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HPAI PRO-POOR HPAI RISK REDUCTION

Surveillance and Control of Highly Pathogenic Avian Influenza (HPAI) in Ghana – An assessment of institutions and actors

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Preface

Since its re-emergence, HPAI H5N1 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 greatest impact to date has been on the highly diverse poultry industries in affected countries. In response to this, 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, significantly less emphasis has been placed on assessing the efficacy of risk reduction measures, including 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 impacts, the UK Department for International Development (DFID) has agreed to fund a collaborative, multidisciplinary HPAI research project for Southeast Asia and Africa.

The specific purpose of the project is to aid decision makers in developing evidence-based, pro-poor HPAI control measures at national and international levels. These control measures should not only be cost-effective and efficient in reducing disease risk, but 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.

http://www.hpai-research.net/index.html.

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Disclaimer

More information

For more information about the project please refer to www.hpai-research.net.

Summary

How does information about a suspected outbreak of avian influenza on the farm level reach the respective authorities? How and through which actors is the response to a confirmed outbreak implemented on the ground? These were the guiding questions for representatives of the Ministry of Food and Agriculture, poultry producers and traders and the research sector, to map out the information and response networks concerning Highly Pathogenic Avian Influenza in Ghana. This report shows the resulting network maps drawn, indicating the actors involved, their different kinds of linkages and the influence that these actors have on making sure that the information about suspected outbreaks on the farm or market level reaches the national authorities and that appropriate and timely response is implemented. While the participants agreed that in the past experience (outbreaks of HPAI on three commercial farms), government agencies and their partners showed an impressive ability to do the right thing at the right time, they also pointed out some bottlenecks that would need further attention – either because there is still a knowledge need that calls for more research or because structures and procedures need to be improved:

- Lack of incentives for traders to report suspicious bird deaths, because there is no compensation scheme for traders. Thus traders are likely to sell sick birds off and contribute to the spreading of the disease.
- Reluctance of farmers to disclose their sources of birds, which makes it difficult to track down where the infection originated / entered the country.
- Double edged role of the media, being both the motor of the bird flu scare (and resulting collapse of poultry market) and the distributor of valuable information. Government representatives agreed on the need to deal more proactively and in partnership with the media.
- Crucial role but low coverage (1 per 5000 farms) of animal health technicians linking rural farms to the rest of the agricultural system, when if comes to disease reporting. Can the coverage be increased or can other district level actors be empowered and trained to support them?
- Compensation procedures and rules were not clear to everyone. Especially informing farmers who are not members of associations remains a challenge.
- Knowledge gap: What is the impact of different length of re-stocking ban and different timing for compensation payment? Early payment lifts immediate stress but might be used for consumption or alternative livelihood activities, if the re-stocking ban is still in place. Compensation payment after the end of re-stocking ban might make it easier for farmers to use money on poultry farming, but how do they meet their immediate survival needs in the meantime?
- So far, experience only with outbreaks on big commercial farms in the South of Ghana. The future may show how the system can react to outbreaks in more remote areas and less commercialised settings.

1. Objective

The objective of this research was to identify the institutions and their relative influence associated with surveillance and control of HPAI in Ghana, the flow of information for disease reporting among institutions, and the institutional responses to disease occurrence. The questions were: Who is involved? How do they communicate about suspected outbreaks? How do they respond to confirmed outbreaks? How influential are they in terms of impacting on information flow and response? What are the remaining bottlenecks?

2. Methods

This report presents Net-Maps drawn by a group of HPAI stakeholders from governmental agencies, farmer and trader organisations and the research sector (see Appendix for complete list) during a multi-stakeholder workshop of the "Pro-Poor HPAI Risk Reduction Strategies Project" in Ghana.

The Net-Map method aims at making implicit knowledge about networks explicit and allowing members of a group to share their knowledge and opinions. Participants gathered the names of actors involved in HPAI communication and defence and mapped, on paper, the flow of information about suspected outbreaks, and the responses to HPAI. In addition, participants identified influential institutions and constrains in relation to the flow of information and responses to the disease. More information on the Net-Map method and its use is available at: http://netmap.wordpress.com/ and see Schiffer and Waale 2008.

3. Results

3.1 The Actors

The participants of the workshop were asked to identify the actors involved in disease reporting and response. These actors could include individuals, groups and institutions. The actors involved in H5N1 surveillance and control in Ghana include (for detailed list see Appendix):

Different kinds of facilities where chicken and eggs are produced:

Peri-Urban Big Farmers (large scale intensive)
Urban Small Farmer (no or low husbandry practice)
Rural Small Farmer (no husbandry practices)

Different levels and units of the Ministry of Agriculture:

National level directors, the minister and laboratories
Regional level directors, laboratories and veterinary officers
District level directors, veterinary officers, extension officers, animal heath technicians, and Veterinary officer at the border posts

Other governmental agencies:

President of Ghana
Ministries and line agencies responsible for environmental protection, communication, health, trade, interior, wildlife and customs/immigration
The police
The poultry board
Decentralized administrative bodies such as the regional coordinating councils and district assemblies and
Research stations

Governmental agencies in neighboring countries:

The veterinary officers at the border posts and the directors of agriculture of neighboring countries

Local level groups and individuals:

Actors involved in agricultural matters such as community livestock workers and
Respectable community members such as assembly members, teachers, chiefs and other opinion leaders.

