typical husbandry system	
Herd/flock numbers	10-50 mixed ages and sexes
Feed	Scavenging, minimal supplementation with crop byproducts, swill
Vaccination level	Low

Biosecurity level	Low
Reproduction management	Natural mating, some use of basket systems.
Key animal health concerns	Newcastle disease, avian influenza viruses, fowl cholera, fowl pox, internal and external parasites
Market integration, level	Low
System vulnerability to climate change	
Temperature change	
Temperature increases	Limited impact given management systems and low productivity.
Temperature extremes	Direct losses and heightened stress with consequential reduction in resilience to disease challenges (though birds are relatively hardy). Heightened losses through mortality would be expected, particularly young birds.
Rainfall	May affect availability of feed
Humidity	May increase disease risks
Extreme events	
Drought	Will negatively affect availability of feed.
Flash flood	Direct losses.
Slow onset flood	May force movement of birds in affected areas. Heightened risk of disease outbreaks. Loss of scavenging areas.
Storm	Direct losses.

System overview	**Field-running layer ducks**
Species	Ducks (*Anas platyrhynchos domesticus)*
Common phenotype(s)/characteristics	Small-medium, white or brown
Example breeds	Commercial breeds such as Triet Giang, indigenous Bau, Co, crosses
Breed origin	Indigenous, exotic (Asia, Europe) crossbreds
Distribution (prominence)	
ECOZONEs	Mekong Delta and nearby areas
National	Mekong Delta and nearby areas
Economic importance (GDP), current	Medium
Livelihood contribution	Medium: not typically raised by the poorest households, but a significant contributor to income for producer households.
Food security contribution	Medium: as above, contribute to nutrition through eggs and spent ducks.
Global genetic diversity (biodiversity index)	Medium-low: predominantly improved breeds and/or crossbreds.
Trends	Static-reducing
Drivers	With increasingly intensive rice production (now approaching 3.5 seasons per year) fallow periods are getting shorter reducing ability to run ducks. Some attempts by policymakers to reduce the employment of this type of duck management system in response to HPAI and other disease concerns. Demand for duck eggs (for DODs, half-hatched and fresh) remains high. The system is very efficient (low-input yet lucrative).
Production	
Productivity indicators	
Primary output(s)	Eggs, spent ducks
Key production figures	100-150 eggs/duck/year
Reproduction rates	N/A
Typical husbandry system	
Herd/flock numbers	500-3000 head
Feed	Scavenging

Vaccination level	Low
Biosecurity level	Low
Reproduction management	DODs
Key animal health concerns	Duck virus enteritis (duck plague), parasites, HPAI, LPAI, possibly egg-drop syndrome
Market integration, level	High
System vulnerability to climate change	
Temperature change	
Temperature increases	Limited effect on these systems
Temperature extremes	Limited effect on these systems, but more so than a general increase in temperature. May increase stress particularly when being transported between fields.
Rainfall	Limited effect on these systems.
Humidity	Limited effect on these systems.
Extreme events	
Drought	Limited effect on these systems.
Flash flood	Limited effect on these systems, possible direct losses in some locations (unusual where these ducks are raised).
Slow onset flood	Limited effect on these systems.
Storm	Possible direct losses.

3.1.4 WILD SPECIES

System overview	**Banteng**
Species	Cattle: Banteng (*Bos javanicus birmanicus)*
Common phenotype(s)/characteristics	Indigenous, Asiatic
Key breeds	Banteng
Breed origin	Native
Distribution (prominence)	Protected areas, native forests
ECOZONEs	Seal-level to at least 2100 masl, dry broadleaf forest.
National	Cambodia particularly, also populations in Lao PDR, Vietnam and Thailand.
Livelihood contribution	Illegal hunting, some interbreeding with domestic stock (likely unintentional)
Global genetic diversity (biodiversity index)	High
Trends	Endangered
Drivers	Loss of habitat, illegal hunting
Production	
Productivity indicators	N/A
Key animal health concerns	HS, FMD, blackleg, anthrax, internal and external parasites
Market integration, level	N/A
System vulnerability to climate change	
Temperature change	
Temperature increases	Changes in available habitat.
Temperature extremes	May stress animals and lead to deaths.
Rainfall	Changes in available habitat.
Humidity	Changes in available habitat.
Extreme events	
Drought	Limit feed availability.
Flash flood	Direct losses.
Slow onset flood	May limit or increase feed availability.

Storm	Low impact.
Conservation	
Habitat in LMB	Prefer open dry deciduous forests with glades, parklands and dense forest patches. More adaptable than kouprey. From sea-level to at least 2100 masl. Mineral licks are important in their habitat. They drink large volumes of water but can survive for extended periods (several days) with no water.
Feeding habits	Ruminant. Grazing and browsing: grasses, sedges, herbs, bamboo, as well as the leaves, fruits, flowers, bark, and young branches of woody shrubs and trees including palms. However, very little is known about the banteng's nutritional requirements, seasonal and annual variation in their dietary preferences, or the composition and quality of their diet.
Breeding	Mating: March-April; gestation ~10 months. Produce sterile males if bred with *Bos taurus*, fully functional with Bali cattle and *Bos indicus* breeds.
Major threats	Hunting and habitat loss, forest fragmentation.
Conservation status	'Banteng is considered Endangered under Criteria A2cd+3cd+4cd. Recent declines in parts of the species' range (especially Indochina) exceed 80% in three generations (generation-length estimated at 8–10 years), whereas in others—particularly Java which is, or was, the species' stronghold—it is not as severe. An overall decline of at least 50% appears likely based on direct observations, the decline in extent of occurrence, and continuing high levels of illegal trade in banteng parts (mainly horns). Similar reductions are projected, largely because of the unrestrained bushmeat trade in Southeast Asia and of hunting for the trade in horns, as well as habitat loss and degradation on Java. The global population is not known, but best-guesses suggest the species could be close to qualifying for EN through C1 and C2a(i).'
Sources	
	http://www.iucnredlist.org/details/2888/0

System overview	**Wild pigs: *Sus scrofa***
Species	Pig (*Sus scrofa*)
Common phenotype(s)/characteristics	Long haired, tusked
Key breeds	Wild pigs
Breed origin	Native
Distribution (prominence)	Protected areas, native forests
ECOZONEs	
National	
Economic importance (GDP), current	N/A
Livelihood contribution	N/A
Food security contribution	N/A
Global genetic diversity (biodiversity index)	High
Trends	Endangered
Drivers	Loss of habitat, illegal hunting
Production	
Productivity indicators	N/A
Primary output(s)	
Key production figures	
Reproduction rates	
Typical husbandry system	N/A
Herd/flock numbers	
Feed	

Vaccination level	
Biosecurity level	
Reproduction management	
Key animal health concerns	
Market integration, level	N/A
System vulnerability to climate change	
Temperature change	
Temperature increases	Limited impact, potential loss of habitat.
Temperature extremes	Limited impact.
Rainfall	Limited impact, may affect available habitat.
Humidity	Limited impact, may affect available habitat.
Extreme events	
Drought	May affect available habitat.
Flash flood	Direct losses.
Slow onset flood	Limited impact, may affect available habitat.
Storm	Limited impact.

System overview	**Wild Poultry**
Species	Wild poultry
Common phenotype(s)/characteristics	Low bodyweight, coloured.
Key breeds	Indigenous: Asiatic
Breed origin	Wild
Distribution (prominence)	Natural systems such as protected areas
ECOZONEs	
National	
Economic importance (GDP), current	N/A
Livelihood contribution	
Food security contribution	
Global genetic diversity (biodiversity index)	
Trends	
Drivers	
Production	
Productivity indicators	N/A
Primary output(s)	
Key production figures	
Reproduction rates	
Typical husbandry system	
Herd/flock numbers	
Feed	
Vaccination level	
Biosecurity level	
Reproduction management	
Key animal health concerns	
Market integration, level	Poaching
System vulnerability to climate change	
Temperature change	Limited impact.
Temperature increases	
Temperature extremes	
Rainfall	May reduce habitats.
Humidity	May reduce habitats.
Extreme events	
Drought	May reduce habitats.
Flash flood	Direct losses.
Slow onset flood	May reduce habitats.
Storm	Limited impact.

