Avian Influenza, Public Health and Smallholder Livelihoods in the Greater Mekong Sub-Region

A Synopsis of Findings of the DFID-Funded ‘Pro-Poor HPAI Risk Reduction’ Research Project

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Preface

Since its emergence, H5N1 HPAI has attracted considerable public and media attention because the viruses involved have been shown to be capable of producing fatal disease in humans. While there is fear that the virus may mutate into a strain capable of sustained human-to-human transmission, the virus' greatest impact to date has been the harm inflicted on the highly diverse poultry industries in some affected countries. HPAI control measures have so far focused on implementing prevention and eradication measures in poultry populations, with more than 175 million birds culled in Southeast Asia alone.

Until now, little emphasis has been placed on assessing the efficacy of risk reduction measures and their effects on the livelihoods of smallholder farmers and their families. In order to improve local and global capacity for evidence-based decision making on the control of HPAI (and other diseases with epidemic potential), which inevitably has major social and economic effect, the UK Department for International Development (DFID) funded a collaborative, multi-disciplinary HPAI research project for Southeast Asia and Africa.

The specific purpose of the project is to aid decision makers in developing evidence-based HPAI control measures at both national and international levels that will be cost-effective and efficient in reducing disease risk, and that will also protect and enhance livelihoods, particularly those of smallholder producers in developing countries, who are and will remain the majority of livestock producers in these countries for some time to come.

Project research teams have carried out a large number of research projects and studies in countries of the Mekong region relating to various aspects of HPAI and HPAI control. This document summarizes the findings of the three-year project and lays out their policy implications. It is hoped that, following review by policy makers and researchers, a definitive project report can be published.

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Disclaimer

Ten Key Findings / Messages

1. HPAI (and LPAI) / AIV) control in domestic poultry poses an unprecedented challenge for the veterinary profession because of (i) the genetic versatility of these viruses, (ii) their invasion of large and geographically dispersed, high turnover domestic poultry populations, and (iii) the possibility of asymptomatic persistence in domestic ducks and possibly other animal reservoirs.
2. Because of the scale of economic risk in their own countries, through a human-to-human transmissible HPAI virus, OECD economies have given primary global policy and financial impetus to risk reduction at HPAI sources. However, empirical evidence on actual and potential domestic damages suggests that the OECD, as well as China and India, should still make much larger investments in risk reduction in current and potential epicentres of AI virus evolution.
3. An important source of HPAI risk in the GMS stems from the co-existence of diverse poultry production systems and species (ducks, quail, chicken, etc), millions of households raising poultry primarily for home consumption, an abundance of small-scale market-oriented poultry enterprises linked to consumers through complex market chains and live bird-markets, and the covert transboundary trade that pervades the region, while the role of wild birds in the spread of HPAI H5N1 in the GMS is negligible.
4. HPAIV H5N1 now appears to be endemic in parts of Greater Mekong Subregion (GMS). We anticipate that it will be difficult to obtain the level of domestic and (especially) external public resources needed to sustain commitments to national risk reduction and coordinated regional control efforts need to be substantially strengthened.
5. Domestically, effective public and animal health policy must arise from and be sustained by sound institutions, with adequate capacity and coordination at the national, regional, and local levels. Unfortunately, governmental institutions in the GMS are very diverse in all these aspects, and HPAI risk management has in some cases been seriously compromised by institutional weakness. These weaknesses and the complexity to the structure of the poultry sector imply that OECD-style top-down disease control approaches are, in many instances, likely to fail.
6. Publicly funded blanket vaccination campaigns are costly and appear to be ineffective against HPAI in areas with a high prevalence of small-scale poultry keepers raising birds in 'traditional' ways mainly for home consumption. Targeted vaccination of specific high-risk groups can achieve comparable risk reduction at a fraction of the cost.
7. Radial approaches to culling birds and destruction of smallholder poultry infrastructure, which are very costly to communities, appear to contribute little to risk reduction and deter broad-based cooperation in HPAI control programmes. Culling should be limited to infected flocks and high risk contacts. Infrastructure can be disinfected, but should not be destroyed.
8. Attempting to improve the bio-security of millions of backyard producers is an ineffective use of scarce resources in the GMS countries, especially public funds in countries with many high priority development objectives. Interventions targeting market-oriented producers and management of the main poultry flows from production to consumption centres is likely to be more cost-effective.
9. Although they comprise the vast majority of poultry keepers in the GMS, smallholders do not presently have a voice in the design of short- and long-term HPAI control and mitigation policies. Omitting this stakeholder group is a mistake that seriously compromises policy effectiveness and legitimacy because smallholders play a crucial role in HPAI risk management due to their geographic dispersion and majority status even if their individual disease risk is comparatively low.
10. It is essential to recognize the smallholder poultry producers as part of a solution (effective disease defense) rather than a problem (infection risk), enlisting them with socially effective policies that recognize and reward their contribution to the national and global commons of disease resistance. Market-oriented polices offer vital opportunities for private cost sharing and self-directed poverty reduction. For example, certification and other product quality/safety initiatives can be self-financed and incentive compatible, a socially effective substitute for open-ended fiscal commitments to public disease monitoring and geographically extensive control measures.

1 Background on HPAI in the Greater Mekong Sub-Region

1.1 Ecology / biology of avian influenza viruses

1.1.1 Key messages

- HPAI (and LPAI) / AIV) control in domestic poultry poses an unprecedented challenge for the veterinary profession because of the genetic versatility of these viruses, their invasion of large and geographically dispersed, high turnover domestic poultry populations, the possibility of asymptomatic persistence in domestic ducks and possibly other animal reservoirs.
- In the GMS context, with relatively weak veterinary public health (VPH) systems and structural features of poultry production and marketing, eradication of HPAI appears nearly unattainable over the medium term. Countries in the region should adapt their policy perspective to an endemic animal health risk or at least sustained defense against recurrent reinfection.
- Although animal health systems are currently focused on HPAI H5N1 and poultry, the lessons of this activity should inform surveillance and preventive interventions for a more inclusive array of livestock species and infectious diseases to more effectively protect global health. The recent appearance of pandemic H1N1 demonstrated how quickly a new influenza virus can emerge in animals and reach the global human population.

1.1.2 Research findings / state of knowledge

1 ***Avian influenza viruses (AIVs) are unrivalled in their evolutionary capacity to adapt to new hosts and changing environments.***

AIVs have high mutation rates typical of RNA viruses (faulty transcription) resulting in relatively high rates of antigenic drift. In addition, due to their segmented genome (8 segments), genetic reassortment can occur in hosts that are infected by more than one AIV strain, facilitating host adaptation and resulting in high rates of genetic shift.

2 ***A plethora of avian influenza viruses are ubiquitous in wild waterfowl.***

AIVs representing nearly all 146 combinations of HA (H1 – H16) and NA (N1 – N9) have been isolated from wild waterfowl where they cause asymptomatic infection. Generally, AIVs exhibit host specificity and are easily transmitted within the aquatic environment from one waterfowl species to another through the faecal-oral route. AIVs circulating in wild birds can spill over to domestic terrestrial poultry, in which, initially, they are of low pathogenicity (LPAIVs), causing mild respiratory disease. Non-waterfowl wild bird species appear to play a less important role for virus circulation, but can still fulfil a function as so-called bridge species that expose domestic poultry to infection.

3 ***In the 1990s, low pathogenicity AIVs (LPAIVs) have dramatically spread globally in commercial poultry, establishing chicken-adapted lineages.***

Numerous outbreaks of avian influenza in domestic poultry due to H9N2 subtype occurred in the late 1990s in Germany, Italy, Ireland, South Africa, the USA, Korea, and China. More recently, H9N2 viruses have been reported in Middle Eastern countries and have been responsible for widespread and serious disease problems in commercial chickens in Iran and Pakistan. Virus genome analyses suggest that H9 subtype viruses of genetically distinct lineages were circulating contemporaneously in different locations. Similarly, H6N1/N2 viruses have repeatedly been isolated from quail in China (perhaps providing parts of the

HPAI H5N1 genome) and H7 LPAIVs have extensively circulated in live bird markets in the USA.

4 ***High pathogenicity AIVs (HPAIVs) arise in terrestrial poultry from LPAIV strains through spontaneous mutation and do not constitute separate stable phylogenetic lineages.***

Only AIV types H5 and H7 seem to have the necessary preconditions switch from low to high pathogenicity with a minor change in HA glycoprotein cleavage site, leading to 'susceptibility' to cleavage by ubiquitous proteases. This change enables the virus to replicate throughout the host thereby increasing host exploitation, pathogenicity, and transmissibility (and possibly the main mode of transmission) (HPAIVs). These HPAIVs remain infectious for wild birds while their pathogenicity for the latter depends on the species and virus strain, but as yet there is no evidence that HPAIVs can be maintained in wild water birds. In domestic ducks, HPAIVs that cause disease in ducks revert to non-pathogenicity for ducks, but not for chickens. Domestic ducks can thus act as incubators and 'trojan horses' for emergent HPAIVs.

5 ***Reports of HPAIV infection in domestic poultry (mainly chicken and turkeys) have increased since the late 1990s.***

While only few reports of HPAI in poultry are available for the 40-year period 1950 to 1990, 16 incidents of distinct HPAIV emergence have been recorded in the Americas, Australia, Europe, South Asia and Southeast Asia since 1990. Severe epidemics have been associated with H5N2 in Mexico, H7N3 in Pakistan, H5N1 in China and beyond, H7N1 in Italy, H7N7 in Holland, and H7N3 in Canada, heavily burdening national animal health systems and causing massive losses to poultry industries (millions of birds had to be slaughtered to control the epidemics).

6 ***Current poultry production and marketing systems enhance the probability of AIV selection for increased pathogenicity.***

Contrary to a widely held belief that parasites evolve so as to co-exist with their host, evolutionary epidemiology predicts that under certain circumstances, such as in large, interconnected, rapid-turnover, genetically homogenous populations, highly pathogenic parasites face a selective advantage. In high-income countries, most HPAI index farms were large scale poultry operations and LPAIV infection could often be detected preceding HPAI outbreaks (nevertheless, backyard farms / small flocks have occasionally been reported as index flocks for HPAI). In low-income countries, in addition to large scale industrial units, live bird markets (LBMs) with their daily influx of new birds act as large farm surrogate reservoirs. LBMs in which multiple bird species are traded are particularly critical because they facilitate reassortment of AIVs adapted to different host species.

7 ***Despite major efforts to control HPAIV H5N1, it is now firmly established in a number of countries in Asia and Africa and continues to evolve.***

HPAIV H5N1 emerged in South China in 1996, caused a major health scare in Hong Kong when the first human cases of infection and death were reported in 1998, continued to circulate and evolve in southern China for another 5 years, and expanded to other countries in southeast Asia in late 2003. In a second wave of expansion in 2005 / 2006, HPAIV H5N1 reached Central Asia, the Middle East, Europe, and Africa. The virus is now endemic in parts of China, Viet Nam, Cambodia, Indonesia, Bangladesh and Egypt. Forty four distinct HPAIV H5N1 genotypes have been identified between 1996 and 2006, with changes in dominant genotypes reflecting major reassortment events and establishment of distinct lineages in poultry in different geographical regions indicating separate foci of endemicity.

8 ***Threats to human health are not restricted to HPAIV H5N1 from poultry, but can arise through emergence of any novel influenza A virus from livestock with sufficient human-to-human transmissibility.***

Although HPAIV H5N1 has captured major headlines since its emergence due to its high case fatality rate in humans, human infections have also been recorded with other AIVs such as H7N7 and H9N2. HPAIV H5N1, on the other hand, has not only been isolated from poultry and humans, but also from pigs, cats, and dogs. As demonstrated by H1N1, an AIV of mixed species origin which first infected humans in 2009, novel viruses can emerge from a very large, spatially dispersed, and diverse pool of animal reservoirs. Given this huge potential for antigenic variation, human populations are unlikely to be protected from novel AIVs through prior exposure and the human health impact of emergent AIVs will largely be determined by their human-to-human transmissibility. The speed with which H1N1 AIVs spread around the globe emphasizes the importance of broad-based surveillance, early detection and characterization, and policy coordination for timely response to evolving AIVs.

1.2 Poultry sector dynamics and consumer preferences

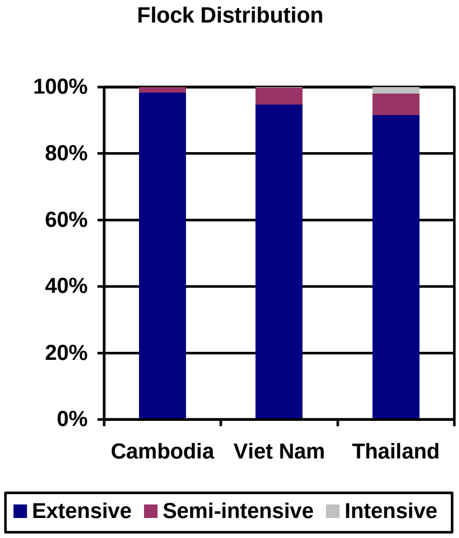
1.2.1 Key messages

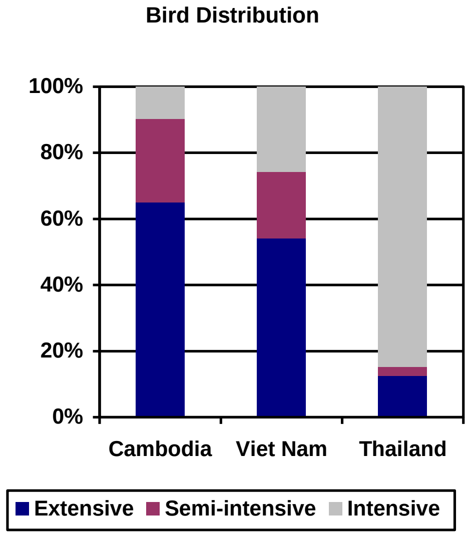
- The GMS region supports diverse species and every stage of sector development, from extensive rural subsistence to fully industrialized export supply chains, co-existing for decades to support diverse local, regional, and global communities.
- The overwhelming majority of producers are smallholders, mainly raising traditional poultry varieties predominantly for home consumption, while the majority of birds are produced in medium and large scale operations, emulating industrial production practices. Small to medium scale, semi-industrial poultry producers are an important element in the on-going poultry sector transition.
- Consumers express strong and persistent preferences and willingness to pay for food safety and quality, the latter remaining favorable to traditional varietiesproduced by smallholders and marketed across low income supply chains and live-bird markets.
- Vendor surveys reveal chronic scarcity of traditional bird varieties, suggesting significant unintended social costs from HPAI control in terms of consumer dissatisfaction and foregone smallholder income.