Private sector actors (apart from farmers)

Input traders
Output traders
Trade associations
Poultry transporters
Private sector veterinarians and
Ghana Telecom

International organizations

Organizations financing training and interventions
Testing samples and coordinating the international aspect of the intervention

Media

3.2. Disease Reporting Network

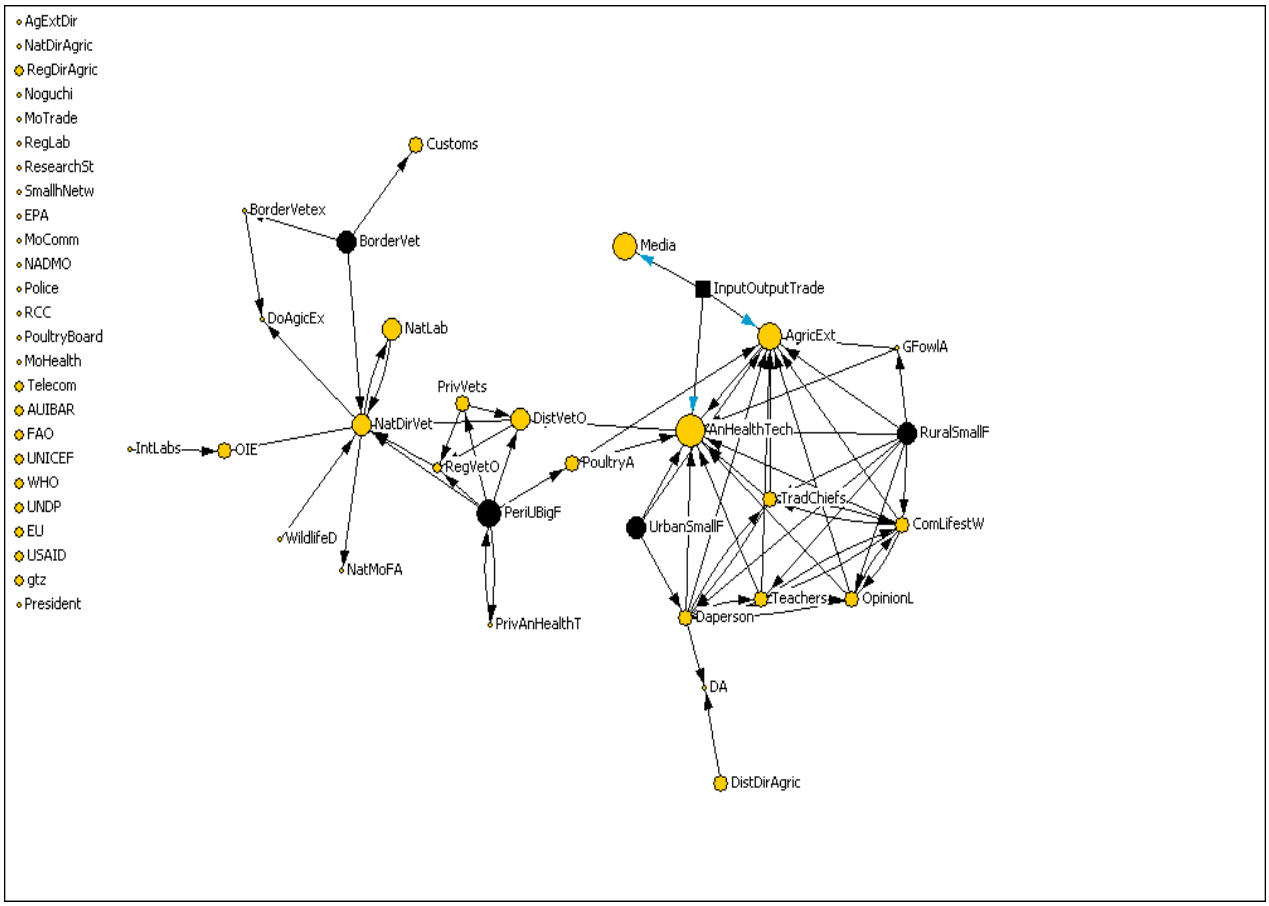
After identifying a list of 65 actors, the next question the participants answered was:

"In case of a suspected outbreak of HPAI, how is the information about the outbreak communicated upward for official confirmation by the respective authorities?"

The flow of information was drawn for outbreaks on the different levels of farms, at the border posts or in the trade system. As Ghana has experienced HPAI outbreaks in the past (on 3 commercial farms) and the participants were involved in the activities around this outbreak, the links drawn are intended to depict the actual situation following a suspected outbreak. However, strictly speaking, the links concerning outbreaks on backyard farms, border posts and the markets are extrapolations from the experience on commercial farms. Further the group was asked:

"How strongly can these actors influence that the information actually reaches the respective authorities?"