ANNEX 4: HOTSPOT CLIMATE CHANGE VULNERABILITY ASSESSMENTS

4.1.1 CHIANG RAI

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Small commercial chicken (broilers; few layers)	Increase in temperature	**Increase of ~5% and 10% in maximum temperatures potentially reaching highs of 42-43°C, relative increase in minimum T of similar proportions.**	H	H[7]	H	**Breed:** typically crossbreds or commercial white breeds, relatively intolerant by comparison with local breeds. **Housing:** confined systems with higher stocking density will increase the impact of higher temperatures on bird physiology. **Feed:** little impact on feed supply as birds are typically fed on purchased complete feeds. However, heightened temperatures in confined/semi-confined systems will reduce VFI, ADG, optimal performance temperatures are in the low to mid 20s, and heighten stress increasing risk of cannibalism and reducing disease resistance. **Animal health:** stock are typically vaccinated against locally prevalent diseases, receive anti-parasitics from feed and are raised in confined or semi-confined systems, marginally reducing the risk of disease entering the flock. Relatively higher stocking densities increase the risk of disease spread if the flock is challenged. T increase effects on pathogen viability and prevalence will alter disease risks, most likely reducing risk. Empirical data is needed. The likelihood and severity of extreme temperature periods is	VL	VH

[7] Negative effects on feeding. Increased likelihood of heat stress. May affect pathogen viability altering risk factors.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
						currently unknown, however, more frequent or more extreme 'snaps' periods will have greater impact than gradual changes in T. **Value:** reduced value through productivity losses and mortality. **Adaptive capacity:** climatic control is not economically viable for these systems. Local AH and extension services are likely relatively good where accessible, remote areas are likely underserved, being more commercial these producers are likely to seek out and utilize available services.		
	Increase in precipitation	**Longer, wetter wet season increase of 5-18%.**	M	M[8]	M	**Breed:** limited significance, lower natural resistance to disease than local breeds but better vaccinated in higher biosecurity systems. **Housing:** higher stocking density increases risk of disease spread. **Feed:** little effect given feeding systems. **Animal health:** increased risk of disease entering the flock (flock to flock) through fomite transmission - risk assessments would need to be conducted. Higher stock density increases risk of transmission between individuals. **Value:** may reduce value through losses (outbreaks may be catastrophic). **Adaptive capacity:** medium, increasing basic biosecurity measures and vaccination management are low cost. Local AH and	M	M

[8] May increase risk of disease transmission through fomites (mud), wet season is typically highest risk for disease outbreaks.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
						extension services are likely relatively good where accessible, remote areas are likely underserved, being more commercial these producers are likely to seek out and utilize available services.		
	Decrease in precipitation	**Shorter dry season possibly with greater variability.**	L	L[9]	L	**Breed:** little impact due to management systems. **Housing:** little impact. **Feed:** little impact as typically bulk of diet is purchased processed feed. **Animal health:** may reduce risk of disease transmission. **Value:** little impact. **Adaptive capacity:** N/A	H	L
	Increase/decrease in water availability	**Variation of approximately 1% increase or decrease in soil water availability.**	L	L[10]	L	**Breed:** little importance. **Housing:** N/A. **Feed:** N/A, commercial feeds. **Animal health:** may alter pathogen viability, not significant. **Value:** N/A. **Adaptive capacity:** N/A	H	L

[9] Limited impact.

[10] Little impact on these systems.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
	Drought	**Reduced frequency of droughts.**	VL	VL[11]	VL	Reduced frequency of droughts. Little impact, potentially positive impact, reduced vulnerability.	VH	VL
	Storms/flash flooding	**Increases maximum daily precipitation (associated with storms, heightened risk of flash flooding).**	M	H[12]	H	**Breed:** no significance. **Housing:** possible direct losses in systems exposed to flash flooding, high wind speeds (shelters vary in quality). **Feed:** little impact unless market access affected (unable to procure feed, sell pigs) **Animal health:** direct losses, heightened stress, reduced disease resilience. **Value:** direct losses will have very high impact in areas exposed to flash flooding. **Adaptive capacity:** Low in areas exposed to flash flooding, would have to relocate. Possibility of investing more in housing to reduce impact of wind and rain but likely economically difficult in most situations.	L	H

[11] Reduced likelihood of drought will have positive, but limited, impact on these systems.

[12] Direct losses among those exposed.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Smallholder cattle/buffalo 'keeping': *Bos indicus,* draft cattle, buffalo	Increase in temperature	**Increase of ~5% and 10% in max. temperatures potentially reaching highs of 42-43°C, relative increase in minimum T of similar proportions.**	M	L[13]	M	The effect on the individual will be difficult to detect, but across herds may be significant. The effects of a gradual increase will be limited as stock are already accustomed to high temperatures. **Breed:** increasing T has limited impact on productivity of *Bos indicus* breeds and buffalo, particularly in the case of low-input asset/draft systems. Extreme temperatures ('snaps') may have direct impacts on animal value, productivity and resilience to disease. **Housing:** stock are rarely housed, though may have access to stalls and usually shade. **Feed:** changes in pasture and forage quality and availability may affect land carrying capacity and stock condition affecting growth rates, reproductive performance and disease resilience potentially in either a positive or negative manner. **Animal health:** stock are rarely vaccinated and/or dewormed and are raised in minimal biosecurity systems. Low stocking densities reduce risk of disease spread. T increase effects on pathogen viability and prevalence will alter disease risks, most likely reducing risk. Empirical data is needed. The likelihood and severity of extreme temperature periods is currently unknown, however, more frequent or more extreme 'snaps' will have greater impact than gradual changes in T.	M	M

[13] Temperatures above 38°C can negatively impact productivity in *Bos indicus* (milk production, and likely growth, but wide variation based on the individual, no available information on draft) but are strongly influenced by past experience. May affect pathogen viability and stock resilience to disease challenges. Effects on cropping systems may alter value and use due to their role and feeding systems (grazing with some cut and carry)

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
						Value: stock are high investment and an important form of wealth storage, their ability to provide traction may be reduced by increased T. **Adaptive capacity:** stock are relatively tolerant. Wholesale changes in husbandry are culturally and economically unlikely. Local AH and extension services are likely relatively good where accessible, remote areas are likely underserved and, despite stock value, cattle keepers typically rarely seek support.		
	Increase in precipitation	**Longer, wetter wet season increase of ~5-18% (on a medium base: ~10-25mm per month).**	L	L[14]	L	**Breed:** high tolerance. **Housing:** limited effect given, typically, shelter is available (under human houses, trees). **Feed:** will likely increase availability and quality of grazing areas and forages. **Animal health:** stock are rarely vaccinated and raised in low biosecurity systems, however, density is low. May affect disease risks, increased mud may increase the likelihood of disease spread through fomites - risk assessments would need to be conducted. **Value:** stock are high investment and an important form of wealth storage, condition may be improved increasing value and capacity to work.	H	L

[14] Effects on feed availability and quality. Effects on cropping systems may become important in terms of value and use of animals, may affect availability of crop residues as supplementary feeds.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
						Adaptive capacity: stock are relatively tolerant, though increased disease risks may have high impacts. Low density systems reduce risk of disease outbreaks despite limited application of AH measures, increased movement and mixing will heighten risks. Wholesale changes in husbandry are unlikely in the short-medium term. Local AH and extension services are likely relatively good where accessible, remote areas are likely underserved and, despite stock value, cattle keepers typically rarely seek support.		
	Decrease in precipitation	**Shorter dry season possibly with greater variability (from a low base: 1-5mm in Jan and Feb - Feb most significant drop from 20 to 15mm).**	M	M[15]	M	**Breed:** high tolerance, but may already be stressed. **Housing: l**imited effect. **Feed:** stock may be undernourished, especially at the end of the dry season/early rainy season, reduced dry season precipitation may exacerbate this problem. **Animal health:** reduced stock condition may increase disease risk. May lose wallowing areas, increasing the above T increase physiological impacts by limiting stock ability to cool themselves. **Value:** stock are high investment and an important form of wealth storage, loss of condition, were this to occur, will effect value and ability to work. **Adaptive capacity:** stock are relatively tolerant but may already be stressed. Wholesale changes in husbandry are unlikely in the short-medium term. Local AH and extension services are likely relatively good where accessible, remote areas are likely	M	M

[15] Effect on availability and quality of grazing areas and forages. Effects on cropping systems may become important in terms of value and use of animals, may affect availability of crop residues as supplementary feeds particularly during extreme dry (drought). May reduce stock ability to reduce body temperature through wallowing.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
						underserved and, despite stock value, cattle keepers typically rarely seek support.		
	Increase/decrease in water availability	**Variation of approximately 1% increase or decrease in soil water availability. Insignificant.**	VL	L[16]	L	Change in soil water availability is negligible. **Breed:** negligible effect. **Housing:** N/A. **Feed:** negligible. **Animal health:** negligible. **Value:** negligible. **Adaptive capacity:** negligible change, N/A.	H	L
	Drought	**Reduced frequency of droughts.**	L	L[17]	L	Reduced frequency of droughts. Positive impact, reduced vulnerability.	VH	L

[16] Effects on availability and quality of grazing areas. Effects on cropping systems may become important in terms of value and use of animals, may affect availability of crop residues as supplementary feeds. May affect stock ability to reduce body temperature through wallowing.

