Building livelihood resilience: a case study of factors affecting farm households' adoption of coping and adaptive strategies in rural Nigeria

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Building Livelihood Resilience: A Case Study of Factors Affecting Farm Households' Adoption of Coping and Adaptive Strategies in Rural Nigeria

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Abstract

Recent research on social and ecological resilience has recognised the importance of identifying opportunities in adversities, providing a wealth of theoretical knowledge; but empirical evidence remains a major gap not only for sustainability debates but also for focusing development objectives. The aim of this paper is to identify aspect of rural livelihoods that assists in sustaining households' coping and adaptive capacities during a crisis, thus attempting to diagnose which element of a livelihood has potential for maximising livelihood resilience and minimising vulnerabilities. This paper takes an example of how a society reorganises under a process of novel change by examining households' coping and risk management strategies in response to shock and stress created by avian influenza (H5N1) outbreaks in rural Nigeria. Using a multivariate probit model accounting for complementarities and substitution effects, the paper shows the significance of social capital, market access, communal insurance and *ex ante* biosecurity investment in influencing responses and in strengthening coping capacities; and argues that these elements may also have potential for maintaining livelihood resilience in the rural area.

1. Introduction

In a world of constant socio-ecological transformation, achieving any significant reduction in poverty requires the development of resilient livelihood systems that have robustness and stability against increasing global climatic stress and unexpected shocks (floods, disease outbreaks, etc). One way of addressing this area can be to learn from how societies respond to periods of change and how a socio-economic system reorganises subsequent to a shock (Gunderson and Holling, 2002). Folke et al. (2002: 12) have posed a critical question on whether or not there are elements that sustain adaptive capacity of social systems in a world that is constantly changing.

Recent research has theoretically addressed this question with emphasis on how a society absorb changes, adapt to trends and develop new ways of taking advantages of novel opportunities (Wisner 2004; Olsson et al., 2004; Folke, 2006) but empirical evidence remains a major gap. An analysis of how a socio-economic unit respond to shocks and risks can serve as an avenue for understanding factors that influence coping and adaptive capacities. Such factors can be adjusted to maximise resilience and minimise vulnerabilities.

Resilience refers to the ability of a social unit (individual, household or group) to absorb or cope with shock or its ability to anticipate and manage risks (Adger 2000). A key characteristic of agricultural households' livelihoods in rural areas is usually the high levels of exposure to production and market failures associated with shocks and risks. Upon the recognition of these factors, farm households would be expected to respond to sudden changes in production or consumption levels; and

manage the risk of losses alike by developing a number of coping and risk management strategies. Coping strategies are the unplanned short-term reactions of households to unanticipated livelihood failure or the *ex post* coping with crisis while risk management or adaptive strategies involve planned attempts to spread risks and reduce 'risk covariance' between different livelihood components (Ellis, 2000a).

Although these definitions attempt to distinguish coping strategy as 'reactive' in motive and risk management strategy as 'proactive' or 'precautionary' in motive, it may be difficult to establish a clear cut-off line between coping and risk management behaviours. Both types of strategies can be adopted simultaneously by a household during a crisis and it may be difficult to establish the exact motive behind households' adoption of each type of strategies. It could also be possible that a strategy may serve the dual role of meeting both short-term goal of coping and long-term goal of managing future risk. Thus, for the purpose of brevity, we refer to both types of household responses together as coping and risk management (CRM) strategies.

CRM strategies are integral aspects of a livelihood system and they can reflect its sustainability or resilience status. They emerge as a result of changes in households' livelihood strategies due to the effect of a shock or stress. Smuckers and Wisners (2008) for example reported livelihood diversification as a risk spreading strategy among Kenyan households faced with stresses caused by drought. An agricultural producing household can also use a migration-based strategy, borrowings and asset divestment or reinvestment in coping with losses from shocks (Eriksen et al., 2005).

In the event of a livelihood shock, a household faces the complex decision of adopting the best possible combination of coping and risk management strategies that will meet its immediate needs and minimise the risk of production and consumption failure in the long-run. In such situation, responses of the affected households can have different implications reflecting their capacity to cope or their ability to bounce back. The objective of this study is to examine factors that influence farm household's coping and risk management adoption decisions subsequent to shocks and stresses created by the 2006 and 2007 avian influenza outbreaks in rural Nigeria. This study illuminates those factors that significantly contribute to the coping and adaptive capacities of farm households.

The remainder of this paper proceeds as follows. The study context and data utilised are presented in the next section. The conceptual framework and estimation procedure are then described. This is followed by a presentation and discussion of empirical results while concluding remarks are provided in the final section.