The result is shown in Map 1. The size of the nodes indicates the influence that actors have on the flow of information about outbreaks (in the perception of the participants). For easier visual structuring of the data, those places where the information *originates from* (source of outbreak) have been indicated by using dark dots. While listing a diverse group of trade actors, the group members basically treated the input and output trade system as a rather homogeneous actor group with the same levels of influence and the same kind of links to the rest of the system. Thus, to simplify the picture, the input and output trade system has been collapsed into one group actor (square node).



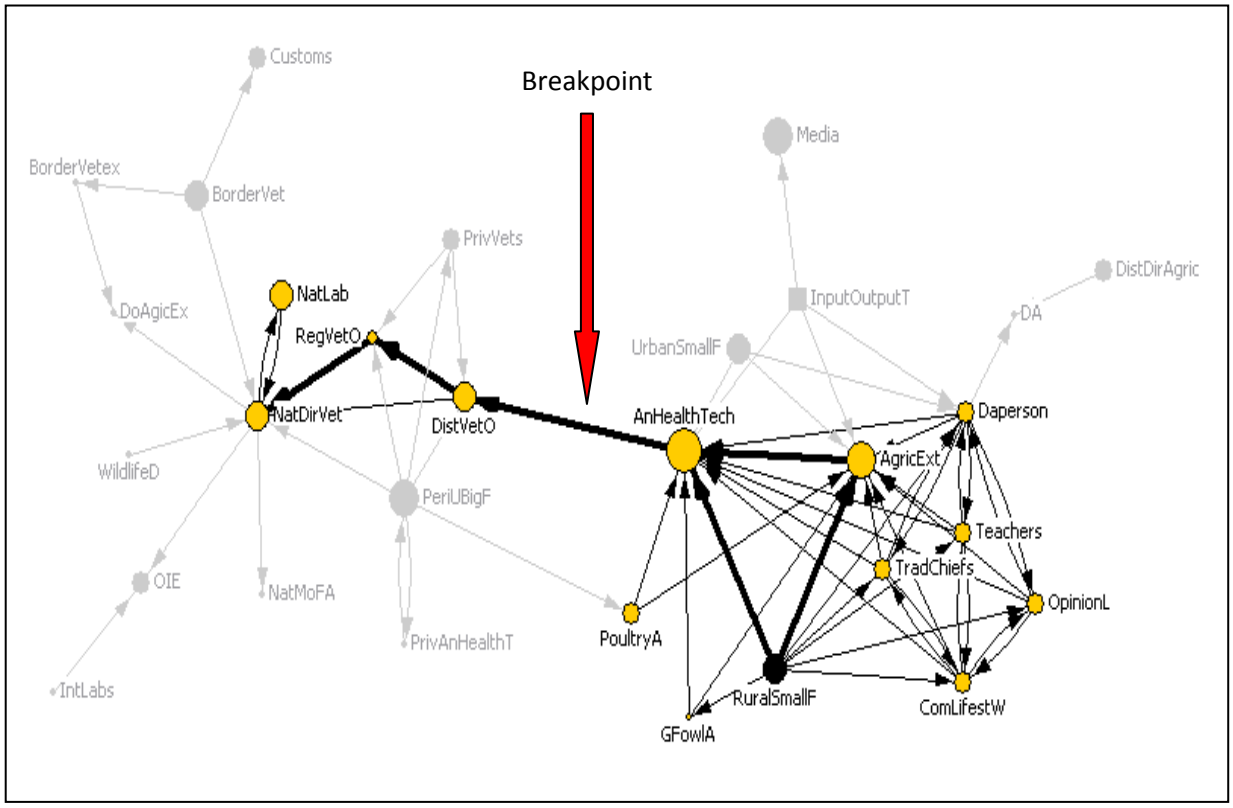
Map 1: Flow of information about outbreak

size of node = influence of actor on effective flow of information
black node = source of outbreak

To allow for a speedy and effective response, the information about a suspected case needs to reach the National Veterinary Services, which communicate with the national and international laboratories and the Minister of Food and Agriculture to initiate the appropriate action. One striking characteristic of the network drawn by the participants is the potential *break point* of

the communication flows between the Animal Health Technician and the District Veterinary Officer. While both, Animal Health Technicians and Agric Extension Agents are important collectors of risk information on the local level, the only link that transmits this information from the frontline staff to the higher levels, comes from the Animal Health Technician to the district officer.

The district officer will report directly by the fastest means with cc's to other people who need to be informed. Note that the agricultural extension agents cover operational area, while the animal health technicians cover zonal areas[1], concentrating in areas with the larger density of animals. Here, it is important to note that the coverage of Animal Health Technicians, who specialize, per farmer was described as relatively low with 1 per 5000 farm households, while the agricultural extension officers tend to be cross purpose specialists covering corps and livestock and described as being 1 per 1,500 households.