[17] Positive effects.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
	Storms/flash flooding	**Increases maximum daily precipitation (associated with storms, heightened risk of flash flooding).**	M	H[18]	H	**Breed:** no effect. **Housing:** some use of housing, stalls or commonly kept beneath human homes, direct losses of infrastructure through flash floods may have short-term impacts on stock and HH wealth, more significantly. **Feed:** possible loss of forage plots. **Animal health:** direct losses, little impact on disease. **Value:** stock are high investment and an important form of wealth storage, losses will have a very significant impact on HHs**.** **Adaptive capacity:** little can be done if exposed to flash flooding, stock may be offered greater protection due to their value. Relocation only method of ensuring safety and unlikely to be feasible for most HHs employing these stock.	L	H

[18] Direct losses among those exposed to flash flooding.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Small commercial pig	Increase in temperature	**Increase of ~5% and 10% in max. temperatures potentially reaching highs of 42-43°C, relative increase in minimum T of similar proportions.**	VH	H[19]	VH	**Breed:** F2+ crossbreds, possibly some pure exotics, more effected/susceptible to temperatures outside optimal ranges than local breeds. Temperatures are already well outside comfort zones (low to mid 20s Celsius) reducing productivity, further increases may have considerable impacts on economic viability. **Housing:** climatic, naturally ventilated, very limited ability to cool, some use of ad hoc water cooling. **Feed: i**ncreased temperatures will reduce VFI, ADG and increase stress on all stock. Lower growth rates in fatteners. Sows: slower return to oestrus, lower ovulation rates, reduced colostrum/milk quality and volume (lower wean weights and higher pre-wean mortality). **Animal health:** increased risk of heat stress reduces resistance to disease. **Value:** loss of productivity - reduced value. **Adaptive capacity:** changing to controlled/more controlled rearing environment is expensive and generally beyond small commercial units. Local AH and extension service capacity is relatively good where accessible, more remote areas have limited access. Typically these farms will seek out and utilize these services more than less commercial livestock systems.	L	VH

[19] Effects on feeding. Likelihood of heat stress. May affect pathogen viability altering disease risk factors.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
	Increase in precipitation	**Longer, wetter wet season increase of 5-18%.**	M	L[20]	M	**Breed:** lower resistance to disease than local breeds. **Housing:** relatively high stocking density. **Feed:** limited effect, generally purchased complete or as concentrates. Those feeding concentrates may find local raw feed prices change (probably reduced). **Animal health:** higher risk of disease outbreaks, transmission through fomites (risk assessments would need to be conducted), and higher stocking density increased risk of intra-herd transmission. However, stock are typically well vaccinated, and may employ some basic biosecurity measures. **Value:** little effect unless disease outbreak occurs, which could have very big impact depending on the disease. **Adaptive capacity:** high, improving basic biosecurity measures is inexpensive. Local AH and extension service capacity is relatively good where accessible, more remote areas have limited access. Typically these farms will seek out and utilize these services more than less commercial livestock systems.	H	M
	Decrease in precipitation	**Shorter dry season possibly with greater variability.**	L	L[21]	L	**Breed:** little impact due to management systems. **Housing:** little impact. **Feed:** little impact as typically bulk of diet is purchased processed feed. May reduce availability of local raw feeds if used.	H	L

[20] May increase risk of disease transmission through fomites (mud), wet season is typically higher risk for disease outbreaks.

[21] Little effect on these systems.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
						Animal health: may alter risk of disease, likely reduce. **Value:** little impact. **Adaptive capacity:** N/A		
	Increase/decrease in water availability	**Variation of approximately 1% increase or decrease in soil water availability.**	L	L[22]	L	**Breed:** little importance. **Housing:** N/A. **Feed:** little importance, largely commercial feeds. Those using significant quantities of local raw feeds may find local buying prices increase. AH: may alter pathogen viability, not significant. **Animal health:** may alter pathogen viability, not significant**.** **Value:** N/A. **Adaptive capacity:** N/A	H	L
	Drought	**Reduced frequency of droughts.**	VL	VL[23]	VL	Reduced frequency of droughts. Little impact, potentially positive impact, reduced vulnerability.	VH	VL

[22] Little effect on these systems.

[23] Limited impact.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
	Storms/flash flooding	**Increases maximum daily precipitation (associated with storms, heightened risk of flash flooding).**	L	VH [24]	H	**Breed:** no significance. **Housing:** possible direct losses in systems exposed to flash flooding, high wind speeds (shelters vary in quality, though are typically better for pigs that other commercial stock). **Feed:** little impact unless market access affected (unable to procure feed) though piggeries are typically located in less remote areas **Animal health:** direct losses, heightened stress, and possible reduced disease resilience. **Value:** direct losses will have very high impact in areas exposed to flash flooding. **Adaptive capacity:** Low in areas exposed to flash flooding, would have to relocate.	VL	H

[24] Direct losses among those exposed; for HHs in areas which may be exposed to flash flooding - local risk assessment required

4.1.2 GIA LAI

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Small commercial pig	Increase in temperature	**~7-18% relative change in max T most prominent in the wet season. Max T increase to 40°C (+3°C) general increase +3-4°C. Min T increase by 12-19% (+3°C).**	M	H	H	**Breed:** F2+ crossbreds, more effected/susceptible to temperatures outside optimal ranges than local breeds. Temperatures are already well outside comfort zones (low to mid 20sC) reducing productivity, further increases may have considerable impacts on economic viability. Increasing minimum temperatures will reduce the impacts of cold. **Housing:** climatic, naturally ventilated, very limited ability to cool, some use of ad hoc water cooling**.** **Feed: i**ncreased temperatures will reduce VFI, ADG and increase stress on all stock. Lower growth rates in fatteners. Sows: slower return to oestrus, lower ovulation rates, reduced colostrum/milk quality and volume (lower wean weights and higher pre-wean mortality). **AH:** increased risk of heat stress reduces resistance to disease. **Value:** loss of productivity - reduced value. **Adaptive capacity:** changing to controlled/more controlled rearing environment is expensive and generally beyond small commercial units. Local AH and extension service capacity is relatively good where accessible, more remote areas have limited access. Typically these farms will seek out and utilize these services more than less commercial livestock systems.	L	H

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
	Increase in precipitation	**Longer, wetter wet season. Increase ~5-14% from a high base: ~5-40mm per month peaking in Aug.**	M	L	M	**Breed:** lower resistance to disease than local breeds. **Housing:** relatively high stocking density. **Feed:** limited effect, generally purchased complete or as concentrates. Those feeding concentrates may find local raw feed prices change (probably lower prices) but this would be an atypical feeding system among these units in Kien Giang. **AH:** higher risk of disease outbreaks, transmission through fomites (risk assessments would need to be conducted), higher stocking density increased risk of intra-herd transmission. Stock are sometimes vaccinated, and piggeries may employ some basic biosecurity measures. **Value:** little effect unless disease outbreak occurs, which could have very big impact depending on the disease. **Adaptive capacity:** high, improving basic biosecurity measures is inexpensive. Local AH and extension service capacity is relatively good where accessible, more remote areas have limited access. Typically these farms will seek out and utilize these services more than less commercial livestock systems.	H	M
	Decrease in precipitation	**Decrease of ~5-8% in dry season, ~1mm per month.**	L	L	L	**Breed:** little impact due to management systems. **Housing:** little impact. **Feed:** little impact on units using complete feeds, may reduce availability of local raw feeds if used. **AH:** may alter risk of disease, likely reduce. **Value:** little impact.	H	L

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
						Adaptive capacity: N/A		
	Increase/decrease in water availability	**Soil water availability change will swing between ~1% increase and ~1.5% decrease. Little significance.**	L	L	L	**Breed:** little importance. **Housing:** N/A. **Feed:** little impact on units using complete feeds, may reduce availability of local raw feeds if used. **AH:** may alter pathogen viability, not significant**.** **Value:** N/A. **Adaptive capacity:** N/A	H	L
	Drought	**No change.**				**N/A**	H	L
	Storms/flash flooding	**Increases maximum daily precipitation (associated with storms, heightened risk of flash flooding).**	M	H	H	**Breed:** no significance. **Housing:** possible direct losses in systems exposed to flash flooding, high windspeeds (shelters vary in quality, though are typically better for pigs than other commercial stock). **Feed:** little impact unless market access affected (unable to procure feed, sell pigs) though piggeries are typically located in less remote areas **AH:** direct losses, heightened stress, and possible reduced disease resilience. **Value:** direct losses will have very high impact in areas exposed to flash flooding. **Adaptive capacity:** Low in areas exposed to flash flooding, would have to relocate. Local AH and extension service capacity is	L	H

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
						relatively good where accessible, more remote areas have limited access, they may support producers in locating and designing more resilient housing.		
Smallholder cattle/buffalo 'keeping': *Bos indicus,* draft cattle, buffalo	Increase in temperature	**~7-18% relative change in max T most prominent in the wet season. Max T increase to 40°C (+3°C) general increase +3-4°C. Min T increase by 12-19% (+3°C).**	M	L	M	The effect on the individual will be difficult to detect, but across herds may be significant. The effects of a gradual increase will be limited as stock are already accustomed to high temperatures. **Breed:** increasing T has limited impact on productivity of *Bos indicus* breeds and buffalo, particularly in the case of low-input asset/draft systems. Extreme temperatures ('snaps') may have direct impacts on animal value, productivity and resilience to disease. **Housing:** stock are rarely housed, though may have access to stalls and usually shade. **Feed:** changes in pasture and forage quality and availability may affect land carrying capacity and stock condition affecting growth rates, reproductive performance and disease resilience potentially in either a positive or negative manner. **AH:** stock are rarely vaccinated and/or dewormed and are raised in minimal biosecurity systems. Low stocking densities reduce risk of disease spread. T increase effects on pathogen viability and prevalence will alter disease risks, most likely reducing risk. Empirical data is needed. The likelihood and severity of extreme temperature periods is currently unknown, however, more frequent or more extreme 'snaps' will have greater impact than gradual changes in T. **Value:** stock are high investment and an important form of wealth storage, their ability to provide traction may be reduced by	M	M