1.2.2 Research findings

1 ***Regional poultry production systems are extremely diverse, in terms of species, production methods, and marketing channels, but traditional smallholder production is ubiquitous.***

Poultry production in the GMS is heterogeneous in all its aspects, with the use of different species, different production and marketing systems, and supports a very diverse range of products and services. Typically, poultry are an integral feature of smallholder agriculture, where the majority of households keep a small (tens of birds) flock of ‘indigenous’, dual-purpose (meat and eggs) birds to meet household consumption needs, social obligations and minor cash expenses, the latter by sales through informal, live bird marketing channels. This traditional, extensive poultry production system is virtually ubiquitous throughout the GMS and comprises over 90% of poultry producers. Simultaneously, however, intensive, industrial poultry production systems, which follow the production model developed in industrialized countries, have been established in all GMS countries. These two poultry production systems are extremes, between which ‘hybrid’ and / or intermediate, **semi-intensive systems** exist, including partial scavenging with feed supplementation, indigenous birds crossed with industrial poultry lines, partial reliance on ‘formal’ input supply systems, but operating at intermediate scales (hundreds of birds) and relying primarily on ‘traditional’, informal live bird marketing networks. Each production model has adaptive advantages and disadvantages and none is likely to disappear completely.





The marketing channels for small scale producers are varied. Small scale producers sell birds through four different channels: aggregators, market vendors, households and other farmers, and restaurants. Aggregators are the currently most common buyers and many birds transit through live-bird markets.

References: J1, W1-5, W9-16, P2, B27, B29

2 ***A distinctive production system in the GMS entails keeping mobile duck flocks that travel extensively to provide pest control and fertilization services in exchange for forage.***

Free-grazing duck systems are a prominent feature of the GMS. Primarily intended for egg production, their farmers transport them intermittently or continuously to graze in rice fields. In southern Viet Nam, particularly in the Mekong River Delta, this itinerant livestock practice is widespread. Free-grazing duck flocks (up to several thousand ducks) travel 10-20 km per day, moving across commune, provincial, and even national borders. For the owners of rice fields, ducks offer pest control and fertilization services, while for duck farmers, free-range grazing reduces the cost of feed by up to 50 percent. Consequently, free-range grazing is an essential component of farmer livelihoods. These interactions are a highly productive utilization of resources for owners of both rice fields and ducks, but introduce serious animal and public health risks from an AIV perspective.

References: W2, W3, B8

3 ***Industrial systems are the fastest growing category of total bird production, but market-oriented smallholder systems by far outnumber industrial production units.***

In Thailand, large-scale industrial poultry production is one of the economy's most important sources of animal-derived food, employment, and income. This intensive, industrial system is characterized by (a) being organized by stages of production with separate primary breeders, multipliers, and finishing producers (often contract farmers), (b) a small number of breeding companies dominating the global supply of genetic material, (c) specialization in meat or eggs and use of specific birds for each product, (d) use of high density feeds tailored to specific stages and lines of production, (e) increasing scales of production (thousands of birds) and (f) growing interconnectedness with the processing and agrofood marketing industries. In Cambodia and Lao PDR, the 'formal', industrial poultry sector occupies a minor share in national poultry production (about 10 percent of poultry meat), while the situation in Viet Nam is intermediate between that of Thailand and Cambodia / Lao PDR (about a quarter of poultry meat). In each of these emerging economies, poultry production generally has grown faster than real incomes because the diet is shifting toward meat, but industrial production has been growing faster than other categories, driven by high levels of investment and restructuring of urban food supply chains. Although the market share of smallholder poultry production is shrinking, market-oriented smallholder producers still outnumber large scale industrial production units.

References: W9, W11, B7, B20, B25, P2, J1

4 ***In lower income countries in the region (Cambodia and Lao PDR), eggs are the most popular poultry consumption item, outnumbering birds 5-10 to 1.***

While the average expenditure was low, duck eggs were the most common poultry product purchased by market consumers, but a significant majority in Cambodia. In Cambodia, one third of respondents reported purchasing duck eggs every day, while more than 80 percent reported purchasing duck eggs at least once per week. On average, respondents purchased about 10 duck eggs per market visit. Approximately half of respondents purchase chicken meat at least once per week, purchasing slightly over one kg per visit. Fifty percent of respondents reported never purchasing duck meat. Duck eggs were significantly more popular in rural and semi-urban regions than in urban regions. Reliance on eggs in these populations suggest it is a more cost effective source of protein. This product is also well suited to distributed, small and medium scale production.

References: I6, I10, W3, W5, W13, W15, W16, B21, B28, B29

5 ***Most urban consumers remain regular patrons of wet markets, and are very discerning consumers of fresh poultry products, preferring 'traditional' to 'industrial' chicken.***

Most grocery shopping occurs at traditional wet markets. In Viet Nam (Hanoi) over half of respondents report never visiting a supermarket, whereas nine out of ten are within 15 minutes of an informal wet market / LBM. These ties to traditional markets are also apparent in Cambodia and Lao PDR, while Ho Chi Minh City has restructured agrofood supplies since HPAI and limits consumer access to wet markets.

Thailand's diversity on the supply side of poultry markets is replicated on the demand side. In Chiang Mai, one quarter of shopping was carried out at supermarkets like Tesco-Lotus. In Nakhon Phanom, one third of shopping occurred at small local shops that were located in storefronts. Respondents in Khon Kaen were most likely to buy directly from a trader or farmer, primarily for indigenous chickens. Wet markets sell live and whole fresh local chickens, while supermarkets sell frozen birds and fresh cuts of industrial chickens. Live birds are cheaper than slaughtered ones and live chickens are preferred because customers can determine their quality and health.

Across the region, consumers in markets with comparable access to local and industrial birds placed a premium of 30-100% on the former (per kilo of rendered meat).

References: B6, B24, J3

6 ***Consumer surveys consistently value food safety ahead of other food product characteristics, with taste a close second.***

Consumers in different regions consistently rate safety as the most important attribute of poultry meat. However, while consumers are concerned about safety, they are limited in their ability to accurately evaluate the safety levels of the meat they purchase. Consumers that purchase live birds base safety considerations on the birds' movement and appearance while people that purchase slaughtered bird evaluate the meat colour and texture. It was very rare that anyone ranked price or taste higher than the safety of the product they buy. Overall, the lack of knowledge of the farm source was the greatest reason for concern about safety, followed closely by disease risk and freshness considerations. Although many consumers prefer the taste of traditional poultry varieties, most urban Thai households primarily consume industrial breeds of chicken in part because they place a high premium on safety. Future systems that assist consumers in determining safety levels (such as branding and safety guarantees) have potential to be important tools in improving consumer options.

References: B6, B24, J3

7 ***Demand for local varieties of poultry often exceeds supply in local markets.***

Because of the high prices that local chicken receives, vendors have incentives to sell as much local chicken as possible. However, very few vendors sell only local varieties but instead sell a combination of local and industrial chicken, if they sell local chicken at all. This is in large part out of necessity since the demand for local chicken is probably insufficient to support an entire vending business. Nonetheless, vendors often reported selling out of local breeds and having trouble procuring sufficient stock, especially during periods of high demand.

While we do not have enough information to quantify any shortages, some findings hint at this scenario. For example, vendors only tend to always purchase industrial chicken from the same trader. However, vendors generally purchase local chicken from four or five different traders. Moreover, many vendors also participate in trading and some even begin to raise their own chickens in order to be able to bring them to market.

References: W9, W16, B14

1.3 Household poultry keeping and marketing

1.3.1 Key messages

- If policy makers want to reduce HPAI risk to animal and human populations, without undue adverse effects on the poor, a better understanding of linkages between households and markets is needed.
- Smallholder poultry are ubiquitous in all low income GMS regions, where these birds contribute directly and indirectly to livelihoods at very low resource cost. The challenge for policy is not to eliminate backyard and small-scale poultry keeping, but to transform them from an emblem of poverty to an agent of poverty alleviation.
- Traditional, low-volume poultry supply chains support livelihoods across extended networks of low-income people through production, distribution, processing, and marketing networks. Policies that prompt smallholder market participation will therefore have strong pro-poor multiplier effects.

1.3.2 Research findings

1 ***Nearly all rural households in the GMS keep poultry for both sustenance and income, specializing in traditional bird varieties raised in low-input systems.***

Although poultry sectors are diverse between GMS countries, backyard chicken are ubiquitous. In Viet Nam for example, depending on the region, 50 to 80mpercent of rural households keep poultry and it was estimated that close to 10 million traditional smallholder flocks (<50 birds) existed in the country. In Cambodia, figures are similar and 60 percent or rural and 25 percent of urban households are estimated to keep poultry, totalling around 2 million backyard poultry keepers. Even in Thailand, where rural incomes are significantly higher than in rural Cambodia and Viet Nam, around 50 percent of rural households keep some poultry, while in Lao virtually all (90 %) rural households keep poultry.

These households tend to keep traditional bird varieties which scavenge for feed in backyards. The flocks are self-replicating and most of the offtake is for home consumption.

References: I6, I10, W2-W5, W9, W15-W16, B1, B4-B6, B9, B14, B21

2 ***Though small in absolute terms, the relative returns to selling poultry products are very high.***

Smallholders invest little to no resources in poultry production and sales of poultry account for only a small percentage of household cash incomes (less than 5%). Nonetheless, the minimal investment in production mean that the percentage returns are extremely high and marketing poultry provides supplemental cash income to some of the poorest households in the region. If a farmer raises a bird for 20 weeks, s/he spends approximately USD0.50 on the bird that s/he can sell for USD3.50. This represents an estimated 700% return to farmers' investments. It is this return, in addition to poultry's role in supplementing household diets and a variety of other services that make poultry such a potentially effective tool in poverty alleviation.

References: W2-W5, W13, W15, B27, B29

3 ***In addition to nutrition and income, poultry offer rural households a complex array of services, including pest control, fertilization, security, and entertainment, and birds and bird products serve a variety of cultural functions.***

Because they are a millennial fixture of rural life in the GMS, poultry are deeply embedded in society and customs. Small flocks in and around households reduce pest damage, provide highly concentrated manure for direct application and composting, and offer surveillance against predatory animals and strangers. On a more personal level, poultry are popular as individual and family pets, and throughout this region they support an extensive, culturally important, and very lucrative cock fighting industry. The importance of this activity is reflected in the value of the most successful birds, which can sell for multiplies of average annual household income.

While cock fighting primarily benefits the male population, poultry keeping is important as an economic and social activity dominated by females.

Finally, poultry are also integrated in many spiritual practices and festival events. It must be recognized that policies repressing backyard poultry production pose a threat to all these socioeconomic values.

References: W1-W5, W13, W15

4 ***The semi-industrial, market-oriented poultry producers are implicated in networks of small enterprise agrofood marketing systems.***

Market-oriented smallholder farmers source their inputs (eggs, day old chicks, some feed and supplements) from small commercial counterparts, and they are linked to downstream markets by individual aggregators and small poultry product vendors in local markets. In the vicinity of Ha Noi, smallholder poultry farmers sell 38% of their poultry directly at the market, 35% sell to traders and the remainder to their neighbours. Of those obtained by traders, 38% were sold directly to consumers, 18% to retailers and 44% to wholesalers. Market interactions are governed by verbal agreements and informal contracts - smallholders and small enterprise downstream intermediaries are deeply embedded in networks of customary trading and mutual insurance. Trust, reliability, credit, conflict resolution, and contract enforcement are main components of these relationships.

For these reasons, any policy that substantially affects smallholder poultry producers will have extensive multiplier effects among the poor. To the extent that control measures adversely affect smallholder commercial viability, this will undermine other small enterprises. If, by contrast, market viability and smallholder product quality can be enhanced, this can increase incomes of their suppliers and downstream partners.

References: W2-W5, B9, B20, B25-29

5 ***Most smallholders market their poultry at the farm gate, selling to aggregators who move their birds downstream to Live Bird Markets (LBM). These relationships often undermine value added and increase disease risk.***

Aggregators reduce transactions and search cost for farmers, but act as monopsonists, reducing farmer bargaining power and their incentives to invest in product quality. Aggregators also blend bird stocks and obscure the origin of individual birds. The former activity can sharply increase infection risk, while the latter creates moral hazard and adverse selection that further undermine the incentive for farmers to invest in larger scale and product quality.

For their part, LBM offer a variety of direct benefits to merchants and consumers, including freshness, discernable product variety and quality, and traditional food values that continue to elicit price premia many GMS markets.

For example, Ha Vi wholesale market, the main market supplying Hanoi has a turn-over of seven to twenty tons of live birds of different species daily, with peak sales reaching 40 tons per day, the equivalent of 20,000 birds.