Map 2: Flow of information from small rural farm to National Director of Veterinary services (bold lines indicate major information flow), note potential breakpoint of information flow between Animal Health Technician and District Veterinary Officer

[1] The extension system of the Ministry of Food and Agriculture follows a decentralized approach, with oversight of extension located on the district level, which is sub-divided in zones (that have zonal supervisors) and these zones are in turn subdivided in operational areas of different agricultural extension workers.

In areas where there are no animal health technicians, individuals report to the agricultural extension officers. As in other countries in the sample, the pathways for small farmers (both urban and rural) and big commercial farmers differ from each other, as the commercial farmers have direct access to the regional and national level actors, while small farmers have to go through their district level intermediaries[2] The group described a high level of exchange of information on the local level, with different agricultural and non-agricultural actors being involved. However, the information about suspected outbreaks only moves up to the next level, if any of these actors contacts the animal health technician. It should also be noted that if there was a suspicious case found at the live bird market or the wet market people were likely to report to the media first to get recognition before the veterinarians. Once the information gets reported to the MOFA it moves to what is called a suspicious case for confirmation and an action plan is developed.

Note that a number of actors who are crucial in the response network (see below) are not or only marginally involved in the network of disease reporting.

One quantitative measure of the position of actors in the network is closeness centrality. Closeness centrality describes how many steps one actor has to take to reach everybody else in the network. A low closeness value indicates that an actor is not very close to the other actors in the network, thus has to go through many intermediaries to reach everyone (see table 2 in the Appendix). In the information network, the animal health technician is the actor who can reach everyone else in the network on the shortest path, which underlines the crucial importance of this actor. This is further underlined by the high influence scoring that participants assigned to the animal health technician.

Bottlenecks in disease reporting

The participants pointed out a number of bottlenecks that might delay the reporting of a suspected outbreak.

Trade system: Lack of incentives to report

While the general assessment was that farmers had strong incentives to report, because of the compensation for culled birds (but not for those died of the disease), the trade system has a different incentive structure. The participants explained that especially a cross border trader with infected birds would have strong incentives to hide the disease from the border veterinary officers or to try to bribe the customs and immigration officer, as there is no compensation plan for traders and thus it is economically tempting to avoid control and sell sick birds off – thus spreading the disease. In case an outbreak is reported at a border post, the information flows both through formal channels (from border veterinary officer in Ghana, through national director of veterinary services in Ghana, national director in neighbouring country, to border veterinary officer in the neighbouring country) and informal channels (directly between the

[2] The municipal assemblies (urban equivalent of district assemblies) do not feature as individual actors on the map. Big farmers have direct access to regional or national level which means the information can flow faster, through less intermediaries, while small farmers have to go through their district level actors, who then move the information up through regional and to national level, likely to loose time in the process.

veterinary officers on both sides of the border). While participants saw some potential challenges concerning the reporting by traders, however, especially in the peak of the scare period, in Ghana the input-output trade system also acted as an informal early warning system, providing information about observed suspicious deaths of birds to the respective authorities and to the media. A closer and more pro-active interaction between the trade system and the Ministry of Food and Agriculture, might enable a systematic use of the information that traders gather as a by-product of their activities.

Positive and negative role of the media

Participants saw the role of the media critically. Ghana has a vibrant and free system of public and private media. During the peak of the bird flu scare especially private radio stations were seen as unnecessarily nurturing panic and thus contributing to the collapse of the market for poultry products. However, participants also related that a meeting between government officials and media representatives was a successful step towards facilitating more realistic reporting and that as the situation moved on the media was a strong partner in distributing valuable information. For future cases, participants recommended a strong pro-active partnership with the media from the start, to make sure that it can fulfil a positive role in crisis management.

3.3. Response Network

After drawing the information network, participants outlined the ways response to an actual outbreak of HPAI involves different actors in the network. They were asked:

"If the outbreak of HPAI is confirmed, how are different actors involved in the response to the outbreak?

The response pathway is similar for small scale and big scale farmers, with the difference that the national and regional level veterinary officers get involved in response at the commercial farm level while the district level veterinary officer takes over the same role on the small farm level. However, in both cases, the animal health technicians, who were crucial in the information network, seem to have a less defined role in the response.

After drawing the networks, participants were asked to assess:

"Once the outbreak is confirmed, how strongly can these actors influence that the appropriate response is implemented successfully?"