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
						increased T. **Adaptive capacity:** stock are relatively tolerant. Wholesale changes in husbandry are culturally and economically unlikely. Local AH and extension service capacity is relatively good where accessible, more remote areas have limited access.		
	Increase in precipitation	**Longer, wetter wet season. Increase ~5-14% from a high base: ~5-40mm per month peaking in Aug.**	L	L	L	**Breed:** high tolerance. **Housing:** limited effect given, typically, shelter is available (under human houses, trees). **Feed:** will likely increase availability and quality of grazing areas and forages. **AH:** stock are rarely vaccinated and raised in low biosecurity systems, however, density is low. May affect disease risks, increased mud may increase the likelihood of disease spread through fomites - risk assessments would need to be conducted. **Value:** stock are high investment and an important form of wealth storage, condition may be improved increasing value and capacity to work. **Adaptive capacity:** stock are relatively tolerant, though increased disease risks may have high impacts. Low density systems reduce risk of disease outbreaks despite limited application of AH measures, increased movement and mixing will heighten risks. Wholesale changes in husbandry are unlikely in the short-medium term.	H	L
	Decrease in precipitation	**Decrease of ~5-8% in dry season,**	M	M	M	**Breed:** high tolerance, but may already be stressed. **Housing: l**imited effect.	M	M

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
		~1mm per month.				**Feed:** stock may be undernourished, especially at the end of the dry season/early rainy season, reduced dry season precipitation may exacerbate this problem. **AH:** reduced stock condition may increase disease risk. May lose wallowing areas, increasing the above T increase physiological impacts by limiting stock ability to cool themselves. **Value:** stock are high investment and an important form of wealth storage, loss of condition, were this to occur, will effect value and ability to work. **Adaptive capacity:** stock are relatively tolerant but may already be stressed. Wholesale changes in husbandry are unlikely in the short-medium term.		
	Increase/decrease in water availability	**Soil water availability change will swing between ~1% increase and ~1.5% decrease. Little significance.**	VL	L	L	Change in soil water availability is negligible. **Breed:** negligible effect. **Housing:** N/A. **Feed:** negligible. **AH:** negligible. **Value:** negligible. **Adaptive capacity:** negligible change, N/A.	H	L
	Drought	**No change.**				**N/A**		

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
	Storms/flash flooding	**Increases maximum daily precipitation (associated with storms, heightened risk of flash flooding).**	M	H	H	**Breed:** no effect. **Housing:** some use of housing, stalls are commonly kept beneath human homes, direct losses of infrastructure through flash floods may have short-term impacts on stock and HH wealth, more significantly. **Feed:** possible loss of forage plots. **AH:** direct losses, little impact on disease. **Value:** stock are high investment and an important form of wealth storage, losses will have a very significant impact on HHs**.** **Adaptive capacity:** little can be done if exposed to flash flooding, stock may be offered greater protection due to their value. Relocation only method of ensuring safety and unlikely to be feasible for most HHs employing these stock.	L	H

4.1.3 KHAMMOUAN

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Smallholder cattle/buffalo 'keeping': *Bos indicus,* draft and yellow cattle, buffalo	Increase in temperature	**~6 to 16% increase in temperature, highest in the early wet season. Constituting an approximate 2-3°C overall T rise with max T predicted to reach 41-42°C. Higher minimum temperatures (1-2°C increase).**	H	M[25]	H	Reduced risk of losses through cold stress. The effect on the individual will be difficult to detect, but across herds may be significant. The effects of a gradual increase will be limited as stock are already accustomed to high temperatures. **Breed:** increasing T has limited impact on productivity of *Bos indicus* breeds and buffalo, particularly in the case of low-input asset/draft systems. Extreme temperatures ('snaps') may have direct impacts on animal value, productivity and resilience to disease. **Housing:** rarely confined or in purpose built housing but typically have access to adequate shelter (under house, trees). Extreme cold snaps may have negative impacts**.** **Feed:** changes in pasture and forage quality and availability may affect land carrying capacity and stock condition affecting growth rates, reproductive performance and disease resilience potentially in either a positive or negative manner. **Animal health:** stock are rarely vaccinated and/or dewormed and are raised in minimal biosecurity systems. Low stocking densities reduce risk of disease spread. T increase effects on pathogen viability and prevalence will alter disease risks, most likely reducing risk. Empirical data is needed. The likelihood and	L	H

[25] Temperatures above 38°C can negatively impact productivity in *Bos indicus* (milk production, and likely growth, but wide variation based on the individual, no available information on draft) but are strongly influenced by past experience. May affect pathogen viability and stock resilience to disease challenges. Effects on cropping systems may alter value and use due to their role and feeding systems (grazing with some cut and carry).

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
						severity of extreme temperature periods is currently unknown, however, more frequent or more extreme 'snaps' periods will have greater impact than gradual changes in T. Stock have suffered during extreme cold periods in the recent past, higher minimum temperatures will reduce the threat of cold stress. **Value:** stock are high investment and an important form of wealth storage, their ability to provide traction may be reduced by increased T. **Adaptive capacity:** stock are relatively tolerant. Wholesale changes in husbandry are culturally and economically unlikely.		
	Increase in precipitation	**Longer, wetter wet season increase of ~5-25% from a high base (~30-60mm per month).**	M	M[26]	M	Significant increase in wet season rainfall is unlikely to harm stock and more likely to increase available feed which may remain available further into the dry season. **Breed:** high tolerance. **Housing:** limited effect given, typically, shelter is available (under human houses, trees)**.** **Feed:** will likely increase availability and quality of grazing areas and forages. **Animal health:** May increase the risk of cold stress if not provided with adequate shelter (minimum predicted wet season temperature ~9°C). Stock are rarely vaccinated and raised in low biosecurity systems, however, density is low. May affect disease	L	M

[26] Effects on cold stress. Effects on feed availability and quality. Effects on cropping systems may become important in terms of value and use of animals, may affect availability of crop residues as supplementary feeds.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
						risks, increased mud may increase the likelihood of disease spread through fomites - risk assessments would need to be conducted. **Value:** stock are high investment and an important form of wealth storage, reduced condition will effect value and ability to work. **Adaptive capacity:** stock are relatively tolerant, though increased disease risks may have high impacts. Low density systems reduce risk of disease outbreaks despite limited application of AH measures, increased movement and mixing will heighten risks. Wholesale changes in husbandry are unlikely in the short-medium term.		
	Decrease in precipitation	**Shorter, drier dry season, reduced precipitation (~10% reduction in Jan-Feb: <1-3mm reduction).**	M	H[27]	H	Decrease in precipitation during the dry season is relatively slight in Khammouan, the key impacts are likely to be at the end of the dry season and early wet season when feed shortages can occur and could become more extreme. **Breed:** Change is small and stock have high tolerance, though may already be stressed. **Housing:** limited effect. **Feed:** stock may be undernourished, especially at the end of the dry season/early rainy season, reduced dry season precipitation may exacerbate this problem. **Animal health:** reduced stock condition may increase disease risk. May lose wallowing areas, increasing the above T increase physiological impacts by limiting stock ability to cool themselves.	L	H

[27] Effect on availability and quality of grazing areas and forages. Effects on cropping systems may become important in terms of value and use of animals, may affect availability of crop residues as supplementary feeds particularly extreme dry (drought). May reduce stock ability to reduce body temperature through wallowing.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
						Value: stock are high investment and an important form of wealth storage, loss of condition, were this to occur, will effect value and ability to work. **Adaptive capacity:** stock are relatively tolerant but may already be stressed. Wholesale changes in husbandry are unlikely in the short-medium term.		
	Increase/decrease in water availability	**General increase in soil water availability peaking at 7% increase in June, slight (<2%) decline in soil water availability Dec-Apr.**	L	L[28]	L	May reduce feed availability during the late dry season, early rainy season. **Breed:** relatively tolerant of low quality/quantity feeding. **Housing:** limited effect. **Feed:** stock may be undernourished, especially at the end of the dry season/early rainy season, reduced dry season soil water availability may exacerbate this problem through reduced availability and quality of sward and forages. **Animal health:** reduced stock condition may increase disease risk. May lose wallowing areas, increasing the above T increase physiological impacts. **Value:** stock are high investment and an important form of wealth storage, reduced condition will effect value and ability to work. **Adaptive capacity:** stock are relatively tolerant but may already be stressed. Wholesale changes in husbandry are culturally and economically unlikely.	H	L

[28] Soil water availability mildly depleted. Effects on availability and quality of grazing areas. Effects on cropping systems may become important in terms of value and use of animals, may affect availability of crop residues as supplementary feeds. May affect stock ability to reduce body temperature through wallowing.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
	Drought	**Reduced frequency of drought.**	L	L[29]	L	Limited change (4% less chance of (drought in October) slightly reduced frequency of droughts. Positive impact, reduced vulnerability.	H	L
	Storms/flash flooding	**Increases maximum daily precipitation (associated with storms, heightened risk of flash flooding).**	M	H[30]	H	**Breed:** no effect. **Housing:** minimal use of housing, beyond stalls or commonly kept beneath human homes, direct losses of infrastructure through flash floods may have limited short-term impacts. **Feed:** possible loss of forage plots. **Animal health:** direct losses, little impact on disease. **Value:** stock are high investment and an important form of wealth storage, losses will have a very significant impact on HH livelihoods. **Adaptive capacity:** little can be done if exposed to flash flooding, stock may be offered greater protection due to their value. Relocation only method of ensuring safety and unlikely to be feasible for most HHs employing these stock.	L	H
Smallholder low-input pig	Increase in temperature	**~6 to 16% increase in temperature,**	M	L[31]	M	Low-productivity management systems, impacts on individuals will be difficult to detect. Reduced risk of losses through cold stress. **Breed:** Local breeds are typically hardier and more adaptable to	H	M

[29] Positive effects.