References: I6, I10, W3-W5, W8-W9, B6-B7, B16

6 ***Adoption of biosecurity measures depends upon the scale of household poultry production.***

Whatever the share of income from poultry, smallholder independent farmers exhibit negligible autonomous biosecurity adoption behaviour. By contrast, most contract and large scale household producers have adopted some form of bio-security measures in order to conform to contracts and/or protect investments undertaken. However, large(r)-scale producers could still benefit from increased access to technical knowledge and inputs.

For example, duck farmers spent 7.5 hours attending to their ducks per day. Despite a large time and financial investment, mortality rates on average remained relatively high (over 10%). Most of the losses came from diseases that, given the level of commitment to the flocks, would seem to be preventable if different measures were adopted. This is one potential area for outreach in the future.

References: B7, B14, B21, B23, B29, J1, J13, J17, J21

7 ***The majority of small scale producers face credit constraints.***

Among all actors in the supply chain, small scale producers are the most likely to face credit constrains. This is true for both borrowers, and non-borrowers, although constraints are much more common among non-borrowers with 87% facing some sort of constraint compared to 58% of borrowers. Credit constraints may discourage smallholders from producing at all, investing in product quality (including animal health), limit consumption, and therefore present a barrier to poverty reduction.

These findings identify major challenges for microfinance to improve credit access by reducing capital constraints among poultry producers. Small scale producers are the most constrained group of all, and inadequate credit access presents a serious limitation to the promotion of commercialization and improved standards of living.

References: I6, I10, W2-W5, W8-W9, B1, B14, B20-B21, P2, J1, J7, J17

8 ***Informal transboundary trade flourishes throughout the region, posing a significant challenge to national disease control policies.***

Both anecdotal evidence and direct observation around the GMS reveal extensive, diverse, and continuous transboundary trade in poultry products, despite the fact that such trade is either forbidden or much more strictly circumscribed. We have observed these flows, especially of live birds and eggs, through both kinship and commercial networks, extending from sources to destinations hundreds of kilometres from border crossings. The scope of this trade poses a significant challenge to any national agenda for disease prevention, renders eradication measures futile, and reveals the necessity of multilateral cooperation to achieve sustained HPAI control.

In Cambodia, for example, interviews with hatchery owners show that approximately 30% of duck eggs in the eastern districts of Kampot province (where most ducks in Kampot are raised) were sourced from Vietnamese farmers. While this type of trade is technically illegal, hatchery owners reported little difficulty in bringing eggs from Vietnam into Cambodia. We observed hatcheries importing duck eggs to be incubated in Cambodian households. However, other studies have observed the importation of live ducklings from Viet Nam to other Cambodian provinces.

Because it adjoins two much more populous economies, the northeast corner of Lao is a crossroads for many forms of trade between China and Viet Nam. Poultry products are no exception to this and, although illegal, trade of this kind is thriving both across commercial and kinship networks. Survey data from the North demonstrates that Chinese poultry products, particularly eggs, are ubiquitous in markets and villages. Virtually all consumers reported seeing Chinese poultry products at their local market, and almost 60% reported buying Chinese eggs. We have observed abundant evidence of established trade in eggs and live birds extending hundreds of kilometres into both neighbouring economies and dominating local trade within Lao.

References: I6, I10, W3, W5, B20-B21, J7

2 Epidemiology of HPAI in the Greater Mekong Sub-Region

2.1 Spatial and temporal patterns of HPAI H5N1 occurrence

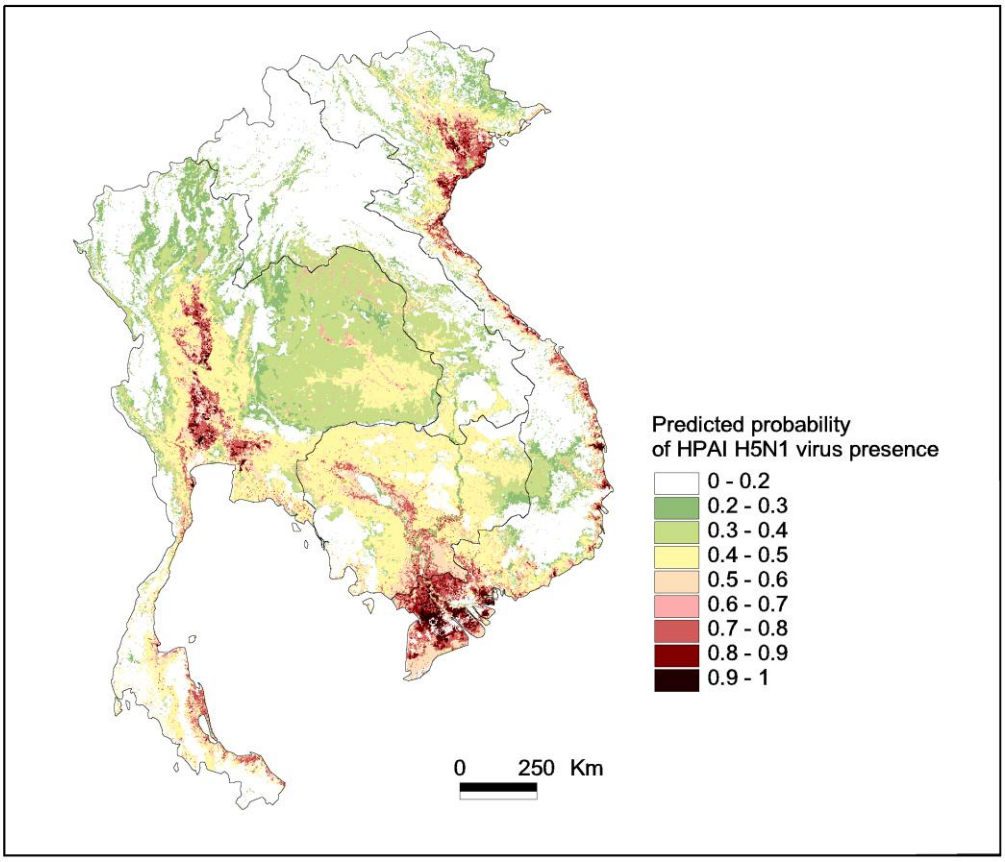
2.1.1 Key messages

- Based on reported outbreaks and phylogenetic evidence, it appears that HPAIV H5N1 was introduced into the GMS countries from southern China during the same time period, probably from late 2003 to early 2004.
- The initial epidemic outbreak wave in 2004 affected a very large number of poultry flocks in central Thailand and northern and southern Viet Nam, areas of high commercial poultry sector activity, while incidence was much lower in Cambodia and Lao PDR. Massive control efforts by Thailand and Viet Nam were able to reduce outbreak incidence substantially, but could not totally eliminate infection.
- In Viet Nam, geographic areas of occurrence of HPAI H5N1 continue to be the same ones identified in the early epidemic waves, characterized by systems with high density of both chickens and ducks, typically not kept in large commercial units, and often in or in the vicinity of areas of high human population density, which contributes to high frequency of live poultry movement, with live bird markets likely to have a key role in the maintenance of infection within a geographical area.
- The occurrence of HPAI H5N1 in Lao PDR and northern Viet Nam is strongly influenced by cross-border trade with southern China while HPAIV infection in Cambodia is apparently determined by disease epidemiology in southern Viet Nam, again in concert with robust informal cross-border trade.

2.1.2 Research findings

1. ***In the initial 2004 wave(s) of infection sweeping across the GMS, HPAI H5N1 had highest outbreak incidence in areas with high duck-rice production.***

   In the initial epidemic waves, HPAI risk in Thailand and Viet Nam was statistically associated with duck abundance, human population and rice cropping intensity but less strongly with chicken numbers. In Viet Nam, the two main HPAI risk clusters (Red and Mekong River Deltas – RRD & MRD) not only coincide with irrigated rice areas in the lowlands, but also with areas of good market access and high poultry transaction frequency. The latter suggests that the trade network, in which live bird markets fulfil a key role, facilitates spread of the virus.



References: B2, B8, J19

2 ***In Viet Nam, the initial epidemic waves showed a cyclical pattern associated with periods of increased domestic demand of poultry products, whereas no such pattern occurred in Thailand.***

A striking feature of the different epidemic waves in Thailand and Viet Nam is that they did not appear to be synchronous, which raises questions about the underlying factors that may define 'hot' periods during which increased virus circulation can be expected. In Viet Nam, the initial epidemics occurred before and during the Tét holiday period when demand for poultry and pork meat is particularly high, suggestive of poultry movements as important determinants of local epidemics.

References: B2, B8, J19

3 ***Cambodia and Lao PDR are primarily affected by infection spillover from neighbouring countries.***

In Cambodia and Lao PDR, HPAI H5N1 outbreaks occurred sporadically, and are probably associated with cross-border poultry trade: in the case of south-eastern Cambodia as spillover from southern Viet Nam and in Lao PDR as a result of poultry trade with southern China and northern Viet Nam. The small extent of the commercial poultry sectors in Cambodia and Lao PDR is a possible reason for the small size of the epidemics in these countries and endemicity is unlikely to develop due to the comparatively low density of poultry.

References: B20, I6, I10

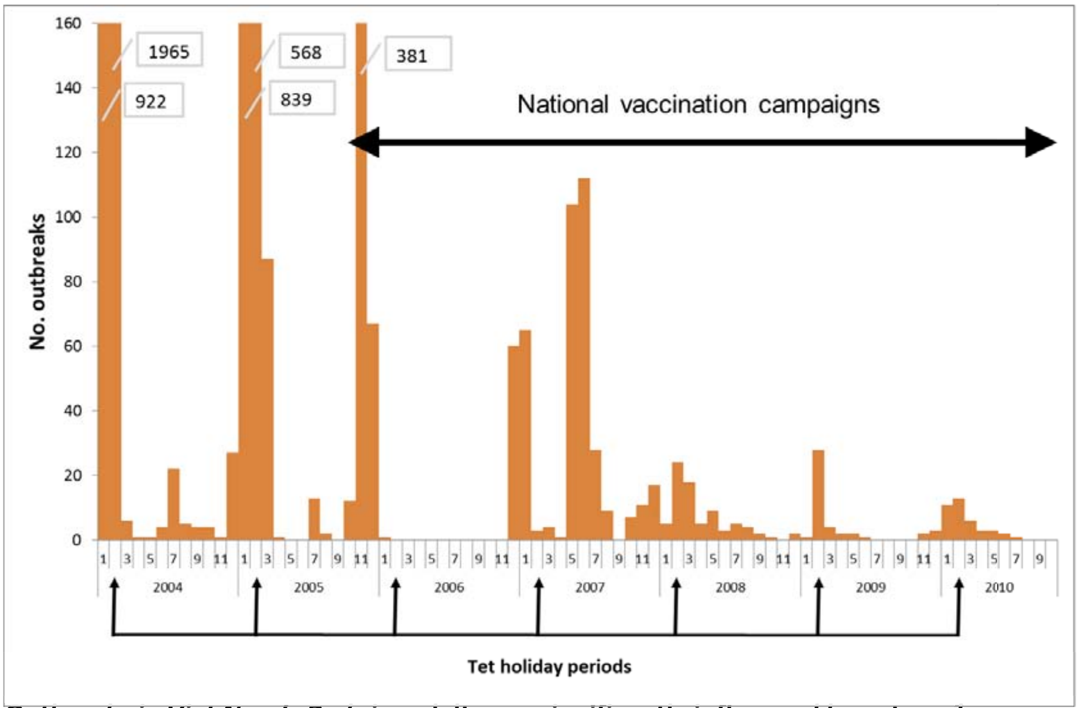
4 ***Thailand has had very few outbreaks since 2005, broadly in the same locations where the early epidemic waves had occurred.***

Thailand has experienced only a very small number of outbreaks since the major outbreak waves in 2004. These outbreaks, caused by descendants of the original HPAIV H5N1 clades, indicate the existence of a local virus reservoir and are believed to be associated with live poultry trade and cock fighting activities of farmers.

References: B13

5 ***In Viet Nam, small numbers of outbreaks still occur around periods of sharply increased poultry demand, but also at other periods of the year,and outbreak numbers are higher than in Thailand.***

In Viet Nam, since introduction of interventions (including large-scale vaccination campaigns in late 2005) outbreak incidence has been reduced significantly. There are still small-scale epidemics around the Tét holiday period, but also at other times of the year. The main foci of infection remain in the two large river deltas, particularly in the Mekong river delta. Outbreak incidence is higher than in Thailand.



6 ***Outbreaks in Viet Nam's Red river delta are significantly influenced by external introductions, whereas in the Mekong river delta there is likely to be a local reservoir of infection.***

In the RRD, the predominant virus clade(s) have changed over time while the original clade still dominates in the MRD. This suggests different mechanisms of introduction and maintenance between the RRD and MRD. Northern Viet Nam seems to be subject to more frequent introductions of virus from southern China, whereas the MRD may have a local reservoir of circulating virus. Mechanisms for local maintenance of virus presence are unclear, but are particularly important in southern Viet Nam (and bordering areas of Cambodia) since introductions from outside the region seem to be less common. Unvaccinated ducks have been implicated on various occasions as the cause of outbreaks in that region. The area within the MRD where the outbreaks occurred is known for a high duck density and large numbers of free-grazing ducks.

References: TBA

2.2 *Risk of between flock transmission of HPAI and of transmission from poultry to humans*

2.2.1 Key messages

- The role of wild birds in the spread of HPAI H5N1 in the GMS is negligible.
- Movements of poultry associated with trade through live bird markets are likely to have a significant role in the spread and maintenance of HPAI H5N1 infection. This effect is further exacerbated through the involvement of domestic waterfowls in this trade which may not show clinical disease.
- A significant amount of HPAI risk arises from information failures and incentive failures in poultry supply chains. For example, poultry aggregators blend birds, compounding infection risk and obscuring bird origins, the latter undermining producer incentives to invest in product quality/health. Transboundary trade in the region is largely illegal and therefore unobservable. Finally, sanction-based surveillance systems drive poultry trade underground, making bird flows (and attendant infection risk) unobservable.
- Risk for human infection with HPAI H5N1 as a result of exposure to infected poultry is extremely low, even in situations where frequent exposure to live virus is likely to occur, such as on poultry farms or at live bird markets. Yet, since the consequences of infection potentially are fatal and any infection may result in reassortment with AI viruses transmissible between humans, every possible effort needs to be made to further reduce the risk of human infection.