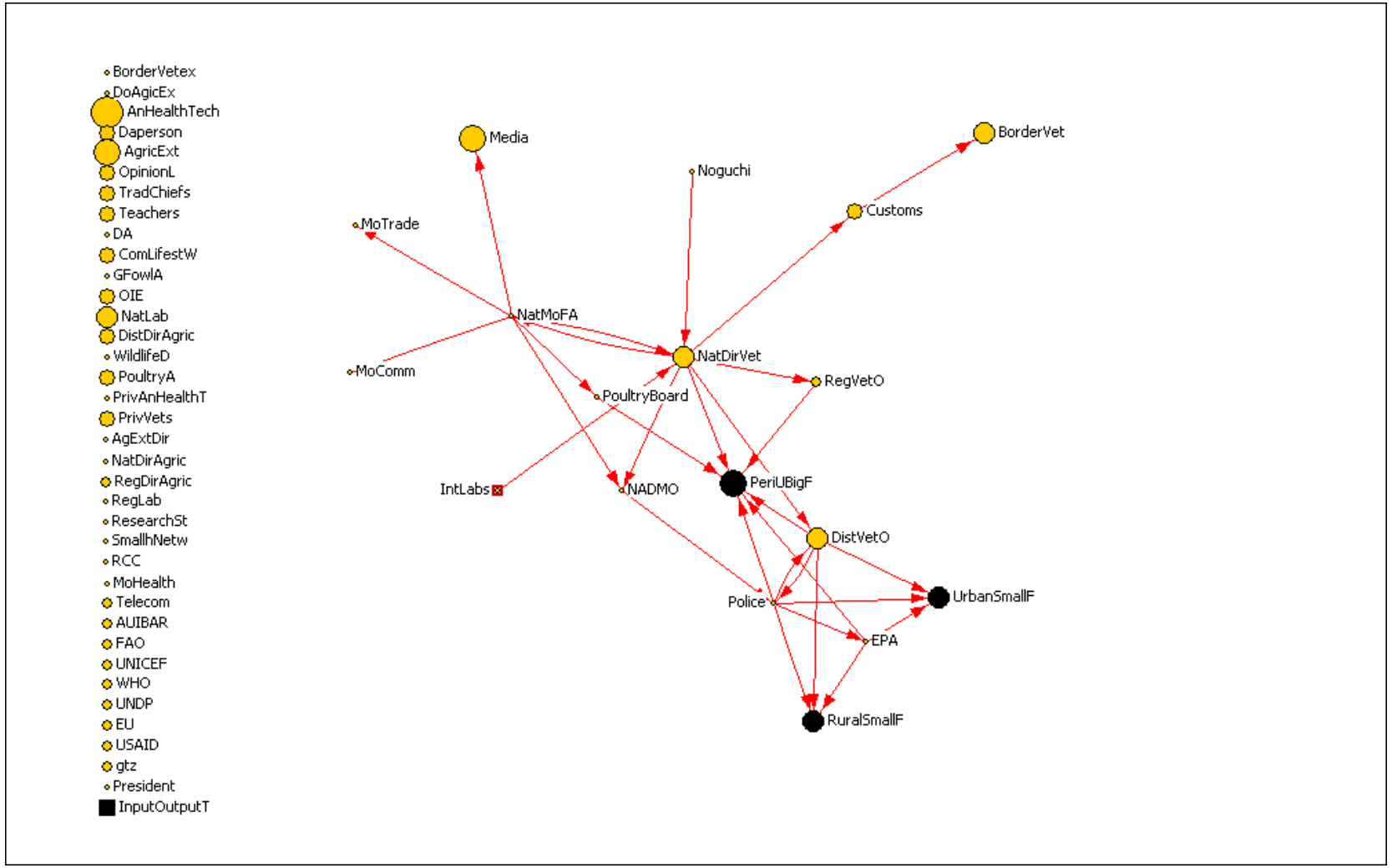
Once the suspected case is confirmed, the response takes the following steps: The director of veterinary services informs the Minister of Food and Agriculture so that the Minister can evoke the animal disease act. In an informal memo he informs all members of the National Committee on Avian Flu Preparedness about the crisis. The committee consists of:

Director of veterinary services
Director of agricultural extension
Immigration services
Noguchi Institute at the University of Ghana, Legon
Ministry of the Interior

National Disaster Management Organization
Ministry of Health
Wildlife Division of the Forestry Commission
FAO
WHO
UNICEF
GTZ
USAID and
EU

After sending out this memo, the Minister of Food and Agriculture talks to the ministries of communication, trade, interior and media. Then they hold a press conference to inform the public about the situation and set the response in motion. The first activity in the field is to quarantine the infected area. The implementation on the ground is done by the police, veterinary services, the environmental protection agency and the National Disaster Management Organization (NADMO) which is housed in the Ministry of Interior and has members across Ministries (Interior, Finance, Health, Welfare, Information, Local Government and Rural Development, Defense, Environment, Science and Technology, Transport and Communications, Planning Commission, Fire Officer). Together these agencies organize and enforce, if necessary, the destruction of the birds in affected areas.

Immigration services are informed about the crises and take action at the border in terms of increasing monitoring. Ghana Telecom supported the response by providing cell-phones and free HPAI hotlines. Other actors who were seen as highly supportive while not directly involved in the enforcement and implementation on the ground were international organizations, who provided funds and training to prepare Ghana to react effectively and efficiently to a HPAI crisis. Farmers were compensated for the birds culled following a compensation plan modeled on the one developed in Nigeria.