[30] Direct losses by flash flooding. Potential loss of stalls, forage plots and access to markets through related events.

[31] Effects on feeding. Likelihood of heat stress. May affect pathogen viability altering disease risk factors.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
		highest in the early wet season. Constituting an approximate 2-3°C overall T rise with max T predicted to reach 41-42°C. Higher minimum temperatures (1-2°C increase).				environmental changes. **Housing:** rudimentary but shelter available, may be confined/semi-confined or able to shelter under buildings, trees. **Feed:** higher T will reduce VFI and ADG but given nature of systems this is of little consequence. Scavenging will be largely unaffected, effects on crops may reduce access to local raw feeds, availability of some forages may be reduced. **Animal health:** stock are rarely vaccinated or treated and are raised in minimal-low biosecurity systems. However, stocking density is low. T increase effects on pathogen viability and prevalence will alter disease risks, most likely reducing risk. Empirical data is needed. The likelihood and severity of extreme temperature periods in this area is currently unknown. **Value:** stock are an impotent form of HH savings, however, their productivity will not be hugely affected by the predicted T increases. **Adaptive capacity:** local breeds are relatively adaptable and resilient, management systems do not stress stock. These systems will only be affected minimally.		

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
	Increase in precipitation	**Longer, wetter wet season increase of ~5-25% from a high base (~30-60mm).**	L	L[32]	L	**Breed:** high tolerance. **Housing:** little effect on stock, able to shelter under buildings/trees if not confined. **Feed:** little effect, may increase availability of scavenge and supplementary raw feeds. **Animal health:** may increase risk of disease incursion though increased risk of transmission by fomites. **Value:** little effect, possibly positive unless disease outbreaks occur - risk assessments would need to be conducted. **Adaptive capacity:** local breeds are relatively adaptable and resilient, management systems do not stress stock. Major risk is increased threat of disease, otherwise little impact or beneficial.	H	L
	Decrease in precipitation	**Shorter, drier dry season, reduced precipitation (~10% reduction in Jan-Feb: <1-3mm reduction).**	L	L[33]	L	**Breed:** high tolerance. **Housing:** no effect. **Feed:** little effect on scavenging may reduce availability of raw feeds which could impact confined systems in particular. **Animal health:** may reduce risk of disease incursion by reducing risk of fomite transmission. **Value:** little effect.	H	M

[32] May increase feed availability through scavenging and/or forages, raw feeds (effects on cropping). May increase risk of disease transmission through fomites (mud), wet season is typically higher risk for disease outbreaks.

[33] May reduce availability of byproduct feeds (cropping), possible reduction in scavenge feed availability.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
						Adaptive capacity: local breeds are relatively adaptable and resilient and are not stressed in these systems.		
	Increase/decrease in water availability	**General increase in soil water availability peaking at 7% increase in June, slight (<2%) decline in soil water availability Dec-Apr.**	L	L[34]	L	**Breed:** little effect. **Housing:** N/A. **Feed:** little effect on scavenging may reduce availability of raw feeds which could impact confined systems in particular. **Animal health:** little effect. **Value:** little effect. **Adaptive capacity:** local breeds are relatively adaptable and resilient and are not overly stressed in these systems, confined pigs may become undernourished.	H	M
	Drought	**Reduced frequency of drought.**	VL	VL[35]	VL	Limited change (4% less chance of (drought in October) **Breed:** relatively high tolerance. **Housing:** N/A **Feed:** scavenging feeds largely will remain relatively available, reduced availability of supplementary local raw feeds will affect confined pigs most.	VH	VL

[34] Little effect on these systems, possible increase in feed availability.

[35] Reduced likelihood of drought will have positive, but limited, impact on these systems.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
						Animal health: little effect, may reduce the likelihood of challenges but if stock are undernourished the risk of infection will be higher. **Value:** little effect on scavenging systems, may reduce condition of confined pigs. **Adaptive capacity:** local breeds are relatively adaptable and resilient and are not overly stressed in these systems, confined pigs may become undernourished.		
	Storms/flash flooding	**Increases maximum daily precipitation (associated with storms [proxy], heightened risk of flash flooding).**	M	VH [36]	VH	**Breed:** N/A. **Housing:** shelters and housing for confined pigs may be lost through extreme winds or flash flooding. **Feed:** little effect on scavengers, loss of forages and other raw feeds may negatively affect confined pigs. **Animal health:** direct losses. Storms may stress stock increasing the risk of disease outbreaks. **Value:** losses will have a significant impact on HH savings increasing HH vulnerability. **Adaptive capacity: v**ery low for those exposed to flash flooding, changes in management to reduce risk are culturally and economically unlikely.	VL	L

[36] Direct losses among those exposed.

4.1.4 KIEN GIANG

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Small commercial pig	Increase in temperature	**~6-13% relative change in max T. Significant upward shift of ~3°C overall, with highs predicted to reach 42°C. Smaller increases in min T of ~1-2°C.**	VH	H[37]	VH	**Breed:** F2+ crossbreds, more effected/susceptible to temperatures outside optimal ranges than local breeds. Temperatures are already well outside comfort zones (low to mid 20s Celsius) reducing productivity, further increases may have considerable impacts on economic viability. **Housing:** climatic, naturally ventilated, very limited ability to cool, some use of ad hoc water cooling. **Feed:** increased temperatures will reduce VFI, ADG and increase stress on all stock. Lower growth rates in fatteners. Sows: slower return to oestrus, lower ovulation rates, reduced colostrum/milk quality and volume (lower wean weights and higher pre-wean mortality). **Animal health:** increased risk of heat stress reduces resistance to disease. **Value:** loss of productivity - reduced value. **Adaptive capacity:** changing to controlled/more controlled rearing environment is expensive and generally beyond small commercial units. Local AH and extension service capacity is sub-optimal where accessible, more remote areas have limited access. Typically these farms will seek out and utilize these services more than less commercial livestock systems.	L	VH

[37] Effects on feeding. Likelihood of heat stress. May affect pathogen viability altering disease risk factors.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
	Increase in precipitation	**Increase in wet season precipitation of ~8-15% (~10-30mm per month).**	M	L[38]	M	**Breed:** lower resistance to disease than local breeds. **Housing:** relatively high stocking density. **Feed:** limited effect, generally purchased complete or as concentrates. Those feeding concentrates may find local raw feed prices change (probably lower prices) this is common in more remote areas. **AH:** higher risk of disease outbreaks, transmission through fomites (risk assessments would need to be conducted), and higher stocking density increased risk of intra-herd transmission. Stock are sometimes vaccinated, and piggeries may employ some basic biosecurity measures. **Value:** little effect unless disease outbreak occurs, which could have very big impact depending on the disease. **Adaptive capacity:** high, improving basic biosecurity measures is inexpensive. Local AH and extension service capacity is sub-optimal where accessible, more remote areas have limited access.	H	M

[38] May increase risk of disease transmission through fomites (mud), wet season is typically higher risk for disease outbreaks.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
	Decrease in precipitation	**Decrease in dry season precipitation of ~6-12% (variable) (~1-7mm per month).**	L	L[39]	L	**Breed:** little impact due to management systems. **Housing:** little impact. **Feed:** little impact as typically bulk of diet is purchased processed feed. May reduce availability of local raw feeds if used. **Animal health:** may alter risk of disease, likely reduce. **Value:** little impact. **Adaptive capacity:** N/A	H	L
	Increase/decrease in water availability	**Decrease in soil water availability throughout the year (4-8%) most severe reduction during the wet season.**	L	L[40]	L	**Breed:** little importance. **Housing:** N/A. **Feed:** little importance, largely commercial feeds. Those using significant quantities of local raw feeds may find local buying prices increase. **Animal health:** may alter pathogen viability, not significant. **Value:** N/A. **Adaptive capacity:** N/A	H	L

[39] Little effect on these systems.

[40] Little effect on these systems.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
	Drought	**Increased likelihood of drought, most significant increase in Apr (20% increase).**	L	L[41]	L	**Breed:** little importance. **Housing:** N/A. **Feed:** little importance, largely commercial feeds. Those using significant quantities of local raw feeds may find local buying prices increase. **Animal health:** may alter pathogen viability, will likely reduce risk**.** **Value:** N/A. **Adaptive capacity:** N/A	H	L
	Storms/flash flooding	**Increases maximum daily precipitation (associated with storms, heightened risk of flash flooding).**	M	H[42]	H	**Breed:** no significance. **Housing:** possible direct losses in systems exposed to flash flooding, high wind speeds (shelters vary in quality, though are typically better for pigs that other commercial stock). **Feed:** little impact unless market access affected (unable to procure feed, sell pigs) though piggeries are typically located in less remote areas **Animal health:** direct losses, heightened stress, and possible reduced disease resilience. **Value:** direct losses will have very high impact in areas exposed to	L	H

[41] Little effect on these systems.