2.2.2 Research findings

1 ***Wild birds have a negligible role in the spread and maintenance of infection in the GMS.***

While wild birds in some instances might have been associated with the introduction of infection into the domestic poultry population, this source has several orders of magnitude lower importance for the spread and maintenance of HPI H5N1 infection, compared with human activities associated with domestic poultry. This conclusion is supported by the relatively clear trade association of the early outbreak waves in Viet Nam, and outbreak occurrence in northern Viet Nam along recognised trade routes (e.g. Dien Bien Phu). Also, the risk pathway from release of live HPAIV H5N1 by wild birds through to exposure of domestic poultry that then has infection as a consequence is likely to be less effective, than any risk pathways associated with the poultry value chain.

Indeed, it is apparent that a very important source of risk, arising from covert transboundary trade that pervades the region, may have been misattributed to wild birds.

References: B2, J19

2 ***Market-oriented poultry producers are more important to the spread of infection than subsistence-oriented backyard poultry keepers.***

Traditional subsistence-oriented small-scale backyard poultry producers do not appear to have been the main spreader of HPAI H5N1 virus in the initial waves of infection, and there is no conclusive evidence that these smallholder poultry present HPAI outbreak risks that are commensurate with the control resources that have been targeted at them. Indeed, it appears that the large number of backyard poultry keepers present much lower national risk than the much fewer but larger scale commercial producers.

References: B5

3 ***The poultry trade network operating through LBMs is of key importance to spread and maintenance of HPAI infection***.

The poultry trading network has an important role in the spatial spread of infection. The network involves farmers, poultry traders and consumers, with the traders linking between different farms when collecting birds as well as through unsold birds going back from an LBM to the home of the trader. Data from Viet Nam indicate that LBMs host a highly dynamic population consisting of a mixture of domestic and potentially wild bird species, representing a potentially large geographic area from which birds were sourced. Infected poultry will shed large amounts of virus, resulting in significant environmental contamination. It is therefore likely that within villages, through poultry traders collecting birds and at live bird markets there is a high risk of indirect transmission through contaminated humans or fomites. Waterfowl species are considered to become infected, shed virus without necessarily progressing to a clinical disease stage, and therefore are likely to have a key role in the spread and maintenance of infection.

References: J7, J20, P13

4 ***Live bird markets can in themselves maintain infection chains and potentially have an important role in the molecular evolution of HPAIV H5N1.***

Live bird markets are a key feature of the epidemiology of H5N1 in that they allow the mixing of birds from a large number of sources and of different species, including chickens and waterfowls. Given the likely absence of hygiene at most LBMs, they thereby can be seen as large flocks that have a high turnover (daily) linked to a multitude of source populations, and may be able to maintain silent infection, without necessary occurrence of noticeable outbreaks. This also increases the potential for antigenic drift as well as reassortment.

References: P13, J10

5 ***Fighting cock associated activities probably also have a non-negligible importance in the spread of infection within the region.***

Fighting cocks are ubiquitous amongst the backyard and small scale commercial poultry producers in Thailand and other GMS countries, and result in additional mechanisms of potential spread of infection through movements to and from cock fighting events. Research in Thailand showed that biosecurity varies significantly between fighting cock arenas.

References: W7, B13, P14

6 ***Mathematical models have confirmed that the RRD and areas around Bangkok provide the conditions that support high incidence of transmission.***

A transmission model for the North of Viet Nam confirmed the RRD as a hotspot for sustained onward transmission. It is likely that the same conclusion can be drawn for the MRD, although this had not been specifically modelled. A similar model for Thailand highlighted areas around and to the North of Bangkok and, to a far lesser extent the Khorat Plateau in the east of Thailand as areas at risk of onward transmission given epidemiological conditions such as those leading to the 2004 wave.

References: B19, J6, I9

7 ***HPAI H5N1 transmission risk from poultry to humans is very low but exposures remain poorly understood.***

The risk of HPAIV H5N1 transmission from poultry to humans is very low, as evidenced in the low morbidity, but case fatality rates are very high. Exposure risk is highest amongst producers as well as in live bird markets. Viet Nam has had the highest reported cases and fatalities in the GMS with 59 deaths and 119 cases between 2003 and August 2010. Second is Thailand with 25 cases and 17 fatalities, followed by 10 cases and 8 fatalities in Cambodia and 2 cases and 2 fatalities in Lao PDR. It needs to be emphasized that in particular the case numbers are likely to be an underestimate.

Epidemiologic investigations of human HPAI H5N1 cases have shown that transmission of HPAIV H5N1 from poultry to humans is currently limited to individuals who may have been in contact with the highest potential concentrations of virus shed by poultry. This suggests that there may be a minimum level of virus concentration needed for effective transmission to occur and that circulating HPAIV H5N1 strains have not yet mutated to transmit readily from either poultry to human, and clearly not from human to human. The mode of transmission varies within and between countries ranging from exposure to poultry or poultry products during a visit to a wet market to preparing infected poultry or swimming or bathing in ponds, which are frequented by poultry.

It is likely that direct and indirect human-poultry contact patterns differ within and between countries. Such differences demonstrate that the potential risk of transmission of HPAIV H5N1 from poultry-to-humans is not uniform across age and gender and therefore may not be uniform within or across countries.

It has to be concluded that infection of humans with HPAIV H5N1 is fairly unlikely, even in the absence of specific hygienic prevention measures. Nevertheless, any human case of infection apart from the high case fatality rate, represents potential for virus reassortment that could produce a virus variant that is transmissible between humans.

References: B15, J21, J24, J25

3 HPAI Control and Impact of HPAI & Control Measures

3.1 *Driving forces of HPAI control*

3.1.1 Key messages

- Because of the scale of economic risk in their own countries, OECD economies have given primary global policy and financial impetus to HAPI risk reduction. However, empirical evidence on actual and potential domestic damages suggests that the OECD, as well as China and India, should be investing much more in overseas risk reduction.
- At the multilateral level, effective response to a global health threat has been constrained by partially conflicting aims and approaches, within and between the donor community, and in relations with and between beneficiary countries.
- Domestically, effective public and animal health policy must arise from and be sustained by effective policy institutions, with adequate capacity and coordination at the national, regional, and local levels. Unfortunately, governmental institutions in the GMS are very diverse in all these aspects, and HAPI risk management has been seriously compromised by institutional weakness in many cases.
- In addition to capacity challenges, institutional rivalry, rent seeking, and political influence have further undermined effective risk management. Most of these discordant forces persist in compromising HPAI and other animal disease policy across the region, raising both the cost of prevention and the risks of further economic damage.
- Although they are the vast majority of poultry keepers in the GMS, do not presently have a voice in the design of short- and long-term HPAI control and mitigation policies. Omitting this stakeholder group is a mistake that seriously compromises policy effectiveness and legitimacy.

3.1.2 Research findings

1 ***Economies with the highest potential economic damage from HPAI, including the OECD, China, and India, are seriously underinvesting in risk reduction at home and abroad.***

To support more evidenced-based approaches to global health strategy, we developed an economic model of the expected value of pandemic disease prevention. Based on best available outbreak, mortality, and actuarial data, our results suggest that present commitments to research and public health practice related to influenza prevention and management are far below the value that could be realized by higher investments. In particular, we estimate that the current cost of saving a life from increasing such spending is a fraction of the statistical value of human life in most countries, but dramatically smaller for OECD actuarial values. Moreover, in very populous countries like China and India, lower per capita loss estimates are offset by enormous numerical incidence at comparable mortality rates. For these reasons, both the high income and high population countries have a strong justification to spend more on flu prevention and mitigation.

The second challenge is to target increased spending. In the age of globalization, highly contagious diseases pose risks everywhere, regardless of where they originate. For this reason, countries that have already achieved high levels of disease suppression may remain vulnerable to infection from areas with higher incidence or ambient outbreak risk. The economic benefits that individual nations draw from a commons of global disease prevention are roughly proportional to their current living standards, as this is a proxy for the magnitude of damages that would arise from worker disability, mortality, and other economic disruptions. Thus, regardless of the geographic origin of such diseases, wealthier countries have a greater economic stake in protecting this commons, and should thereby be willing to make greater investments to conserve it, regardless of where those investments are made. It is in everyone's interest that preventative investments be allocated most efficiently, and to economists this means the place where one dollar yields the largest reduction in risk of pandemic origination. In the case of HPAI, for example, most experts believe that the most cost-effective risk reductions can currently be concentrated in the so-called 'epicentre' countries of Southeast Asia, where there dense human and poultry populations live in close daily proximity.

2 ***In Thailand, concerns of the export-oriented industrial poultry sector were influential determinants of the country's HPAI responses*.**

Undoubtedly the single most significant factor influencing the Thai government's perception of and response to the spread of HPAI has been the industrial poultry sector, comprising predominantly the export-oriented broiler producers and to a lesser extent, the layer industry. The major export-oriented producer companies are represented in their interactions with government officials and the media by a handful of highly organized and sophisticated lobbying groups. Many decisions taken by Thai officials reflect close interaction with the industrial lobby whose main concern was to maintain / regain their access to global export markets. To their credit, the industrial producers contributed financially to a scheme to boost compensation to smallholder farmers who surrendered their birds.

In contrast to the industrial poultry producers, cock fighting enthusiasts, who are estimated to number in the hundreds of thousands, were among the most vocal and persistent critics of the government's approach to influenza control. Were the cock-fighting enthusiasts an isolated lobby unto themselves it is likely that their protests would have gone unheeded. However, in many respects they became the voice for the multitude of backyard poultry producers who felt their interests to have been marginalized in the national debates about HPAI and its control. As such, both rural constituencies and the Thai media seem to have placed disproportionate weight on the views of fighting cock enthusiasts.

One of the starkest tradeoffs in Thai policy-making related to HPAI was balancing of the interests of the large producers against those of the small- to medium- sized entities. Clearly feeding into the government's pattern of decision-making was a broader concern with regenerating the country's foreign reserves, which had been badly depleted during the economic crisis of the late-1990s. Of all the subclasses of poultry producers, only the industrial producers contributed substantially to this larger national goal, which may partly explain why on most issues Thai government sided with the large producers.

References: S3

3 ***In Viet Nam, despite assertive central government participation in HPAI policy and expenditure, fragmentation of authority within the structure of government from central to local levels constrained HPAI responses.***

Viet Nam's HPAI policy process was characterised by top down/technical perspectives supported by the central government and foreign donors. These narratives reinforced the political and commercial interests of a national/international elite. While divisions and nuances existed, there was a close convergence of interests and perspectives between global and centralist national actors. This powerful nexus pushed a particular approach that involved mass culling and comprehensive vaccination, and projected a narrative of success to the nation and the world.

However, major discrepancies exist between central and local policies, and between policy intents and policy results. Implementation of policies is extremely contentious, with competition for resources intersecting with competition for power. Local governments played a complex role in the policy process. In most policy decisions, they were not consulted but were expected to bear consequences if those decisions were hard to implement. In policies such as culling and vaccination that stretched their capacity and that provoked intense resistance from farmers, local governments were in a bind. Except the large cities which had more reasons to fear a pandemic and whose leaders had better chances of promotion, most provinces appeared to go with the flow from the central government but only did what they could realistically do. What this means is they only acted when there are tough orders and abundant money flowing from the centre, but stopped enforcing central policies when the flow slowed down. In sum, the role of local officials was insignificant in the formulation of AI policy but crucial in the implementation phase as the power of the central government only applied to the extent that it could mobilise resources to back up its policies.

References: S4

4 ***In Cambodia, institutional weaknesses are exacerbated by strong patronage politics and power monopolies.***

When HPAI outbreaks started in Cambodia (Jan 2004), the government established a National Committee for Disaster Management, imposed poultry movement restrictions and permitted culling of infected flocks without compensation. However, law enforcement is weak and compliance is low. As soon as the first human victim was confirmed (Feb 2005), the focus shifted from animal to human health and the Ministry of Health (MoH). Because animal surveillance was intended to warn of risks to humans, the repeated discovery of human victims without any poultry outbreaks reported created major tension between the ministries and MoH is seen as a more viable implementer of donor funded projects than its counterpart, the Ministry of Agriculture and Fisheries (MAFF).

Corruption, quarrels, rivalries and competition between political parties, ministries and departments hamper collaboration and goal achievement. The private sector is not a driving force in HPAI control. Overall, GoC perceives the risks posed by HPAI to be low and authorities have been unwilling to commit State resources, but donors were more than willing to step in and by end-2008, Cambodia had received some US$35 million in foreign assistance for HPAI control.

References: S2

5 ***Smallholder farmers were generally blamed for the disease and became the targets for HPAI control.***

Smallholder poultry farmers were singled out as the main culprits for the introduction and spread of HPAI. In Thailand and Viet Nam HPAI control measures (culling, production and marketing bans) appear to have been particularly severely applied to smallholder poultry keepers and owners of grazing ducks while compensation payments were preferentially made available to larger scale commercial producers. In Viet Nam, compensation for culling was delayed and insufficient, in part because many provinces were not willing to provide the 50 percent matching fund as the central government ordered, or because they compensated only farmers who owned larger stocks.