2. Study Area, Avian Influenza Outbreaks and Household Responses

Since the first detection of avian influenza virus in a poultry farm in Nigeria in 2006, outbreaks have been recorded in 25 out of 36 states in the country as at 2008. HPAI is a poultry disease that causes not only supply shocks due to bird losses but also demand shocks due to reduced poultry sales and market disruption. The emergence of this shock does not result only in loss of income and livelihoods but also create a significant level of risks of future HPAI outbreaks (UNDP, 2006).

About 60% of Nigerian households presently obtain their livelihoods from the agricultural sector (Obi et al. 2008). The poultry sub-sector contributes 9-10% to the

Nigerian agricultural GDP with a net worth of $250 million (FDLPCS, 2007). Poultry keeping is part of life in the country because it represents an entry point into business with a small startup capital required. As a result, the industry is dominated by small-scale poultry producers.

The Federal Department of Livestock and Pest Control Services (FDLPCS, 2007) reported that Nigeria's poultry sub-sector is made up of 60% village extensive and backyard intensive poultry (flock size: 5 – 999 birds; minimal or no biosecurity), 15% semi-commercial (flock size: 1000 – 4999 birds; medium level of biosecurity) and 25% commercial (5000 – hundreds of thousands, high level of biosecurity). This structure of the poultry industry establishes the rationale for focusing on rural poultry.

Apart from poultry producers, the disruption of markets caused by HPAI outbreaks can as well lead to indirect effects on welfare outcomes of other stakeholders within the poultry value chain (farm employees, feed millers, petty traders of poultry foods, etc). The UNDP (2006) rapid appraisal assessment reveals that the official confirmation of HPAI in Nigeria caused initial panic resulting in a total boycott of poultry and poultry products. Within two weeks, egg and chicken sales declined by 80.5% and up to 4 months after, prices had not recovered up to 50% pre-outbreak levels.

Also, besides direct bird losses to the virus, the disease control policy currently being implemented in the country which involves culling of birds in infected areas and compensation payments to the poultry owners can also have a significant effect on flock sizes. At the onset of the outbreak in 2006, 45% decline in flock size due to culling was recorded (UNDP, 2006). The total number of affected poultry farmers increased to 2,735 in January 2008. As at that time, a total of about 1.3

million birds had been culled and about ₦623 million paid out in compensation (according to consultation to the record of the World Bank assisted avian influenza project). The average number of birds culled per poultry owner ranges from as low as 14 to as high as 14771 reflecting that all categories of poultry farmers including the smallholders were affected.

At the individual level, a woman keeping poultry in the Delta can lose up to US $132 poultry income (26% of annual national minimum wage) (Obi et al., 2008). According to a more recent study by Okpukpara et al. (2009), poultry sales contributes about 14% to the average poultry producing household's total annual income. These authors used different scenarios of HPAI risk and changes in flock size to predict that a smallholder may loss between US $25 and US $64 of its annual livestock income.

However, generally several studies have reported that poultry contribution to household total income in developing countries is minimal with many of these authors concluding that the income impact of HPAI is most important to large scale poultry producers while the food security impact is most important to the poor smallholders (Burgos et al., 2008; Birol and Asare-Marfo, 2009; Diao, 2009; Birol et al., 2010). Nevertheless, this suggests that the outbreaks of HPAI may affect food security of rural households who produce poultry and consume part of what they produce. While we recognise this aspects, there is yet to be any study that investigate the consequential effects of poultry and poultry income losses on households' subsequent decisions in coping with the minimal losses and in managing the risk of future livelihood failures (due to the treat of potential outbreaks).

As evident in Birol et al.'s (2010) study which considers a case study of four African countries, even in the absence of an actual outbreak the effect of the threat of a potential outbreak can have a significant impact on smallholders' livelihood outcomes. Thus this study makes a critical assumption that a loss of (and risk of losing) birds and poultry income may be enough to stimulate changes in household livelihood decisions. The coping and risk management strategies of households considered in this study complement the existing studies that have explored only income and food security effects (Obayelu, 2007; You and Diao, 2007; Iannotti et al., 2009; Okpukpara et al., 2009).

Nasarawa being the state where the most significant impact on rural poultry has been recorded in the country was chosen as the study area. There were a total of 204,267 households and about 1.86 million people in the state in 2005. Livelihoods in the state are generally agriculture-based with over 70% of the population engaged in subsistence crop and livestock farming (Bagudu, 2005). Ajayi et al. (2005) estimated that there are about 2 million cattle, 3.3 million goats, 2 million sheep, 0.21 million pigs and 6.3 million birds in Nasarawa state. Poultry production is mainly rural-based with birds being kept under a free-range or scavenging system of production.