[42] Direct losses among those exposed.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
						flash flooding. **Adaptive capacity:** Low in areas exposed to flash flooding, would have to relocate. Local AH and extension service capacity is sub-optimal where accessible, more remote areas have limited access, they may support producers in locating and designing more resilient housing.		
Field running layer ducks	Increase in temperature	**~6-13% relative change in max T. Significant upward shift of ~3°C overall, with highs predicted to reach 42°C. Smaller increases in min T of ~1-2°C.**	M	L[43]	M	**Breed:** generally high tolerance. **Housing:** birds are unsheltered while ranging, sheltered at night. Little effect. **Feed:** scavenging, T increase effects on rice cultivation will affect availability of scavenging areas (ducks scavenge fallow rice fields). Intake may be somewhat reduced but of little consequence to these systems. **Animal health:** stock are rarely administered preventative or treatment animal health products and are raised in minimal biosecurity systems and system involves frequent mixing with other flocks and wild birds. T increase effects on pathogen viability and prevalence will alter disease risks, most likely reducing risk. Empirical data is needed. **Value:** Little effect.	VL	M

[43] Very little data available on these systems, however, little impact would be expected given their typical behavior, heightened temperatures may reduce VFI and extremes could increase stress. Effects on rice cultivation will be most significant and producers have limited adaptive capacity if changes do occur in rice production. Dept. of Animal Health policy is unlikely to support these systems.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
						Adaptive capacity: birds and systems are relatively adaptable and resilient in terms of T, management systems do not stress birds. Animal health capacity is limited and underutilized.		
	Increase in precipitation	**Increase in wet season precipitation of ~8-15% (~10-30mm per month).**	M	VL[44]	L	**Breed:** high tolerance. **Housing:** no effect. **Feed:** little effect, may increase feed availability. **Animal health:** little impact, ducks are raised in water-based systems. **Value:** little effect. **Adaptive capacity:** N/A	H	L
	Decrease in precipitation	**Decrease in dry season precipitation of ~6-12% (variable) (~1-7mm per month).**	L	L[45]	L	**Breed:** high tolerance. **Housing:** no effect. **Feed:** scavenging feeds will remain relatively available but effects on rice cultivation may alter access to scavenging areas. **Animal health:** little effect on these systems. **Value:** little effect. **Adaptive capacity:** birds are relatively adaptable and resilient and are not stressed in these systems. Effects on rice cultivation	H	L

[44] Limited effect on feed availability and AH. Effects on rice cultivation will be most significant.

[45] Limited effect on feed availability or disease in these systems. Effects on rice cultivation will be most significant.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
						may alter management systems.		
	Increase/decrease in water availability	**Decrease in soil water availability throughout the year (4-8%) most severe reduction during the wet season.**	L	L[46]	L	**Breed:** little effect. **Housing:** N/A. **Feed:** little effect. **Animal health:** little effect. **Value:** little effect. **Adaptive capacity:** local birds are relatively adaptable and resilient and are not stressed in these systems. Effects on rice cultivation may alter management systems.	H	L
	Drought	**Increased likelihood of drought, most significant increase in Apr (20% increase).**	M	L[47]	M	**Breed:** little effect. **Housing:** N/A **Feed:** scavenging feeds will remain relatively available but effects on rice cultivation may alter access to scavenging areas. **Animal health:** little effect, may reduce the likelihood of challenges. **Value:** little effect. **Adaptive capacity:** local birds are relatively adaptable and resilient and are not stressed in these systems. Effects on rice	H	M

[46] Will have little effect as stock are raised in scavenging systems. Effects on rice cultivation will be most significant.

[47] Limited impact on these systems, may reduce availability of scavengable feed. Effects on rice cultivation will be most significant.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
						cultivation may alter management systems.		
	Storms/flash flooding	**Increases maximum daily precipitation (associated with storms, heightened risk of flash flooding).**	M	VH [48]	VH	**Breed:** N/A. **Housing:** little effect. **Feed:** little effect. **Animal health:** direct losses. Storms may stress stock increasing the risk of disease outbreaks. **Value:** direct losses through flash flooding will have a high impact. **Adaptive capacity:** very low for those exposed to flash flooding, changes in management to reduce risk are, for cultural and economic reasons, highly unlikely.	VL	H

[48] Direct losses if exposed to flash flooding.

4.1.5 MONDULKIRI

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
Smallholder cattle/buffalo 'keeping': *Bos indicus,* draft cattle, buffalo	Increase in temperature	**High predicted increases in T of 10-18%, general increase of ~4°C in the dry season with max 45°C, in the east of the province possibly reaching 46°C during the late dry season.**	H	M[49]	M	The effect on the individual will be difficult to detect, but across herds may be significant. The effects of a gradual increase will be limited as stock are already accustomed to high temperatures. **Breed**: increasing T has limited impact on productivity of *Bos indicus* breeds and buffalo, particularly in the case of low-input asset/draft systems. Extreme temperatures ('snaps') may have direct impacts on animal value, productivity and resilience to disease. **Housing**: stock are rarely housed, though may have access to stalls and shade. **Feed**: changes in pasture and forage quality and availability may affect land carrying capacity and stock condition affecting growth rates, reproductive performance and disease resilience potentially in either a positive or negative manner. **AH:** stock are rarely vaccinated and/or dewormed and are raised in minimal biosecurity systems. Low stocking densities reduce risk of disease spread. T increase effects on pathogen viability and prevalence will alter	L	H

[49]Temperatures above 38°C can negatively impact productivity in *Bos indicus* (milk production, and likely growth, but wide variation based on the individual, no available information on draft) but are strongly influenced by past experience. May affect pathogen viability and stock resilience to disease challenges. Effects on cropping systems may alter value and use due to their role and feeding systems (grazing with some cut and carry).

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
						disease risks, most likely reducing risk. Empirical data is needed. The likelihood and severity of extreme temperature periods is currently unknown, however, more frequent or more extreme 'snaps' will have greater impact than gradual changes in T. **Value**: stock are high investment and an important form of wealth storage, their ability to provide traction may be reduced by increased T. **Adaptive capacity**: stock are relatively tolerant. Wholesale changes in husbandry are culturally and economically unlikely. In part due to low population density AH and extension services are suboptimal, particularly in more remote areas; producers rarely utilize the services that are available.		
	Increase in precipitation	**Wet season increase of 5-15% (on a high base:~ 5-70mm per month).**	L	L[50]	L	**Breed:** high tolerance. **Housing:** limited effect. **Feed:** will likely increase availability and quality of grazing areas and forages. **AH:** may affect disease risks, increased mud may increase the likelihood of disease spread through fomites - risk assessments would need to be conducted. Stock are rarely vaccinated and raised in low biosecurity systems, however, density is low.	L	L

[50]Effects on feed availability and quality. Effects on cropping systems may become important in terms of value and use of animals, may affect availability of crop residues as supplementary feeds

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
						Value: stock are high investment and an important form of wealth storage, condition may be improved increasing value and capacity to work. **Adaptive capacity:** stock are relatively tolerant, though increased disease risks may have high impacts. Low density systems reduce risk of disease outbreaks despite limited application of AH measures, increased movement and mixing will heighten risks. Wholesale changes in husbandry are unlikely in the short-medium term.		
	Decrease in precipitation	**Dry season reduction up to ~12% (from a medium-low base: less 2-3 mm per month Dec-May).**	M	H[51]	H	**Breed:** high tolerance, but may already be stressed. **Housing:** little effect. **Feed:** stock are commonly undernourished, especially at the end of the dry season/early rainy season, reduced dry season precipitation may exacerbate this problem. **AH:** reduced stock condition may increase disease risk. May lose wallowing areas, increasing the above T physiological impacts. **Value:** stock are high investment and an important form of wealth storage, loss of condition, were this to occur, will effect value and ability to work.	L	H

[51] Effect on availability and quality of grazing areas and forages. Effects on cropping systems may become important in terms of value and use of animals, may affect availability of crop residues as supplementary feeds particularly extreme dry (drought). May reduce stock ability to reduce body temperature through wallowing.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
						Adaptive capacity: stock are relatively tolerant but may already be stressed. Wholesale changes in husbandry are culturally and economically untenable. In part due to low population density AH and extension services are suboptimal, particularly in more remote areas; producers rarely utilize those services that are available.		
	Decrease in water availability	**Reduction overall, most extreme April to August (-15 to -20% in the uplands and -6 to -10% in the eastern areas of the province). Soil water availability significantly depleted.**	M	M[52]	M	May reduce feed availability during the late dry season, early rainy season. **Breed:** relatively tolerant of low quality/quantity feeding. **Housing:** limited effect. **Feed:** stock are commonly undernourished, especially at the end of the dry season/early rainy season, reduced dry season soil water availability may exacerbate this problem through reduced availability and quality of sward and forages. **AH:** reduced stock condition may increase disease risk. May lose wallowing areas, increasing the above T related physiological impacts. **Value:** stock are high investment and an important form of wealth storage, reduced condition will effect value and ability to work.	H	M

[52]Effects on availability and quality of grazing areas. Effects on cropping systems may become important in terms of value and use of animals, may affect availability of crop residues as supplementary feeds. May affect stock ability to reduce body temperature through wallowing.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
						Adaptive capacity: stock are relatively tolerant but may already be stressed. Wholesale changes in husbandry are culturally and economically unlikely. In part due to low population density AH and extension services are suboptimal, particularly in more remote areas; producers rarely utilize the services that are available.		
	Increase in water availability	N/A						
	Drought	**Increased likelihood and severity of droughts (notably in April), change is significant.**	H	VH[53]	VH	Significant predicted increase in drought duration, frequency and severity in Mondulkiri and stock are generally undernourished any increase in frequency or severity of drought may have significant impacts on stock in the late dry season and early wet season when feed deficits do occur. **Breed:** high tolerance but may already be stressed. **Housing:** no effect. **Feed:** reduced feed availability and quality will negatively impact condition, stock are likely already undernourished/in danger of being undernourished. **AH:** further reductions in stock condition will reduce resilience to disease challenges. Dry conditions tend to	L	VH