Smallholder farmers had no voice in the policy-making process, but, despite being neglected, small farmers were not powerless as a group. Their common weapon was passive resistance to, or active efforts to circumvent, state policies: buying and selling chicks despite the government ban; selling and even eating sick poultry to recoup the losses; and hiding poultry from veterinary officials.

References: S1-S4

6 ***Donor coordination has been sub-optimal and has contributed to distortions in the HPAI response in some countries.***

Despite the Paris Declaration, the One-UN initiative and multi-donor platforms and funding mechanisms etc. their HPAI response in GMS countries has been sub-optimal. Donor aid has created major distortions, confusions and has fuelled patronage networks, undermining the incentives of states and state agencies to respond. Donors, at least in the initial phases of support acted in emergency mode and strictly separated emergency from development responses, thereby neglecting livelihood aspects of control measures and at times counteracting measures implemented by other branches of the same agency.

Within the emergency response modality, donors showed a strong resistance to integrating other poultry or livestock disease issues with HPAI, even if the latter cause much more severe losses and if their control would rule out differential causes of poultry mortality, facilitating the detection of HPAI. (For example, Newcastle disease (ND) presents a similar clinical picture to HPAI and coordinated ND vaccination could facilitate the early detection of HPAI.)

References: S1-S4, B17-B18

3.2 Applied control measures and their efficacy

3.2.1 Key messages

- Large-scale vaccination programmes are unable to eradicate infection, or even to avert recurrent outbreaks in areas with a high prevalence of small-scale poultry keepers.
- Intensive active surveillance can reduce the risk of infection to a negligible level, but at a cost that is probably unsustainable and in any case competes with other high priority development objectives.
- A control/prevention programme should aim to introduce active surveillance targeted at high risk sub-populations, incl. potentially live bird markets, and make only very limited and strategic use of vaccination.
- Participatory surveillance has potential for complementing others surveillance approaches in scenarios where the poultry keepers cannot be reached effectively by other means
- Enhanced biosecurity at all stages in the value chain is desirable, but probably difficult to achieve without generating appropriate incentives. LBMs have a particular importance in this context, and the introduction of rest days associated with market disinfection may help to disrupt infection chains.
- Compartmentalisation or zoning may allow creating infect-free units, but it needs to be supported by effective biosecurity, movement control and surveillance, as has been demonstrated by Thailand
- All stakeholders involved in the poultry value chain should be incentivised to appreciate the importance of biosecurity, movement control and reporting. Information campaigns as well as use of participatory approaches are very useful in this context.
- Culling of affected and ‘at risk’ poultry in response to outbreaks has been an important measure in dealing with the early large-scale epidemics as well as the relatively small-scale outbreaks occurring in the GMS since 2005.
- Financial compensation for culled poultry is an important component of the control programme. There needs to be an appropriate balance between the scale of culling (particularly of ‘at risk’ poultry) and the level of compensation, so as not to incentivise for a

flock to become infected or the opposite behaviour resulting in underreporting or illegal sale of potentially infected poultry.

3.2.2 Research findings

1 ***Thailand focussed its HPAI control on enhanced detection through large-scale active surveillance and culling without permitting the use of vaccination*.**

In Thailand, measures adopted for disease containment adhered closely to provisions laid out by FAO, WHO and OIE: Comprehensive cull of all susceptible poultry from farms located within a 5-km radius. Compensation was among the highest paid in SE-Asia. Movement restrictions were imposed within a 50-km radius of outbreak locations. A 90-day ban imposed on export of poultry from affected areas.

From mid 2004, due to the reduction in outbreaks achieved by the disease containment policy, it was possible to focus on large-scale active surveillance involving diagnostic assessment of very large numbers of samples collected from farms, as well as in relation to movements and slaughter. Any outbreaks were controlled using culling within zones of only 1-km radius. Information campaigns were implemented in relation to human health protection and poultry biosecurity.

To specifically protect industrial poultry farms from infection through exposure to potential presence of infection in backyard and small-scale commercial production systems, a government-funded scheme was implemented that involved establishment of disease-free compartments surrounding some industrial poultry farms. The biosecurity protocol involves intensive surveillance for infection in a 2-km buffer zone around the compartmentalised farms, as well as other measures.

References: W7

2 ***Viet Nam opted for a control programme consisting of surveillance, vaccination and slaughter.***

Viet Nam implemented a wide range of control measures, including large-scale culling, movement controls and closure of live poultry markets, banning poultry keeping in some major cities, campaigns to educate the public about preventive measures. The culling policy was revised after the first epidemic wave (44 million birds culled) as it became clear that extensive culling based on pre-established geographic criteria (i.e. 1-km radius ring culling) was too expensive and hard to perform given that farmers were not willing to give up apparently healthy birds. In addition to the direct cost of culling, farmers demanded compensation, which represented a major fiscal burden. In subsequent waves, targeted culling of high-risk bird populations immediately adjacent to infected farms was employed, dramatically reducing the number of birds culled. From 2005 onwards, Viet Nam launched comprehensive, nationwide vaccination campaigns for all birds, to a large extent funded by donors[1].

Vaccination coverage achieved by the mass vaccination campaigns was at best moderate. Although the within-flock reproductive number of infection (R0) has been significantly reduced in the fourth epidemic wave (vaccination-based control policy) when compared to the second epidemic wave (depopulation-based control policy), the mean within-flock R0 of the fourth epidemic wave was still not significantly below unity, suggesting problems with obtaining the required vaccination coverage within some flocks. MARD is therefore gradually revising its vaccination strategy and HPAI control policies.

References: B19, J6

[1] Overall, donor support to Viet Nam amounted to US$ 1.35 *per capita* (Vu, 2009)

3 ***Cambodia's control programme is less intensive than either Thailand's or Viet Nam's, and does not involve public vaccination campaigns.***

Cambodia's control policy involves poultry movement restrictions and permitted culling of infected flocks without compensation. Also, 3-km protection zones and 10-km surveillance zones were established around outbreaks. Temporary suspension of sales and purchases of birds was mandated. However, law enforcement is weak and compliance is low. Despite the occurrence of at least four reported HPAI outbreaks in Cambodian chicken flocks, and four reported human deaths from HPAI in Kampot, zero respondents reported having their birds culled. At least two villages reported HPAI outbreaks in their villages, however, none of the respondents had experienced culling.

References: I6, B21, S2

4 ***A comparison between the approaches chosen particularly in Thailand and Viet Nam suggests that large-scale vaccination represents a significant challenge when attempting to achieve the necessary vaccination coverage to produce extinction of infection.***

The estimated interval between time of infection and report in Thailand was comparable to that during outbreaks in Viet Nam pre-vaccination (2004/5 wave). As the Thai wave involved approximately six times the number of outbreaks than in Viet Nam, this suggests that the impact of surveillance efforts upon the size and scale of spread is likely to vary between regions and different waves of outbreaks.

Large-scale vaccination does not eliminate infection (e.g. Viet Nam), whereas a control strategy without vaccination involving a combination of activities including targeted surveillance such as practiced in Thailand around compartmentalised poultry production units appears to be able to eliminate infection, and definitely prevent outbreaks of disease. Compared to vaccination, market hygiene improvements appear to be more cost-effective.

Overall, control measures in place during the 2007 wave of outbreaks in Viet Nam reduced the number of communes capable of spreading infection by an estimated 11%. This was achieved at a far lower social and economic cost than during previous waves. However these gains have to be balanced against the cost of maintaining levels of effective protection in an endemic situation. As estimates suggest that the infectious period has increased following vaccination, the impact of waning levels of immunity as the initial impetus to vaccinate is lost, coupled with the effects these changes may have upon the ability to detect outbreaks, remains an issue which needs to be addressed.

References: B10, B19, J6

5 ***Gains in detection would have had a large impact upon the scale and duration of both the 2007 wave and any which may occur in the future supporting the notion that more targeted surveillance may be necessary for effective control***.

The key to effective prevention of spread in the event of outbreaks is their early detection, as has been demonstrated by mathematical models. The most cost-effective mechanism for achieving this goal will be to incentivise farmers to report any suspect cases and for the animal health authorities to be able to react quickly.

References: B10, J6

6 ***Smallholder risk perceptions limit their economic interest in biosecurity investments, and these must be changed with incentives that recognize their contribution to larger social objectives.***

Biosecurity does not come in 'black or white' but in shades of grey, that is an operation is not either biosecure or bio-insecure. Biosecurity is incremental, i.e. one measure can be put on top of another, and sensibly should address the biggest risk(s) first. This, however, means that biosecurity is to a large extent context-specific and, although in qualitative terms it is known how the HPAI H5N1 virus may move, there are no hard figures as to the relative importance of different pathways of infection in different production systems.

As all investments, investing in biosecurity is subject to the law of diminishing returns and it is neither economically efficient, nor biologically feasible, to reach 100% biosecurity. For privately funded investment in biosecurity the benefit to the individual needs to at least cover the cost over the lifetime of the investment. Given that investing in biosecurity has a fixed cost component, cost per bird protected will be lower for larger production units than for smaller production units, hence economic incentives differ by scale of production (in addition to the fact that larger flocks have more transactions and therefore often more risky contacts than small flocks). Consequently, smallholder behaviour of limited investment in biosecurity is economically rational.

Approaches to disease control need to be congruent with local social, cultural and political realities. Behaviour change approaches, central to HPAI control, need to build on an understanding of existing behaviour, as the latter is likely to have very solid foundations, otherwise they are likely to fail.

Biosecurity 'kills several birds with one stone' and returns at the beginning of the 'biosecurity function' are high. If context-specific (i.e. proven to work and not requiring radical changes in a given environment and production system), the introduction / improvement of biosecurity is potentially pro-poor rather than anti-poor, provided producers have access to the required capital and knowledge, and are given sufficient time and support to adapt.

References: B4, B6, B9, B16, P2, P9

3.3 Livelihoods and economic impacts of HPAI & HPAI control

3.3.1 Key messages

- Through complex vertical and horizontal economic linkages and adaptive changes, severe HPAI epidemics affect virtually all segments of society, albeit to different extent and over different time scales.
- Collectively, small-scale subsistence-oriented poultry keepers suffered the largest cumulative economic losses from HPAI and HPAI control in the GMS but disease posed the highest livelihoods threat to, in their majority small-scale, market-oriented poultry producers and market agents.
- The loss of poultry dying from HPAI is dwarfed by the impacts resulting from public control measures and consumer / market reactions, which affect the entire industry, irrespective of the infection status of a particular enterprise. This actually offers wide scope for mitigating the impact of HPAI through well-designed public HPAI risk management programmes.

3.3.2 Research findings

1 ***HPAI causes economic losses through a complex mixture of impacts acting through direct and indirect pathways.***

HPAI affects animal production via three main pathways. Firstly, HPAI causes direct losses to producers and other actors connected to the production and marketing of poultry through morbidity and mortality and the private costs associated with *ex-ante* risk mitigation or *ex-post* coping measures and the need to reinvest in replacement birds. Second, HPAI has severe impacts through government intervention, which carries a cost borne by the public at large and affects producers and associated up- and downstream actors. Thirdly, HPAI impacts arise through demand shocks created by consumer fears of contracting the disease. In concert, these impacts can lead to irreversible industry readjustments.

References: W2-W5, J4

2 ***Drastic disease control measures and consumer reactions to HPAI have severe impacts on all actors in poultry supply chains irrespective of the specific infection status of their flocks.***

On a national scale, direct poultry losses from HPAI and HPAI related culling were minor in Cambodia and Lao PDR, while both in Thailand and Viet Nam some 60 million birds were culled during the initial waves in 2004, which at the time represented between 20 and 30 percent of the standing poultry population. Compensation payments and other public mitigation measures implemented by the respective governments transferred some of the financial burden from the private to the public sector. Apart from direct losses, movement restrictions, marketing bans and consumer reluctance to purchase poultry and poultry products led to a severe drop in activity throughout the entire market-oriented sector of the poultry industry in the GMS, affecting feed producers, traders, processors and retailers (not eligible for compensation). The economic downturn of the poultry sector was partially compensated by increasing activity and prices in sectors producing substitute food products.

References: W2-W5, J4

3 ***Smallholder poultry producer households have well-developed strategies to cope with one-time losses of their poultry.***

The majority of (poor) poultry keeping households can withstand one-time losses of their poultry, even though reduction / foregoing of poultry income is likely to negatively affect household nutrition and within-household bargaining power and expenditure allocation of women (which is particularly targeted at safeguarding the welfare of children). Strategies for coping with HPAI (but more so with HPAI control measures) of the poor are diverse and combine (i) increasing income from other sources and (ii) foregoing consumption. 'Negative' coping strategies are consumption of sick / dead birds and sale of the remainder. These households do not perceive HPAI as a serious threat to their livelihood, in contrast to threats such as losing a rice harvest, social insecurity or floods.

References: W1-W5, J4

4 ***Poultry production and processing standards promoted by the industrial / corporate sector are reducing the prospects for smallholder poultry development.***

The industrial / corporate poultry sector has adapted to HPAI by exerting increasing control over every stage of production and raising safety standards. The high costs required to build the necessary infrastructure and difficulty of securing loans without collateral, make it unlikely that low-income households would be able to enter into any stage of industrial poultry production. Even farmers that presently have contracts may have difficulty adapting to the current hyper-competitive conditions if they are required to make expensive upgrades to farm infrastructure. The high fixed costs of processing, controlled primarily by the integrators, pose another barrier prohibiting entry of independent farms into the system. Additionally, in Thailand, because of export restrictions and changing consumer demands, processing plays an increasingly important role in the organization of poultry production.