Map 3: Response to actual outbreak; size of node = influence on effective response; black node = source of outbreak

In terms of degree centrality (number of direct links per actor), the different farm types and the national director of veterinary services range especially high in terms of in-degree (incoming links). The other actors involved in the response receive one or two incoming links, pointing towards a rather clear line organisation of the response. Many of these links originate either from the Minister of Food and Agriculture (initiating the response) or from the national director of veterinary services (coordinating the response), who range highest in terms of out-degree (see Appendix, table 3 and 4). This means: In the response network, there are few actors coordinating activities (Minister and National Director, high out-degree), thus the others involved get their directives from few source (low in-degree), to enable them to coordinated and concerted action on the farm level (high in-degree). This clear division of responsibilities and centralized coordination might be one of the reasons why the Ghanaian authorities were able to react in a concerted and timely manner.

As the national director of veterinary services and the Minister of Food and Agriculture are central in directly initiating and implementing the response, they establish close links to all different areas of the network, which is reflected in their high closeness centrality. While the peri-urban big farmers range high in terms of closeness centrality as well, the rural and urban small farmers seem to be more removed from some actors in the network. This might be due to the fact that the response for commercial farms comes directly from the national or regional level, while the response for small farms comes from the national level, going though regional and district level actors until it reaches the local farm level. However, the group participants seemed confident that outbreaks both on small and big farms would be reported in a timely manner. So far the experience in Ghana is limited to outbreaks on commercial farms.

Bottlenecks in the response network

The participants mentioned a number of bottlenecks that challenged the ability of the system to ensure a rapid and effective response.

Information about compensation not clear to everyone

Participants criticised that the information about compensation and other procedural issues was not clearly delivered to all those concerned. Members of producer organisations had a higher chance of being targeted by agricultural frontline staff, but even in the discussion group, participants disagreed about the question whether or not compensation would be paid for birds that died from the disease (instead of only compensating for culled birds). One participant proposed that this conception might be due to the fact that in the real case, some officials of the Ministry of Food and Agriculture "took pity in the farmer and counted all dead birds for compensation."

Market shocks and distortion

While the outbreaks and the resulting scare led to a serious shock on the market, some participants observed that traders used the situation strategically to bargain for lower prices with small farmers who had incomplete price information. Some producers also had to find a different place to market their eggs as markets were closed.

Time lapse in compensation payment: Positive or negative?

In terms of compensation payment, participants had different opinions about the effects of a time lapse in payment, which occurred in the past, on the farmers. On the one hand, timely payment would enable the farmer to meet his or her immediate needs after having lost an important source of livelihood. On the other hand, farmers who received payment before the end of the ban on re-stocking, were very unlikely to invest this money in poultry

again and would rather either use it for consumption or invest in alternative livelihoods. Thus they were not able to restock when the ban was lifted.

Extended ban on re-stocking

The re-stocking issue was made more severe by the fact that the government of Ghana decided to impose a ban of 3 months instead of the internationally recommended 20 days.

Disincentives for reporting

Two hazards to an effective eradication of the disease at the source are the reluctance of traders (especially cross border) to report outbreaks as discussed above and the reluctance of farmers with an outbreak on their farm to disclose their sources of life birds.

Weak District Assemblies

The District Assemblies were seen in need of information and empowerment to be able to take more responsibility instead of always having to rely on action from the national level.

Challenging logistics of culling

In terms of logistics, the actual destruction and disposal of tens of thousands of birds with limited technical infrastructure and in tropical climate proved put a great strain on the extension agents involved and participants criticised that no additional funds/compensation was made available for the workers involved in the task. Participants criticised that there was not a well thought out plan for destruction and disposal of animals.

Appendix:

Table 1: Participants in working group

	Name	Designation/Organization
1.	Dr. Enoch Boye-Mensah Koney	Director, Veterinary Services Department, Ministry of Food and Agriculture
2.	Dr. Ebenezer Nortey Barnor	SPINAP-AHI Country Coordinator, Deputy Director, Veterinary Services Dept.
3.	Mr. John S. Torto	Chairman, Ghana National Poultry Farmers Association, Oyarifa Livestock Farmers Association
4.	Dr. George Addo Opoku-Pare	Head, Veterinary Laboratory Veterinary Services Directorate P.O. Box M 161, Accra, Ghana
5.	Dr. Joseph Awuni	Veterinary Laboratory Veterinary Services Directorate P.O. Box M 161, Accra, Ghana
6.	Dr. Francis Kwabena Peterson	Deputy Director, Veterinary Services Regional Veterinary Officer-Greater Accra Region Ministry of Food and Agriculture P.O. Box M 199, Accra, Ghana
7.	Mr. Justin Hehesy Ankah	Ag. Director, Animal Production Directorate Ministry of Food and Agriculture P.O. Box AN 5779 Accra-North, Ghana
8.	Dr. Naaminong Karbo	Animal Scientist/Director, ARI CSIR-Animal Research Institute P.O. Box AH 20, Achimota, Ghana
9.	Mr. John S. Torto	(Ghana National Poultry Farmers Association) Chairman, Oyarifa Livestock Farmers Association Ankonam Farm, Oyarifa, Accra, Ghana
10.	Dr. William Kwabena Ampofo	National AI Working Group Senior Research Fellow, Virology Department Noguchi Memorial Institute for Medical Research University of Ghana, P.O. Box LG 581 Legon, Accra, Ghana
11.	Dr. Paa-Kobina Turkson	Epidemiologist, Animal Science Department, University of Cape Coast
12.	Dr. Paulo Duarte	Epidemiologist, International Livestock Research Institute (ILRI)
13.	Dr. Clare Narrod	Senior Research Fellow, International Food Policy Research Institute (IFPRI)