[53]Will likely reduce the availability and quality of grazing areas and forages for cut and carry. May reduce access to adequate quantity and quality drinking water. Negative effects on stock condition, value and resilience.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
						reduce disease risk but this will be outweighed by reduced longer-term resilience, particularly important in the following wet season. If drinking water is not available serious negative animal health impacts can be expected. **Value:** stock are high investment and an important form of wealth storage, reduced condition will effect value and ability to work. **Adaptive capacity:** stock are relatively tolerant, but are often already stressed/will be stressed. Wholesale changes in husbandry are culturally and economically untenable. In part due to low population density AH and extension services are suboptimal, particularly in more remote areas; producers rarely utilize those services that are available.		
	Storms/flash flooding	**Increases maximum daily precipitation (associated with storms, heightened risk of flash flooding)**	M	H[54]	H	**Breed:** no effect. **Housing:** minimal use of housing, beyond stalls or commonly kept beneath human homes, direct losses of infrastructure through flash floods may have limited short-term impacts. **Feed:** possible loss of forage plots. **AH:** direct losses, little impact on disease. **Value:** stock are high investment and an important form of wealth storage, losses will have a very significant	L	H

[54]Direct losses by flash flooding. Potential loss of stalls, forage plots and access to markets through related events.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
						impact on HH livelihoods. **Adaptive capacity:** little can be done if exposed to flash flooding, stock may be offered greater protection due to their value. Relocation only method of ensuring safety and unlikely to be feasible for most HHs employing these stock.		
Scavenging chicken: dual purpose	Increase in temperature	**High predicted increases in T of 10-18%, general increase of ~4°C in the dry season with max 45°C, in the east of the province possibly reaching 46°C during the late dry season.**	M	L[55]	M	**Breed:** probably high tolerance. **Housing:** limited use of housing, typically roosting under homes or in trees. **Feed:** scavenging, T increase will have little effect. Intake may be somewhat reduced but of little consequence to these systems. **AH:** stock are almost never administered preventative or treatment animal health products and are raised in minimal biosecurity systems. However, stocking density is very low. T increase effects on pathogen viability and prevalence will alter disease risks, most likely reducing risk. Empirical data is needed. The likelihood and severity of extreme temperature periods in this area is currently unknown.	H	M

[55]Very little data available on these systems, however, heightened temperatures will likely reduce VFI and extremes could increase stress.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
						Value: Little effect. **Adaptive capacity:** local birds are relatively adaptable and resilient, management systems do not stress birds. In part due to low population density AH and extension services are suboptimal, particularly in more remote areas; owners of scavenging chickens very rarely utilize these services that are available.		
	Increase in precipitation	**Wet season increase.**	M	L[56]	M	**Breed:** high tolerance. **Housing:** no effect. **Feed:** little effect. **AH: m**ay increase risk of disease incursion. **Value:** little effect. **Adaptive capacity:** local birds are relatively adaptable and resilient; management systems do not stress birds. AH and extension services are suboptimal, particularly in more remote areas; owners of scavenging chickens very rarely utilize these services that are available.	H	M
	Decrease in precipitation	**Dry season reduction (September).**	L	VL[57]	L	**Breed:** high tolerance. **Housing:** no effect. **Feed:** little effect.	M	M

[56]Limited effect on feed availability, may increase risk of disease transmission through fomites.

[57]Limited effect on feed availability, may reduce risk of disease transmission through fomites.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
						AH: may reduce risk of disease incursion by reducing risk of fomite transmission. **Value:** little effect. **Adaptive capacity:** local birds are relatively adaptable and resilient and are not stressed in these systems. AH and extension services are suboptimal, particularly in more remote areas; owners of scavenging chickens very rarely utilize these services that are available.		
	Decrease in water availability	**Reduction overall, most extreme April to August (-15 to -20%).**	L	VL[58]	L	**Breed:** little effect. **Housing:** N/A. **Feed:** little effect. **AH:** little effect. **Value:** little effect. **Adaptive capacity:** local birds are relatively adaptable and resilient and are not stressed in these systems. These systems will only be affected minimally. AH and extension services are suboptimal, particularly in more remote areas; owners of scavenging chickens very rarely utilize these services that are available.	H	L
	Increase in water availability	N/A			L			

[58]Will have little effect as stock are scavengers raised in low density, low productivity systems under very little stress.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
	Drought	**Increased likelihood and severity of droughts (notably in April), change is significant.**	M	VL[59]	Low	**Breed:** little effect. **Housing:** N/A **Feed:** scavenging feeds will remain relatively available. **AH:** little effect, may reduce the likelihood of challenges. **Value:** little effect. **Adaptive capacity:** local birds are relatively adaptable and resilient and are not stressed in these systems. AH and extension services are suboptimal, particularly in more remote areas; owners of scavenging chickens very rarely utilize these services that are available.	H	L
	Storms/flash flooding	**Increases maximum daily precipitation (associated with storms, heightened risk of flash flooding).**	M	H[60]	H	**Breed:** N/A. **Housing:** little effect. **Feed:** little effect. **AH:** direct losses. Storms may stress stock increasing the risk of disease outbreaks. **Value:** little effect. **Adaptive capacity:** very low for those exposed to flash flooding, changes in management to reduce risk	L	H

[59]Limited impact on these systems, may reduce availability of scavengable feed.

[60]Direct losses if exposed to flash flooding.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
						are, for cultural and economic reasons, highly unlikely.		
Banteng	Increase in Temperature	**High predicted increases in T of 10-18%, general increase of ~4°C in the dry season with max 45°C, in the east of the province possibly reaching 46°C during the late dry season.**	M	L[61]	M	Very little information on the effects of T increase on the physiology of banteng is available but the effects are probably of little significance. However, may change availability of habitat and/or force banteng to migrate. Changes in household livelihoods may force further incursions by households into the natural habitats of banteng, to graze livestock and source NTFPs, increasing the risk of transmission of disease from domesticated stock to banteng, and possibly increasing the risk of poaching.	L	M
	Increase in precipitation	**Wet season increase.**	L	VL[62]	L	Unlikely to have substantial impacts on banteng populations, may increase available browse and grazing areas. Will likely reduce incursion of domesticated stock into banteng areas with greater availability of fodder.	L	M

[61]No available data on physiological effects on banteng, likely to be very low (*Bos indicus* and low stress). Heightened temperatures may alter availability and quality of available habitat. May affect pathogen viability and banteng resilience to disease challenges.

[62]Greater precipitation may alter availability and quality of available habitat directly, or indirectly through land clearing for agriculture.

[63]Decrease in precipitation may alter availability and quality of available habitat directly, or indirectly through land clearing for agriculture.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
	Decrease in water availability	**Reduction overall, most extreme April to August (-15 to -20%).**	M	M[64]	M	May reduce availability of drinking water and available browse and grazing areas, forcing banteng to migrate. May increase incursion of domesticated stock into banteng areas increasing the risk of disease incursion.	L	M
	Increase in water availability	N/A						
	Drought	**Increased likelihood and severity of droughts (notably in April).**	M	M[65]	M	Predicted increase in drought duration, frequency and severity in Mondulkiri. Drought conditions may reduce availability and quality of habitat, feed sources and availability of water, potentially weakening the animals and increasing the risk of disease, possibly forcing migration or reducing current habitats. Drought conditions may force households and livestock further into banteng habitats for grazing, collection of forages and hunting, increasing the risk of livestock to banteng disease transmission and direct losses.	L	M
	Flooding	N/A						

[64]Decrease in water availability may alter availability and quality of available habitat directly, or indirectly through land clearing for agriculture.

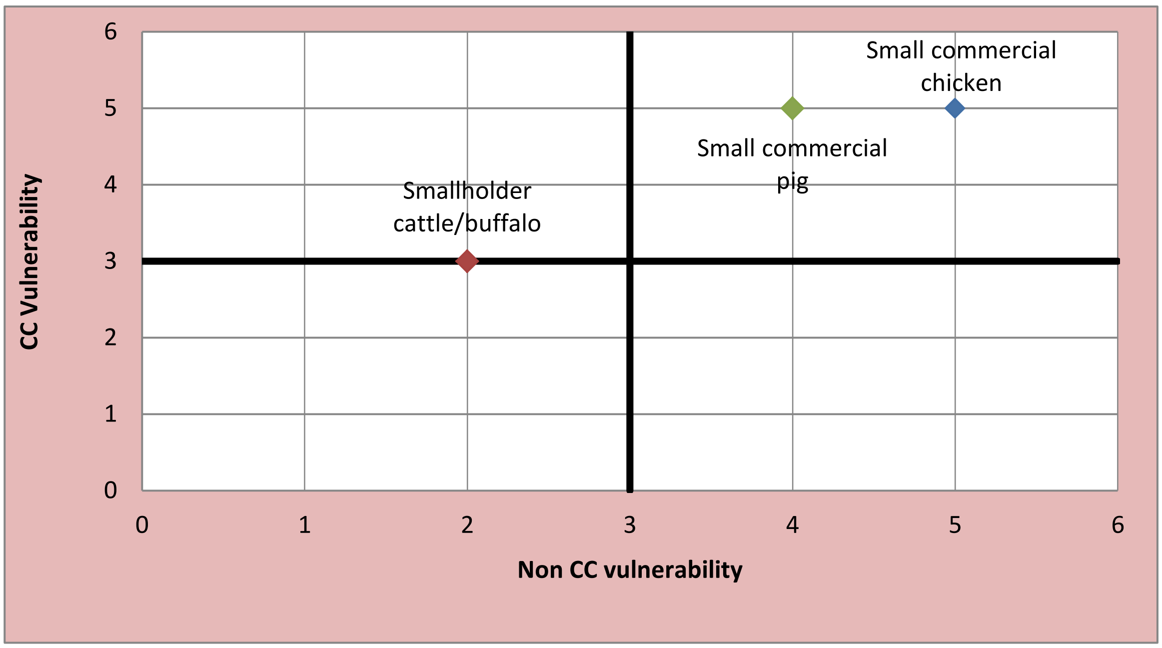
[65]Droughts may alter availability and quality of available habitat. May increase incursion of domestic stock.