References: W4, J4

5 ***Changing market environments in response to HPAI pose more serious threats to smallholder poultry producer livelihoods than HPAI itself.***

In Thailand, changes in market conditions as an indirect result of the HPAI outbreaks have made it difficult for small-scale poultry farmers to sustain their rural enterprises. Despite the absence of large outbreaks since 2005, there have been significant movements out of the native chicken sector during 2006 and 2007. Households who grew chicken in the past continue to do so for own consumption, but they see sharply diminished prospects of a livelihood from this enterprise. Conditions for smallholder poultry production have not significantly changed in Cambodia and Lao PDR while the situation in Viet Nam is somewhat intermediate.

References: W4, J4

6 ***Low-income urban consumers are neglected stakeholders in HPAI control.***

Poultry products are important to urban diet and nutrition. While HPAI caused transitory scarcity and price increases in these products, control measures had a much larger and longer effect. Because lower income households across the GMS who spend more than half their income on food, these price shocks seriously undermine real living standards and may lead to nutrition insecurity. While long term sector transition might lower the cost of meat, existing small enterprise supply chains will continue to feed most of the poor, and these need to be stabilized.

References: B6, B24, J6

7 ***Consumers have re-evaluated the risk posed by poultry and adjusted their consumption habits.***

With regard to consumer adjustment, it appears that the GMS has reached a stage of '*fading public concern creating a new equilibrium state characterized by chronic low-level anxiety*', where the impact of HPAI is mainly manifested in the frequency of consumption and quantity of poultry consumed. Whereas in Viet Nam for example 60 percent of the surveyed population used to consume poultry several times a week in 2003, in 2006 the majority of respondents consumed poultry a few times a month. Thai consumers have not discernably changed their long term consumption patterns, which generally comprise traditional birds as specialty food and industrial chicken for prepared retail foods.

References: J4

8 ***Poultry producers who bore the largest cumulative economic burden of HPAI differ from those whose livelihoods are most severely affected by the disease.***

Collectively, small-scale subsistence-oriented poultry keepers suffered the largest cumulative economic losses from HPAI and HPAI control in the GMS while the disease posed the highest livelihoods threat to market-oriented poultry producers and market agents (in their majority usually relatively small-scale enterprises) specialized in poultry. The reason for this discrepancy is that the latter only represent a minority of producers, but a minority whose livelihoods are most affected by longer lasting HPAI outbreaks and / or protracted control measures due to their relatively high investments and specialization in poultry.

References: J4, I9

3.4 Alternative approaches to HPAI control

3.4.1 Key messages

- Poultry sector transition will surely continue in the GMS, but abrupt changes could destabilize livelihoods among the economically vulnerable rural majority.
- A broad spectrum of socially constructive policy options that can reduce HPAI risk while improving economic conditions for poor farmers exists.
- These policies should be localized to the diverse realities of the region, but coordinated to the extent this is cost effective.

- Market-oriented polices offer vital opportunities for private cost sharing and self-directed poverty reduction. For example, certification and other product quality/safety initiatives can be self-financed and incentive compatible, a socially effective substitute for open-ended fiscal commitments to public disease monitoring and geographically extensive control measures.
- Biosecurity standards and poverty reduction can be advanced with incentive compatible, privately financed quality schemes like certification.
- Governments can support these pro-poor supply networks by facilitating grassroots producer/vendor cooperation, extension services, and generally maintaining an environment congenial to small enterprise development.

3.4.2 Research findings

1 ***Given the structure of current market incentives, smallholder poultry keepers are unlikely to adopt compulsory bio-security measures.***

Diseases are part and parcel of their everyday experience and local responses are determined by local cultural rather than by imposed technical rationales. There is a direct link between the perceived value of poultry and the optimum disease management approach. Higher valuation of live poultry will increase the care taken, possibly enhancing monitoring efforts and thereby reducing the culling radius. Enhancing the value of poultry, via improved marketing and safety, would ultimately result in less drastic HPAI control policies.

References: W2-W5, B16, B21

2 ***Any attempt to formalize markets without maintaining low transactions costs will displace low income participants.***

Numerically, small farmers and enterprises dominate the market populations across GMS agrofood systems. These networks confer livelihoods on such low income agents only because the costs of participation are very low. If control measures impose significant additional costs on the operations of any category of participation in these markets, they will be forced out quickly. Moreover, because of low savings and the need to re-commit to some other livelihood activity, displacement like this can be irreversible.

References: B6, W6

3 ***Diffusion of coping mechanisms along food supply chains, supported by incentive-compatible policies, can enhance social effectiveness of public and private HPAI risk management programmes***.

By promoting risk sharing supply chain relationships, such as contracting, certification, and traceability, individual agents can contribute to a local commons of lower disease risk, more credible product quality, and higher value added across low income networks extending from farmers to consumer households. In these circumstances, every supply chain participant has a shared interest in more diligent safety production, distribution, and marketing practices. Such virtuous cycles of value creation/sharing can overcome endemic problems of moral hazard and adverse selection.

References: I8, W6, B6-B7, B11, B23-B24, J13, J15, J18

4 ***Control measures can undermine safety.***

Adverse incentives in control measures can lead to a variety of unintended and undesirable outcomes:

- Producers loss aversion may lead them to circumvent health standards, sell illegally, hide or swap stocks, etc.
- Traders may actually profit in these circumstances by purchasing animals known to be

sub-standard and reselling them without this information.

- Buyers with low levels of risk aversion can also facilitate trade in sub-standard animals by ignoring minimum sanitary requirements to save money (this includes households, restaurants and butchers).

At all three levels, incentives exist for behaviour that will increase surveillance costs, undermine animal health standards, and transfer disease risk down the supply chain.

References: B6, W4, W6

5 ***Control measures can undermine value creation.***

By blending animals without adequate regard for safety, traders contribute to bio containment problems and undermine value in three ways:

- Spill over of disease risk – blending promotes contagion within and between species.
- Adverse selection – masking producer sources reduces incentives to invest in quality, increasing risk and reducing producer incomes.
- Perception of these uncertainties undermines consumer willingness to pay (programme credibility, perceived safety standards)

References: B6, W6

4 ***Development of incentive-compatible policies critically depends on information technologies.***

The time lag between infection and detection, both at the bird and flock level, will affect policy design and the impact of these policies. When, in an ideal situation, detection is low-cost and immediate, one can introduce incentives like penalties for not reporting sick animals and having them culled. A penalty that is equal to the 'social cost' of not culling is 'optimal', and is superior to a subsidy for culling (compensation for sick birds) because the subsidy will result in over-production and under-investment in prevention. Also, when information is imperfect, 'ring' culling is a crucial disease control measure. Earlier (and more accurate) information will reduce the optimum radius of culling and thereby spare resources and livelihoods.

References: B6, J13

5 ***In the absence of 'perfect' information, systems of 'carrots and sticks' need to be introduced.***

The sticks include heavy penalties for knowingly contributing to the spread of disease (i.e., knowingly exposing other flocks to infection). At the same time, awards should be given for self-reporting of infection. Compensation should not make having one's own flock culled profitable, but should allow farmers to maintain their livelihood.

References: B6, J13

6 ***Consumers continue to exhibit a preference for local poultry breeds and are willing to pay significant premia for this preference, which can be used to finance self-sustaining and credible supply chains for healthier, higher quality poultry.***

Modelled on organic, fair-trade, and other specialist product strategies, this approach combines better incentive properties for progressive risk management with product quality development, correcting for negative surveillance/control effects and opening the potential for private agency to improve product quality. Traditional bird varieties, because they have demonstrated they can command premium prices, will be the primary objective of this market reform activity.

References: I8, W6, B6-B7, B11, B23-B24, J13, J15, J18

7 ***The need for improved disease surveillance is global, willingness to pay at each location may be small, but gains may be substantial.***

Based on a simple statistical value of life calculation, we estimate that the gain from reduced pandemic risk is in the billions of dollars, annually. The private sector is unlikely to invest optimally in development of improved surveillance and risk reduction measures. Therefore, development of disease surveillance technologies has a global public good element, and their development should be supported by public sources. To deal with distributional issues within and across countries and regions, a regime of penalties should be accompanied by fixed transfers, including from third countries which benefit from reduced disease risk.

References: TBA

4 Synthesis and Implications for the Control of HPAI and other Diseases in the GMS

4.1 General observations about livestock disease control in the GMS

- The GMS countries are diverse across all institutional aspects relevant to animal disease control, including the role of agriculture in the overall economy, livestock sector and market structure, individual and societal risk perceptions related to livelihoods and public health, national and local governance systems, etc. This diversity limits the generality of national solutions and poses a challenge to multilateral coordination.
- Standard disease response prescriptions that populate international guidelines and are replicated in country plans assume well-functioning human and animal health systems, rapid and efficient response capacity, and up-to-date epidemiological information and technical expertise, none of which prevail in most GMS countries. Technocratic, expert-driven, top-down solutions falter in the face of bureaucratic and political complexity, institutional weakness, and local market imperfections.
- Diseases can be controlled and even eradicated without reducing transmission risk to ZERO. To be cost effective, control measures should first be applied to the highest risk groups / areas / activities and proceed down the risk hierarchy as resources allow and aggregate risk necessitates.
- Disease control authorities need to recognize that the risk of livestock disease is a combined result of biological processes and economic behavior extending across the entire agrofood sector, including livestock keepers, their input suppliers, their downstream market partners, and of agents within the animal and public health system itself. 'Conventional' disease control strategies, emphasizing public surveillance and economic sanctions, present significant long term fiscal obligations and adverse incentive problems.
- Distinct socio-cultural constructions regarding agrofood practice, hygiene, risk, and the role of livestock strongly influence public and private perceptions and responses. Disease control policies thus need to be adapted to local, national and regional institutional realities. For example, smallholder poultry producers may play an essential role in protecting a global commons of disease resistance, but it is not rational for them to internalize something like pandemic risk without appropriate incentives.
- Disease control policies that disrupt livelihoods may have unintended consequences, such as increasing disease risk by driving production and trade underground. At the same time, the perennial nature of this disease threat and potential cost of a pandemic mandate more determined risk management. The challenge is to sustain public investment in disease defenses, while redoubling our commitment to effective policy design and implementation.
- The economic importance of the livestock sector suggests that a broad spectrum of public-private partnerships should be available for incentive-compatible and cost-effective disease risk management. These are well developed in OECD economies, but in lower income countries the potential for this remains unfulfilled.
- Research and investment to enhance low cost animal health monitoring / surveillance should be a major international priority. Empirical evidence on their own actual and potential domestic damages suggests that OECD countries are seriously underinvesting in overseas risk reduction.

4.2 General observations about HPAI and HPAI control in the GMS

- In the short term it will be impossible to eradicate HPAI H5N1 infection from the region. It is entirely feasible, however, to reduce rates of transmission to a degree that forestalls development of local reservoirs of infection and detects incursions before they have spread 'out control'. Targeted control measures, such as reducing infection risks at live bird markets, as well as prevention measures aimed at domestic duck production, would make important contributions to this 'second-best' objective.
- Transboundary HPAI transmission risk within the GMS appears to be high and Thailand, Lao PDR, and Viet Nam are continuously exposed to HPAIV introductions from southern China. In this setting, national and international resources for domestic eradication will not achieve their objectives, suggesting an urgent need for more determined multilateral policy coordination.
- Although their individual risk is statistically much lower than that of large operations, because of their geographic dispersion and majority status, smallholders can play a crucial role in HPAI risk management. It is essential, however, to recognize the rural poor as part of a solution (effective disease defense) rather than a problem (infection risk), enlisting them with socially effective policies that recognize and reward their contribution to the national and global commons of disease resistance.
- HPAI risk management in the GMS can only be successful if it is compatible with the realities of rural peoples' livelihoods. Poultry are rarely the primary source of income for rural households, and within the household level or small scale poultry 'enterprise', HPAI is not normally the disease of primary concern. If this disease is seen as exceptional by others, emergency responses need to communicate this with meaningful development responses that reward smallholders for internalizing national or global health risks. Unfortunately, these two 'response modalities' are decoupled both at international and national levels.
- Within the emergency response modality, there is a strong resistance to integrating other poultry or livestock disease issues with HPAI, even if the latter cause much more severe losses and if their control would rule out differential causes of poultry mortality, facilitating the detection of HPAI. (For example, Newcastle disease (ND) presents a similar clinical picture to HPAI and coordinated ND vaccination could facilitate the early detection of HPAI.)
- Support for producer 'diversification' and quality improvements appear a more promising tool for HPAI risk reduction than targeted compensation for stock losses. The same reasoning applies to production and trade bans, which cannot be enforced and may make matters worse.
- Product certification is a systemic remedy that can be used to create virtuous quality cycles, combining risk reduction with higher product value along supply chains of low income market participants. Well designed monitoring and traceability systems can improve the terms of market access for the rural poor, making many of them better off as a result of HPAI control policies and, at the same time, facilitating disease control. Moreover, surveys of willingness to pay for these quality characteristics suggest that such schemes could be privately financed and managed, reducing long term public financial commitments.
- The epidemiology of HPAI is evolving over time, and public and private HPAI risk management strategies must to the same. This calls for adaptive institutional mechanisms that are capable of 'learning' and dealing with systemic uncertainty regarding disease risk and response.