List of Actors in the information and response network

Facilities where chicken and eggs are **produced**:
- Peri-Urban Big Farmers (large scale intensive)
- Urban Small Farmer
- Rural Small Farmer (no husbandry practices)

Different levels and units of the **Ministry of Agriculture:**
- National Ministry of Food and Agriculture / Minister of Food and Agriculture
- National Director of Agricultural Extension Services
- National Director of Veterinary Services
- Other National Directors of Agriculture
- National Diagnostic Laboratory
- Regional Director of Agriculture
- Regional Diagnostic Laboratories
- Regional Veterinary Officer
- Agricultural Extension Workers
- District Director of Agriculture
- Animal Health Technicians (district level)
- Veterinary Officer at the Border Post
- District Veterinary Officer

Other governmental agencies:
- President of Ghana
- Environmental Protection Agency (EPA)
- Customs/Immigration 0fficer (Customs)
- District Assembly
- Ministry of Communication
- Ministry of Health
- Ministry of Trade
- Ministry of Interior (National Disaster Management Organization)
- Noguchi Institute (University of Ghana, Legon)
- Police
- Poultry Board
- Regional Coordinating Council
- Research Stations
- Wildlife Division of the Forestry Commission

Governmental agencies in neighboring countries:
- Veterinary Officer at the Border Post of a Neighboring Country
- Director of Agriculture of a Neighboring Country

Local level groups and individuals
- Community Livestock Worker
- District Assembly Person
- Opinion Leaders on Community Level
- Teachers
- Traditional Chiefs

Private sector actors (apart from farmers)
- Day-Old Chicken Providers
- Egg Sellers Association
- Mobile Egg Traders
- Sedentary Egg Traders
- Importers of Life Poultry
- Mobile Life Bird Traders
- Stationary Life Bird Traders
- Poultry Transporters
- Veterinary Medicine Suppliers
- Feed Suppliers
- Private Animal Health Technicians
- Private Sector Veterinarians
- Ghana Telecom

International Organisations
- African Union Inter-African Bureau for Animal Resources (AUIBAR)
- European Union
- Food and Agricultural Organization
- Gesellschaft fuer Technische Zusammenarbeit
- International confirmation Laboratories
- World Organization for Animal Health
- United Nations Development Programme
- United Nations Children's Fund
- United States Agency for International Development
- World Health Organization

Producer and Trader Associations:
- Guinea Fowl Association
- Poultry Association
- Smallholder Network
- Wet Market Association

And the Media

Actor codes:

AgExtDir	Director of Agricultural Extension Services
AgricExt	Agricultural Extension Workers
AnHealthTech	Animal Health Technicians (district level)
AUIBAR	African Union Inter-African Bureau for Animal Resources
BorderVet	Veterinary Officer at the Border Post
BorderVetex	Veterinary Officer at the Border Post of a Neighboring Country
ComLifestW	Community Livestock Worker
Customs	Customs/immigration 0fficer
DA	District Assembly
Daperson	District Assembly Person
DistDirAgric	District Director of Agriculture
DistVetO	District Veterinary Officer
DoAgicEx	Director of Agriculture of a Neighboring Country
DOC	Day-Old Chicken Providers
EggA	Egg Sellers Association
EggTradeMob	Mobile Egg Traders (Agents of the sedentary egg traders)
EggTradeStat	Sedentary Egg Traders
EPA	Environmental Protection Agency
EU	European Union
FAO	Food and Agricultural Organization
FeedSuppl	Feed Suppliers
GFowlA	Guinea Fowl Association
gtz	Gesellschaft fuer Technische Zusammenarbeit
ImpLifeBirds	Importers of Life Poultry
IntLabs	International confirmation Laboratories
LiveBirdMob	Mobile Life Bird Traders (agents of the sedentary live bird traders)
LiveBirdStat	Sedentary Live Bird Traders
Media	Media
Medicine	Veterinary Medicine Suppliers
MoComm	Ministry of Communication
MoHealth	Ministry of Health
MoTrade	Ministry of Trade
NADMO	Ministry of Interior (National Disaster Management Organization)
NatDirAgric	Other National Directors of Agriculture
NatDirVet	National Director of Veterinary Services
NatLab	National Diagnostic Laboratory
NatMoFA	National Ministry of Food and Agriculture / Minister of Food and Agriculture
Noguchi	Noguchi Institute (University of Ghana, Legon)
OIE	World Organization for Animal Health
OpinionL	Opinion Leaders on Community Level
PeriUBigF	Peri-Urban Big Farmers
Police	Police
PoultryA	Poultry Associations
PoultryBoard	Poultry Board
President	President of Ghana
PrivAnHealthT	Private Animal Health Technicians