System component or assets	Threat	Interpretation of threat	Exposure	Sensitivity	Impact Level	Impact Summary	Adaptive capacity	Vulnerability
	Storms/flash flooding	**Increases maximum daily precipitation (associated with storms, heightened risk of flash flooding).**	M	M[66]	M	Banteng are located in forested areas which generally afford good protection from storms. Flash flooding may cause direct losses.	L	M

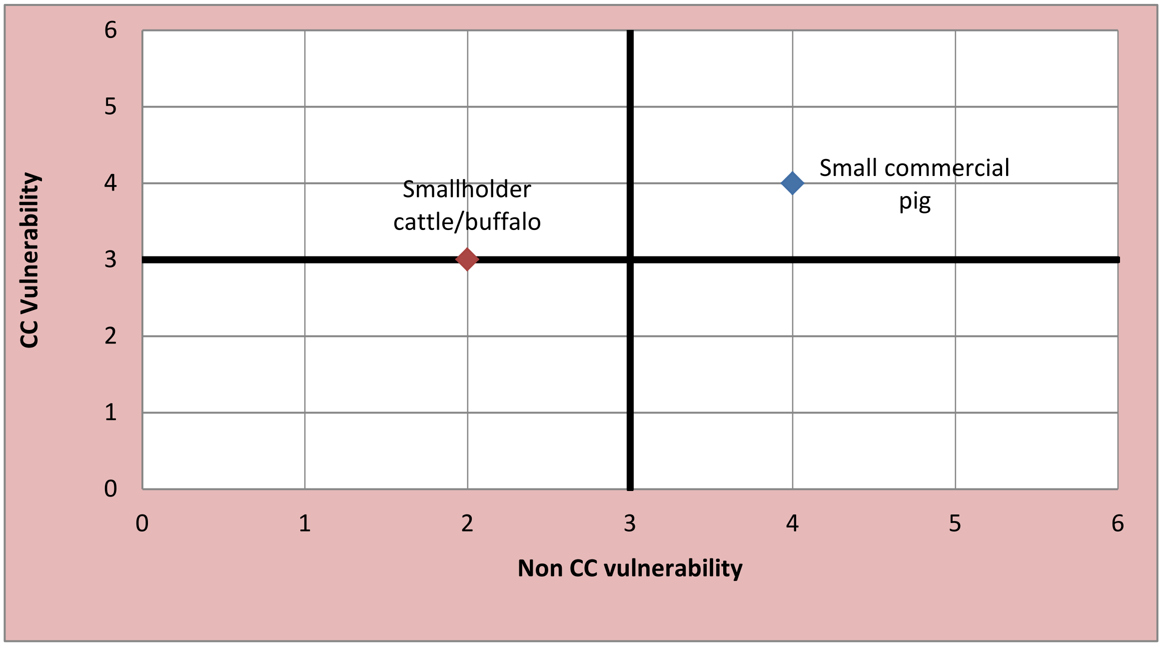
[66]Possible direct losses.

ANNEX 5: CLIMATE VERSUS NON CLIMATE VULNERABILITY BY HOTSPOT PROVINCE

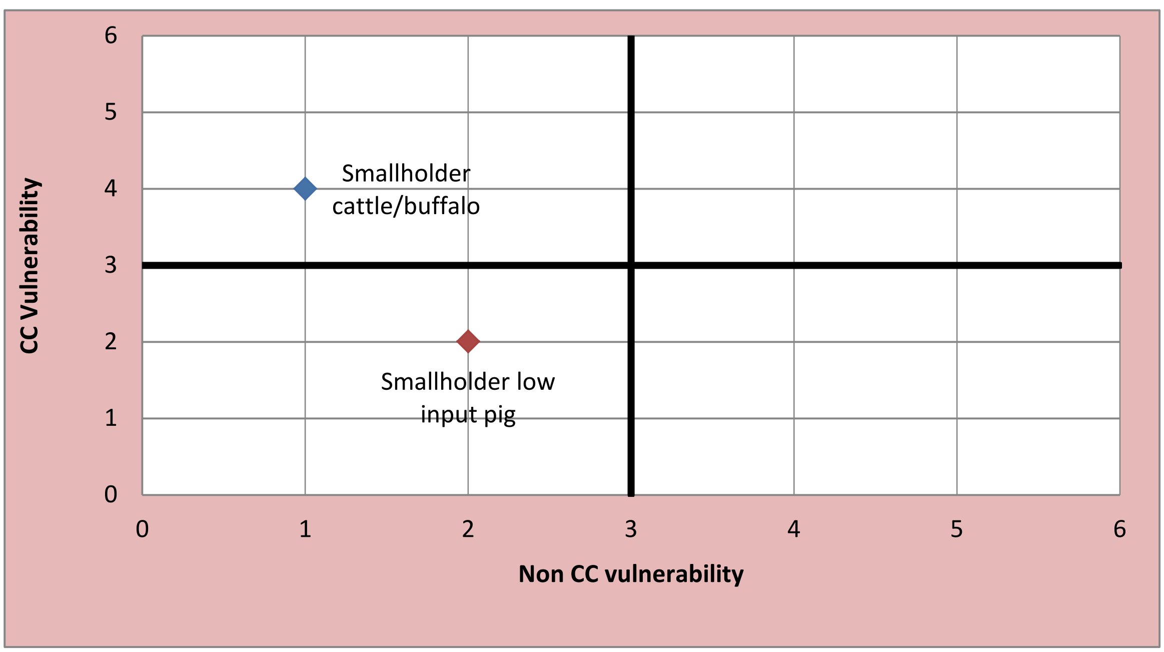
5.1.1 CHIANG RAI



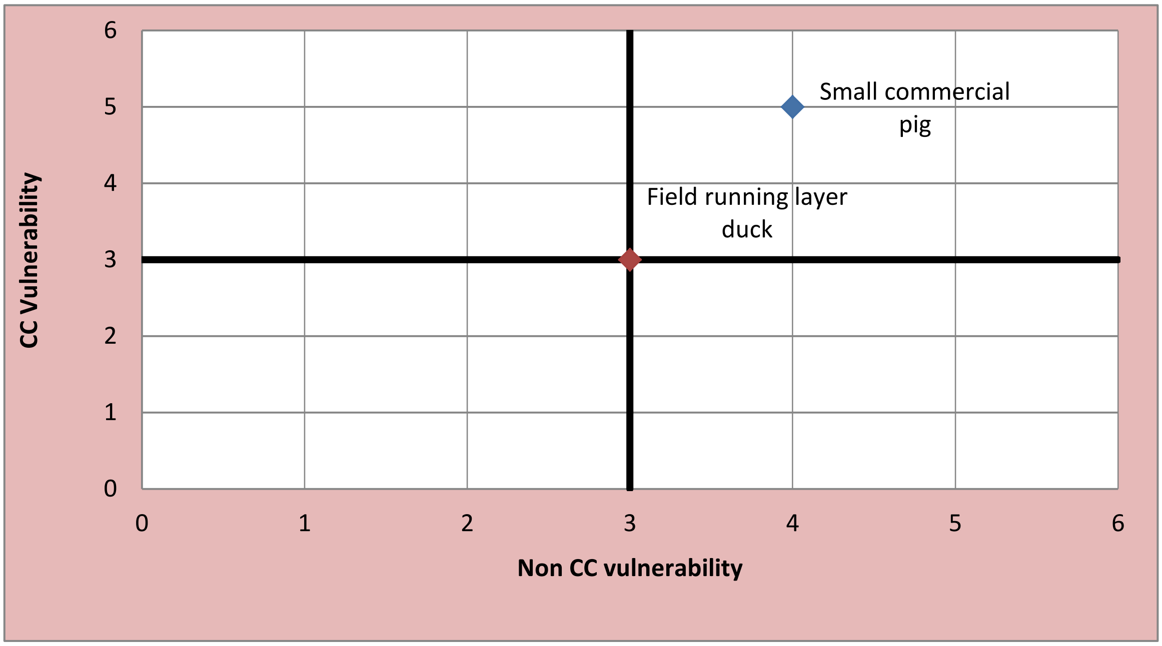
5.1.2 GIA LAI



5.1.3 KHAMMOUAN



5.1.4 KIEN GIANG



5.1.5 MONDULKIRI