4.3 Specific observations / recommendations about HPAI control in the GMS

- HPAIV H5N1 now appears to be endemic in parts of the GMS and domestic and (especially) external public resources for control measures will be difficult to sustain at previous levels.
- Attempting to improve the bio-security of millions of backyard producers is an ineffective use of scarce resources, especially public funds in countries with many high development priorities.
- Publicly funded, blanket vaccination campaigns are costly and appear to be ineffective. Targeted vaccination of specific high-risk groups can achieve comparable risk reduction at a fraction of the cost.
- For within-country areas with apparent endemic infection (e.g. Mekong delta in Viet Nam), eradication programmes should be considered, but carefully targeted at the mechanisms responsible for maintenance of infection.
- Hygiene and diagnostic effectiveness needs to be improved in live bird markets and allied supply chains. These include poultry trade networks (e.g. allow movement in one direction – downstream; limit distance travelled), live bird markets (rest days, species segregation) and targeted duck surveillance, including accreditation of infection-free duck farms.
- Establishment of infection-free zones or compartments is possible, as has been demonstrated by Thailand, and can be used as 'success stories' and technology incubators. Economic outcomes for these groups may also induce emulation/adoption elsewhere.
- Pilot interventions in Viet Nam have shown that privately financed animal health improvement strategies, such as certification and contracting, may provide more effective and sustainable risk reduction than long term commitments to publically financed surveillance and sanction systems because consumers exhibit strong preferences for local, non-industrially raised poultry and manifest this through willingness to pay price premia.
- Cross-border trade, particularly with southern China, is an important mechanism for recurrent introduction of infection to the GMS region. This risk needs to be managed, or national eradication programs will be futile. Simple prohibitions of cross-border trade are ineffective and create informal flows that make infection processes unobservable. The only practical solution is multilateral coordination to effectively monitor flows of animals, products, and infrastructure.
- Reducing virus prevalence in poultry will significantly reduce the risk of humans to become infected, and this can be further reduced by public education campaigns limiting high risk behaviour.

5 Annexes

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5.2 *Project publications*

5.2.1 Internal project reports

Nr.	Title
I1	**Esmonde, L** (2008). *Cross-Country Comparison of the Impact of HPAI: Analysis for Evidence-Based Pro-Poor Policy Formulation*. 42pp
I2	**Kazybayeva S, Otte J, and D. Roland-Holst** (2008). *A Social Accounting Matrix for Cambodia 2004*. 27pp
I3	**Sriboonchitta S, Otte J, and D Roland-Holst** (2009). *A Social Accounting Matrix for Thailand, 2006*. 33pp
I4	**Scoones I and P Forster** (2008). *One World, One Health: Learning from the international response to avian influenza*. 78pp
I5	**Hong Hanh PT, Nhan LT, Otte J, and D Roland-Holst** (2009). *A Social Accounting Matrix for Viet Nam, 2005*. 53pp
I6	**Heft-Neal S, Otte J, and D. Roland-Holst** (2009). *Assessment of Smallholder Indigenous Poultry Producer Viability in Cambodia*. 130pp
I7	**Prakarnkamanant A, Mastin A, Patanasatienkul T, Kasemsuwan S, Wongsathapornchai K, Chanachai K, Otte J and D. Pfeiffer** (2009). *Quantitative Risk Assessment of the risk of HPAI H5N1 introduction via cock fighting activities into the 1-km buffer zones surrounding compartmentalised broiler farms in Thailand*. 51pp
I8	**Southern Viet Nam Center for Agricultural Policy** (2010). *Pilot Certified Free Range Duck Supply Chains for Ho Chi Minh City*. Final Report. 34pp
I9	**Hartemink N, Tiensin T, Heesterbeek H and P Walker** (2010). *Mathematical model for studying the spread of Avian Influenza between sub-districts in Thailand*. 24pp
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I11	**CAP-IPSARD** (2010). *Viet Nam poultry market and policy options under HPAI*. 42pp
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W2	**Burgos S, Hinrichs J, Otte J, Pfeiffer D, and D Roland-Holst** (2008). *Poultry, HPAI and Livelihoods in Viet Nam – A Review*. 41pp
W3	**Burgos S, Hinrichs J, Otte J, Pfeiffer D, *et al*.** (2008). *Poultry, HPAI and Livelihoods in Cambodia – A Review.* 29pp
W4	**Burgos S, Otte J, Pfeiffer D, Metras R, *et al*.** (2008). *Poultry, HPAI and Livelihoods in Thailand – A Review*. 46pp
W5	**Burgos S, Otte J, and D Roland-Holst** (2008). *Poultry, HPAI and Livelihoods in Lao PDR – A Review*. 38pp
W6	**Ifft J, Otte J, Roland-Holst D, and D Zilberman** (2009). *Poultry Certification for Pro-Poor HPAI Risk Reduction.* 37pp

Nr.	Title
W7	**Kasemsuwan S, Poolkhet C, Patanasatienkul T, Buameetoop N *et al*.** (2009). *Qualitative Risk Assessment of the Risk of Introduction and Transmission of H5N1 HPAI Virus for 1-km Buffer Zones Around Compartmentalised Industrial Poultry Farms in Thailand.* 42pp
W8	**Burgos S, Otte J, and D Roland-Holst** (2009). *Poultry, HPAI and Livelihoods in Myanmar – A Review.* 35pp
W9	**Heft-Neal S, Kahrl F, Otte J, and D Roland-Holst** (2009). *Assessment of Smallholder Indigenous Poultry Producer Viability in Thailand*. 71pp
W10	**Van Kerkhove M** (2009). *HPAI/H5N1 Transmission Risks: Pathways from Poultry to Humans.* 33pp
W11	**Sriboonchitta S, Chaiwan A, Heft-Neal S, Otte J, and D Roland-Holst** (2010). *Promoting Rural Livelihoods and Public Health in Through Poultry Contracting: Evidence from Thailand*. 33pp
W12	**Sriboonchitta S, Chaiwan A, Kahrl F, Heft-Neal S, Otte J, and D Roland-Holst** (2010) *Livestock Promotion for Market Oriented Rural Poverty Alleviation*. 16pp
W13	**Behnke D, Otte J, and D Roland-Holst** (2010). *Micro Contracting and the Smallholder Poultry Supply Chain in Lao PDR*. 26pp
W14	**Changanngakham P, Behnke D, Otte J, and D Roland-Holst** (2010). *Promoting Rural Livelihoods and Public Health Through Poultry Microfinance: Evidence from Lao PDR*. 35pp
W15	**Behnke D, Otte J, and D Roland-Holst** (2010). *Assessment of Smallholder Indigenous Poultry Producer Viability After HPAI: Evidence from Lao PDR*, 149pp
W16	**Heft-Neal S, Kahrl F, Otte J and D Roland-Holst** (2010). *Synthesis of Findings on Smallholder HPAI Risk and Control in Thailand and Cambodia*. 39pp

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Nr.	Title
S1	**Scoones I, and P Forster** (2008). *The International Response to Highly Pathogenic Avian influenza: Science, Policy and Politics*. STEPS Working Paper 10, Brighton: STEPS Centre
S2	**Ear S** (2009). *Cambodia's Victim Zero: Global and National Responses to Highly Pathogenic Avian Influenza*. STEPS Working Paper 16, Brighton: STEPS Centre
S3	**Safman, R** (2009). *The Political Economy of Avian Influenza in Thailand.* STEPS Working Paper 18, Brighton: STEPS Centre.
S4	**Vu T** (2009). *The Political Economy of Avian Influenza Response and Control in Vietnam*. STEPS Working Paper 19, Brighton: STEPS Centre.

Available at: http://www.steps-centre.org/publications/index.html#working

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B2	**Pfeiffer D, Minh PQ, Martin V, Epprecht M, and J Otte** (2007). *Temporal and Spatial Patterns of HPAI in Viet Nam*
B3	**Otte J and D. Roland-Holst (2007)**. *HPAI Control Measures and Household Incomes in Viet Nam*
B4	**Roland-Holst D, Epprecht M, and J Otte** (2008). *Adjustment of Smallholder Livestock Producers to External Shocks: The Case of HPAI in Viet Nam*
B5	**Otte J, Pfeiffer D, Soares-Magalhaes R, Burgos S, and D Roland-Holst** (2008). *Flock Size and*

Nr.	Title
	HPAI Risk in Cambodia, Thailand, and Viet Nam
B6	**Ifft J, Otte J, D. Roland-Holst, and D Zilberman** (2008). *HPAI Control from a Demand Side Perspective*
B7	**Ifft J, Otte J, Roland-Holst D, and D Zilberman** (2008). *Smallholder Poultry Supply Chains in the Ha Noi Region*
B8	**Gilbert M, Xiao X, Pfeiffer D, Epprecht M, *et al.*** (2008). *Ducks, Rice and People - the Key to HPAI Risk in the Mekong Region*
B9	**Miers H** (2008). *Poverty, Livelihoods and HPAI*
B10	**Walker P, Cauchemez S, Metras R, Dung DH, Pfeiffer D, and A Ghani** (2008). *Modelling the Temporal and Spatial Dynamics of the Spread of HPAI H5N1 in Northern Viet Nam*
B11	**Ifft J, Otte J, Roland-Holst D, and D Zilberman** (2009). *Smallholder Poultry Certification for Pro-Poor HPAI Risk Reduction*
B12	**Otte J, Hinrichs J, Rushton J, Roland-Holst D, and D Zilberman** (2009). *Impacts of Avian Influenza on Poultry Production in Developing Countries*
B13	**Kasemsuwan S, Poolkhet C, Patanasatienkul T, Buameetoop N *et al.*** (2009). *Qualitative Risk Assessment of the Risk of Introduction and Transmission of H5N1 HPAI Virus for 1-km Buffer Zones Around Compartmentalised Industrial Poultry Farms in Thailand*
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B15	**Van Kerkhove M** (2009). *HPAI/H5N1 Transmission Risks: Pathways from Poultry to Humans*
B16	**Wiegers E, and J Curry** (2009). Understanding Smallholders' *Decisions towards Adopting HPAI Prevention and Control Measures*
B17	**Sproul T, Zilberman D, Roland-Holst D, and J Otte** (2009). *A Case for Multilateral Investment in Avian Flu Prevention*
B18	**Sproul T, Zilberman D, Ifft J, Roland-Holst D, and J Otte** (2009). *Economics of Avian Flu Policy*
B19	**Walker P, Cauchemez S, Metras R, Do D, Pfeiffer D, and A Ghani** (2009). *Modelling the Temporal and Spatial Dynamics of the Spread of HPAI H5N1 in Viet Nam*
B20	**Van Kerkhove M, Vong S, Holl D, San S, and A Ghani** (2009). *Poultry Movement Networks in Cambodia*
B21	**Heft-Neal S, Otte J, and D Roland-Holst** (2009). *Pro-Poor HPAI Risk Reduction for Small-holder Poultry Supply Chains in Cambodia*
B22	**Burgos S and J Otte** (2010). *Managing the Risk of Emerging Diseases: From Rhetoric to Action*
B23	**Ifft J, Anh Tuan ND, Loc ND, Otte J, and D Roland-Holst** (2010). *Safety Certified Free-Range Duck Supply Chains Enhance both Public Health and Livelihoods*
B24	**Ifft J, Anh Tuan ND, Loc ND, Otte J, and D Roland-Holst** (2010). *Poultry Demand in Ha Noi and Ho Chi Minh City*
B25	**Sriboonchitta S, Chaiwan A, Heft-Neal S, Otte J, and D Roland-Holst** (2010). *Promoting Rural Livelihoods and Public Health in Through Poultry Contracting: Evidence from Thailand*
B26	**Sriboonchitta S, Chaiwan A, Kahrl F, Heft-Neal S, Otte J, and D Roland-Holst** (2010). *Livestock Promotion for Market Oriented Rural Poverty Alleviation*
B27	**Behnke D, Otte J, and D Roland-Holst** (2010). *Micro Contracting and the Smallholder Poultry Supply Chain in Lao PDR*
B28	**Changanngakham P, Behnke D, Otte J, and D Roland-Holst** (2010). *Promoting Rural Livelihoods and Public Health Through Poultry Microfinance: Evidence from Lao PDR*
B29	**Behnke D, Otte J, and D Roland-Holst** (2010). *Assessment of Smallholder Indigenous Poultry Producer Viability After HPAI: Evidence from Lao PDR*

Available at: http:/www.hpai-research.net

5.2.5 Books

Nr.	Title
L1	**Zilberman D, Otte J, Pfeiffer D, and D Roland-Holst** (2011). *Human and Environmental Health and the Future of Animal Agriculture, Springer Verlag.*

5.2.6 Published conference abstracts, papers and posters

Nr.	Title
P1	**Soares-Magalhaes R, Wieland B, Otte J, Dung DH, and D Pfeiffer** (2007). *Simulation modelling of highly pathogenic avian influenza (HPAI) H5N1 poultry outbreaks in Viet Nam.* In: E. Camus, E. Cardinale, C. Dalibard, D. Martinez, J.F. Renard and F. Roger (eds) Proceedings of the 12th International Conference of the Association of Institutions of Tropical Veterinary Medicine (AITVM). Montpellier, France, August 20 -23, 2007. AITVM, Utrecht, The Netherlands. P 63-67.
P2	**Hinrichs J** (2008). *Poultry Sector Restructuring in Viet Nam – Managing the Economics for Change.* AI Symposium for Asian-Australian Association of Animal Production Societies (AAAP) Congress – 24 September 2008, Hanoi, Viet Nam
P3	**Otte J, Hinrichs J, Rushton J, Roland-Holst D, and D Zilberman** (2008). *The Economic Impact of HPAI – A Global Review.* AI Symposium for Asian-Australian Association of Animal Production Societies (AAAP) Congress – 24 September 2008, Hanoi, Viet Nam
P4	**McLeod A** (2009). *Economics of AI Management and Control in a World with Competing Agendas*. Seventh International Symposium on Avian Influenza - 9 April 2009, Athens, Georgia (USA)
P5	**Metras R, Soares Magalhaes RJ, Hoang Dinh Q, Fournié G, Gilbert J, Dung DH, Roland-Holst D, Otte J, and D Pfeiffer** (2009). *Pilot study for the implementation of a traceability scheme for smallholder poultry farms in Northern Viet Nam*. Poster presented at the SVEPM Meeting in London, UK, April 2009.
P6	**Fournie G, Metras R, Soares Magalhaes RJ, Hoang Dinh Q, Gilbert J, Dung DH, Roland-Holst D, Otte J, and D Pfeiffer** (2009). *Modelling the impact of vaccination on silent spread of HPAI H5N1 during the final stages of the small-holder production cycle in northern Viet Nam.* Abstract and presentation at the 12th International Symposium on Veterinary Epidemiology & Economics (ISVEE), 10-14 August 2009, Durban, South Africa.
P7	**Hinrichs J, Otte J, and J Rushton** (2009). *Epidemiological and economic implications of HPAI vaccination in developing countries*. Abstract and poster at the 12th International Symposium on Veterinary Epidemiology & Economics (ISVEE), 10-14 August 2009, Durban, South Africa.
P8	**Ifft J, Otte J, Roland-Holst D, and D Zilberman** (2009). *Poultry certification for pro-poor HPAI risk reduction*. Abstract and presentation at the 12th International Symposium on Veterinary Epidemiology & Economics (ISVEE), 10-14 August 2009, Durban, South Africa.
P9	**Ifft J, Otte J, Roland-Holst D, and D Zilberman** (2009). *Economic Decision Making of Smallholder Poultry Producers After Avian Influenza Outbreaks: Evidence from Viet Nam*. Abstract and presentation at the 12th International Symposium on Veterinary Epidemiology & Economics (ISVEE), 10-14 August 2009, Durban, South Africa.
P10	**Metras R, Soares Magalhaes RJ, Hoang Dinh Q, Fournie G, Gilbert J, Dung DH, Roland-Holst D, Otte J, and D Pfeiffer** (2009). *Feasibility study for tracing of smallholder poultry in Northern Viet Nam.* Abstract and presentation at the 12th International Symposium on Veterinary Epidemiology & Economics (ISVEE), 10-14 August 2009, Durban, South Africa.