PrivVets	Private Sector Veterinarians
RCC	Regional Coordinating Council
RegDirAgric	Regional Director of Agriculture
RegLab	Regional Diagnostic Laboratories
RegVetO	Regional Veterinary Officer
ResearchSt	Research Stations
RuralSmallF	Rural Small Farmer
SmallhNetw	Smallholder Network
Teachers	Teachers
Telecom	Ghana Telecom
TradChiefs	Traditional Chiefs
Transport	Poultry Transporters
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
UrbanSmallF	Urban Small Farmer
USAID	USAID
WetMarketA	Wet Market Association
WHO	World Health Organization
WildlifeD	Wildlife Division of the Forestry Commission

Table 2: Degree Centrality = Number of links per actor in the risk communication network

Actor	*Degree*	*InDegree*	*OutDegree*
AnHealthTech	22	21	1
AgricExt	21	20	1
Daperson	11	5	6
Media	11	11	0
NatDirVet	10	6	4
ComLifestW	9	4	5
RuralSmallF	8	0	8
OpinionL	7	3	4
TradChiefs	7	3	4
Teachers	7	3	4
PeriUBigF	7	1	6
DistVetO	5	3	2
InputOutputTrade	5	2	3
RegVetO	4	3	1
LifeBirdMob	4	0	4
LifeBirdStat	4	0	4
BorderVet	3	0	3
UrbanSmallF	3	0	3
GFowlA	3	1	2
PoultryA	3	1	2
PrivVets	3	1	2
ImpLifeBirds	3	0	3
Transport	3	0	3
DOC	3	0	3
Medicine	3	0	3
FeedSuppl	3	0	3
BorderVetex	2	1	1
DoAgicEx	2	2	0
DA	2	2	0
OIE	2	2	0
NatLab	2	1	1
PrivAnHealthT	2	1	1
Customs	1	1	0
NatMoFA	1	1	0
DistDirAgric	1	0	1
IntLabs	1	0	1
WildlifeD	1	0	1

Table 3: Closeness centrality in communication network

Actor	*Closeness*
AnHealthTech	0.014
DistVetO	0.013
AgricExt	0.012
PoultryA	0.011
NatDirVet	0.010
Daperson	0.010
RuralSmallF	0.010
PeriUBigF	0.010
OpinionL	0.010
TradChiefs	0.010
Teachers	0.010
ComLifestW	0.010
EggA	0.010
WetMarketA	0.010
UrbanSmallF	0.010
RegVetO	0.010
EggTradeMob	0.010
EggTradeStat	0.010
LifeBirdMob	0.010
LifeBirdStat	0.010
ImpLifeBirds	0.010
Transport	0.010
DOC	0.010
Medicine	0.010
FeedSuppl	0.010
GFowlA	0.009
PrivVets	0.009
Media	0.008
BorderVet	0.008
DoAgicEx	0.008
OIE	0.008
DA	0.007
NatMoFA	0.007
NatLab	0.007
WildlifeD	0.007
PrivAnHealthT	0.007
BorderVetex	0.006
Customs	0.006
IntLabs	0.006
DistDirAgric	0.006

Table 4: InDegree in the response network = from how many agents do actors directly receive response?

Actor	*InDegree*
PeriUBigF	6
NatDirVet	3
UrbanSmallF	3
RuralSmallF	3
Police	2
DistVetO	2
NADMO	2
NatMoFA	1
EPA	1
Customs	1
RegVetO	1
PoultryBoard	1
BorderVet	1
Media	1
MoTrade	1
MoComm	1

Actor	*OutDegree*
NatDirVet	6
NatMoFA	6
Police	5
DistVetO	4
EPA	3
NADMO	1
Customs	1
RegVetO	1
PoultryBoard	1
IntLabs	1
Noguchi	1

Table 5: OutDegree in response network = how many agents do actors directly giveresponse to?

Actor	*Closeness*
NatDirVet	0.038
NatMoFA	0.031
PeriUBigF	0.031
NADMO	0.031
DistVetO	0.030
Police	0.028
RegVetO	0.026
PoultryBoard	0.026
Customs	0.025
IntLabs	0.024
Noguchi	0.024
EPA	0.024
UrbanSmallF	0.022
RuralSmallF	0.022
Media	0.021
MoTrade	0.021
MoComm	0.021
BorderVet	0.018