Nr.	Title
P11	**Otte J, Roland-Holst D, Zilberman D, and D Pfeiffer** (2009). *Pro-poor HPAI risk management in the greater Mekong region.* Abstract and presentation at the 12th International Symposium on Veterinary Epidemiology & Economics (ISVEE), 10-14 August 2009, Durban, South Africa
P12	**Ifft J, Roland-Holst D, and D Zilberman** (2009). *Valuation of Safety-Branded and Traceable Free Range Chicken in Ha Noi: Results from a Field Experiment.* Selected Presentation and Paper at the Annual Meeting of the American Agricultural Economics Association, Milwaukee, July 26-28, 2009.
P13	**Fournié G, Guitian FJ, Mangtani P, and AC Ghani** (2009). *Impact of the implementation of rest days in live bird markets on the dynamics of H5N1 highly pathogenic avian influenza: a modelling approach*. In: Newton, J.R., Pfeiffer, D.U. (Eds.), Proceedings of Annual Meeting held at London, UK, 1st - 3rd April, 2009. Society of Veterinary Epidemiology and Preventive Medicine, pp196-206.
P14	**Prakarnkamananta A, Mastin A, Kasemsuwan S, Patanasatienkulb T, Chanachai K, Wongsathapornchaic K, Otte J, and D Pfeiffer (2010).** *Risk of introduction of H5N1 HPAI via cock fighting activities*. Poster presented at the Emerging Infectious Disease Conference held in Chonburi, Thailand on June 3-4, 2010.

5.2.7 Publications in peer reviewed journals

Nr.	Title
J1	**Burgos S, Hong Hahn PT, Roland-Holst D, and SA Burgos** (2007). *Characterization of Poultry Production Systems in Vietnam*. Int. J. Poultry Sci., 6(10), 709-712
J2	**Pfeiffer DU, Minh PQ, Martin V, Epprecht M, and MJ Otte** (2007). *An analysis of the spatial and temporal patterns of highly pathogenic avian influenza occurrence in Vietnam using national surveillance data*. Veterinary Journal 174 (2): 302-309; doi:10.1016/j.tvjl.2007.05.010.
J3	**Pfeiffer DU** (2007). *Assessment of H5N1 risk and the importance of wild birds*. Journal of Wildlife Diseases, 43(3), S47-S50.
J4	**Otte J. Hinrichs J, Rushton J, Roland-Holst D, and D. Zilberman** (2008). *Impacts of avian influenza virus on animal production in developing countries*. CAB Review: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources, 3, No 080
J5	**Leibler JH, Otte J, Roland-Holst D, Pfeiffer DU, Soares-Magalhaes R, Rushton J, Graham JP, and EK Silbergeld** (2009). *Industrial Food Animal Production and Global Health Risks: Exploring the Ecosystems and Economics of Avian Influenza*. EcoHealth, 6(1):58-70**.**
J6	**Ifft J, Roland-Holst D, and D Zilberman** (2009). *Impact of Quality Characteristics on Demand for Chicken in Viet Nam.* ARE Update, Vol. 12, No. 4, Mar/Apr, 2009.
J7	**Ear S and Burgos Caceres S** (2009). *Livelihoods and Highly Pathogenic Avian Influenza in Cambodia*. World's Poultry Science Journal, 65, 633-639
J8	**Burgos Caceres S and J Otte** (2009). *Blame apportioning and the Emergence of Zoonoses over the Last 25 Years*. Transboundary and Emerging Diseases, 56, 375-379
J9	**Walker PT, Cauchemez S, Metras R, Dung DH, Pfeiffer D, and A Ghani** (2010). *A Bayesian Approach to Quantifying the Effects of Mass Poultry Vaccination upon the Spatial and Temporal Dynamics of H5N1 in Northern Vietnam*. PLoS Computational Biology, 9pp; doi:10.1371/journal.pcbi.1000683.
J10	**Soares-Magalhaes R, Ortiz-Pelaez A, Kim Lan LT, Dinh Quoc H, Otte J, and D Pfeiffer** (2010). *Associations between attributes of live poultry trade and HPAI H5N1 outbreaks: A descriptive and network analysis study in northern Viet Nam*. BMC Veterinary Research, 6, 10; doi: 10.1186/1746-6148-6-10.

Nr.	Title
J11	**Hinrichs J, Otte, J, and J Rushton** (2010). *Technical, Epidemiological and Financial Implications of Large-scale National Vaccination Campaigns to Control HPAI H5N1*. CAB Review: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources, 5, No 021
J12	**Soares Magalhaes RJ, Pfeiffer DU, and J Otte** (2010). *Evaluating the control of HPAIV H5N1 in Vietnam: virus transmission within infected flocks reported before and after vaccination*. *BMC Veterinary Research,* 6(1), 31; doi: 10.1186/1746-6148-6-31.
J13	**Ifft J, Roland-Holst D, and D Zilberman** (accepted)**.** *Production and Risk Prevention Responses of Free Range Chicken Producers in Viet Nam.* American Journal of Agric Economics
J14	**Van Kerkhove MD, Mounts AW, Mumford E, Bresee J, Ly S, Bridges C, and J Otte** (accepted). *Highly Pathogenic Avian Influenza (H5N1): Pathways of Exposure at the Animal:Human Interface*. PLoSONE
J15	**Metras R, Soares-Magalhaes R, Hoang Dinh Q, Fournie G, Gilbert J, Dung DH, Roland-Holst D, Otte J, and D Pfeiffer** (submitted). *A poultry tracing scheme for smallholders Viet Nam: results of a feasibility study*. Rev. Sci. Tech. Status?
J16	**Pfeiffer D, Otte J, Roland-Holst D, Inui K, N. Tung, and D Zilberman** (submitted). *Implications of global and regional patterns of HPAI H5N1 virus clades for risk management.* Journal; status?
J17	**Soares-Magalhaes S, Otte J, and D Pfeiffer** (in prep). *Exploring biosecurity responses to highly pathogenic avian influenza H5N1 in smallholder poultry farms in Viet Nam*.
J18	**Ifft J, Roland-Holst D, and D Zilberman** (in prep). *A Field Experiment to Value the Safety Labelled Free Range Chicken in Ha Noi*. To be submitted to Journal of Development Economics
J19	**Sproul T and D Zilberman** (in prep). *Accidents Happen: The Economics of Stochastic Externalities*. Journal of Political Economy
J20	**Sproul T and D Zilberman** (in prep). *The Economics of Livestock Disease: A Survey*. Invited paper for the International Journal of Environmental Economics, 2010.
J21	**Ifft J, Roland-Holst D, and D Zilberman** (in prep). *Valuing Characteristics of Duck Certification: A Field Experiment in Ho Chi Minh City*.

5.2.8 Publications co-authored by project core team members

Nr.	Title
C1	Graham JP, Leibler JH, Price LB, **Otte J, Pfeiffer DU,** Tiensin Y, and E Silbergeld (2008). *The animal-human interface and infectious disease in industrial food animal production: Rethinking biosecurity and biocontainment*. Public Health Reports 123(3), 282-299.
C2	Gilbert M, Xiao X, **Pfeiffer DU,** Epprecht M, Boles S, Czarnecki C, Chaitaweesub P, Kalpravidh W, Minh PQ, **Otte J,** Martin V, and J Slingenbergh (2008). *Mapping H5N1 highly pathogenic avian influenza risk in Southeast Asia*. Proc. Natl. Acad. Sci. USA 105, 4769-4774; doi:10.1073/pnas.0710581105.
C3	Henning J, **Pfeiffer DU,** and le T Vu (2009). *Risk factors and characteristics of H5N1 highly pathogenic avian influenza (HPAI) post-vaccination outbreaks*. Veterinary Research 40(3), 15.
C4	Clements AC and **DU Pfeiffer** (2009). *Emerging viral zoonoses: Frameworks for spatial and spatiotemporal risk assessment and resource planning*. Veterinary Journal 182(1), 21-30.

5.3 *Project meetings and workshops*

5.3.1 'Internal' workshops / meetings

Nr	Date	Meeting / Workshop Title	Venue
IM1	23-25 Apr 2008	Political Economy of HPAI in SE Asia – Methodology Workshop	Brighton, UK
IM2	28-30 Apr 2008	Workshop of the Thai National Risk Assessment Team under Guidance of RVC	Bangkok, Thailand
IM3	12-13 June 2008	Expert Opinion Elicitation Workshop for the Thai National Risk Assessment Team (Participation of RVC)	Bangkok, Thailand
IM4	19 June 2008	Workshop of the Thai National Risk Assessment at the DLD (Participation of RVC and FAO)	Bangkok, Thailand
IM5	23-24 June 2008	Expert Opinion Elicitation Workshop for Thai National Risk Assessment Team (Participation of RVC)	Chon Buri, Thailand
IM6	1-2 July 2008	Expert Opinion Elicitation Workshop of the Thai National Risk Assessment (Participation of RVC)	Lopburi, Thailand
IM7	22-23 July 2008	Expert Opinion Elicitation Workshop of the Thai National Risk Assessment Team (Participation of RVC)	Bangkok, Thailand
IM8	25 July 2008	Coordination of Modelling Activities across Project Work-Streams (RVC)	London, UK
IM9	5-9 Aug 2008	Workshop of Thai National Risk Assessment Team under Guidance of RVC for Writing-up of the Qualitative RA	Bangkok, Thailand
IM10	4 Sept 2008	Coordination Meeting of Epidemiological and Economic Modelling Work-Streams within GMS Project	London, UK
IM11	29-30 Oct 2008	Workshop of Vietnamese National Risk Assessment Team under Guidance of RVC	Ha Noi, Viet Nam
IM12	26-27 Jan 2009	Workshop of Thai National Risk Assessment Team to define Risk Question for Quantitative RA under Guidance of RVC	Bangkok, Thailand
IM13	27 May 2009	Workshop of Thai Stakeholders to define the Risk Pathways for the Quantitative HPAI Risk Assessment (Participation of RVC)	Bangkok, Thailand
IM14	18 Aug 2009	Workshop of Thai Stakeholders to Review Findings of the Quantitative HPAI Risk Assessment (Participation of RVC)	Bangkok, Thailand
IM15	30 Sept 2009	Workshop of the Viet Nam Qualitative Risk Assessment Team (Participation of RVC)	Ha Noi, Viet Nam
IM16		A. Mastin in Ha Noi TBA	Ha Noi, Viet Nam

5.3.2 'Open' workshops / meetings

Nr	Date	Meeting / Workshop Title	Venue
OM1	12-13 Dec 2007	Inception Workshop on Pro-Poor Policy Options for Control of Highly Pathogenic Avian Influenza (HPAI) in Africa and Southeast Asia[1]	Chiang Mai, Thailand

Nr	Date	Meeting / Workshop Title	Venue
OM2	21-22 Jan 2008	International Meeting on Research Activities on Avian Influenza and Other Transboundary Animal Diseases in South-East Asia[1]	Bangkok, Thailand
OM3	18 June 2008	HPAI and Livelihoods Session of the International Avian Influenza Research Workshop co-organized by DAH (Viet Nam), FAO, and USDA (Plus six plenary presentations)	Hanoi, Viet Nam
OM4	8-10 Oct 2008	International workshop on Avian Influenza H5N1 Research in Cambodia[1]	Sihanoukville, Cambodia
OM5	26-27 Feb 2009	One World, One Health – From Principles to Action; workshop co-hosted by the STEPS Centre and Chatham House	Brighton, UK
OM6	16-17 Apr 2009	Workshop on: Avian Influenza, Public Health and Smallholders: Economic, Epidemiological, and Veterinary Modelling of Alternative Solutions (I) [1] – Organized by UCB	Berkeley, USA
OM7	8-10 Jan 2010	Workshop on: Avian Influenza, Public Health and Smallholders: Economic, Epidemiological, and Veterinary Modelling of Alternative Solutions (II) [1]	Chiang Mai, Thailand
OM8	25-27 Oct 2010		Phuket, Thailand

Agenda, Participants and Proceedings available at: http:/www.hpai-research.net