The first HPAI outbreak in Nasarawa was recorded in 2006 at Garaku district in Kokona local government area (LGA). This was also the time when the first rural bird culling exercise took place in the country affecting six villages and resulting in a loss of 9179 birds of different species. Subsequently, the HPAI virus spread to four other LGAs: Akwanga, Lafia and Obi in 2006 and Karu in 2007. Kokona and Karu LGAs were purposively selected for study to cover all dates of outbreaks. A multistage sampling procedure was adopted.

In the first stage, a village list was drawn following the review of secondary data and consultations with local government officials in Kokona and Karu LGAs. This list included information on various characteristics of the villages in each LGA, such as income status; major livelihoods activities undertaken by the households, for example, crop farming, livestock production and off-farm employment; infrastructure level and quality, including information on the distance to the main road and distance to market centres, and avian influenza status (that is whether or not there have been recorded outbreaks of avian influenza, and whether or not culling and consequent compensation took place).

In the second stage of the multi-stage sampling procedure, two villages per LGA were chosen from the village list based on their characteristics. In Kokona LGA, these villages are Hayin Gada and Angwan Mayo, which were deemed to be similar in terms of several characteristics (such as, income and livelihoods activity portfolio, distance to markets and main road) but differed in terms of avian influenza outbreak status. Likewise in Karu LGA, the two villages selected are Panda and Kubang. The selection of villages with different HPAI status ensures that all different categories of households are captured in the study.

In the third stage, a random sampling of households in each village was conducted using a sampling probability of 0.33. This process resulted in a total of 341 households being selected but it was only possible to administer questionnaires in 337 households in a face-to-face interview. The survey aimed at eliciting information on household responses to the shock and stress caused by HPAI outbreaks and scares in the study area. On average, a household lost up to 170 birds to HPAI/culling in the study villages.

In view of the common finding in the literature from various regions of Africa that there is an existence of a structure in household coping and risk management behaviour, the present study considers households' adoption decisions over time. It has been shown that rural households make coping and risk management decisions in a sequence during a crisis relating to access to their assets, *ex ante* livelihood activities, and the long term security of their future livelihood [Campbell and Trechter, 1982 (North Cameroon); Watts, 1983 (Northern Nigeria); Cutler, 1984, 1986 (Sudan and Ethiopia); de Waal and el Amin, 1986 (Sudan); Pyle, 1992 (Sudan); Webb, 1993 (Ethiopia); de Waal, 2004 (Sudan); Smucker and Wisner, 2008 (Kenya)]. Consistently with this literature, it is common to find that households do not respond in a haphazard manner but based on the severity of the event, duration of the event and other determining factors (Adams et al., 1998).

The survey revealed that the following five coping and risk management strategies were commonly adopted in the study area (Table 1). Households borrowed birds or cash to diversify into non-farm village petty trading or restock poultry; and/or disposed of assets (crop seeds or other livestock species) to meet these goals as well as disposing of the remaining birds to minimise risks.

[Table 1 here]

As many as 50% of the households surveyed in each village immediately sold their remaining birds in other villages or markets outside the area[1] in order to avoid loss to HPAI or culling. The adoption of this risk minimisation strategy is not

[1] Probably taking the advantage of lack of awareness about the disease in more remote areas or in some markets in the nearby town.

significantly different between villages where there have been outbreaks and those where no outbreak has been recorded. Utilisation of resources exogenous to the household appears to be a common strategy in the villages with HPAI outbreaks. For instance, about 35% of households in HG and 33% in PA needed to borrow birds or cash in order to restock or diversify.

A considerable proportion of the households attempted to restart poultry rearing after stopping temporarily. Up to 42% were only able to restock birds partially while about 30% restocked fully up to the *ex ante* levels. More households restocked fully in Kubang (55%) than in any other village. This again reflects differences in event severity. Similarly, about 20% adopted a diversification strategy. It is commonly argued in discussions pertaining to HPAI risk reduction that diversification into non-farm income sources might be a significant channel for reducing livelihood risks (Ellis, 2000a; Roland-Holst et al., 2007).

Although there could be several reasons behind the adoption of a migration-based strategy, households were specifically asked to state strategies adopted in coping with the HPAI shock and in managing the associated risks. In about 16% of the households surveyed, at least one family member quit poultry trading in order to seek employment in a nearby town. This is particularly significant in Panda where about 25% adopted this strategy. Towns nearby to this village are Karu and Keffi. The former is the seat of the local government council while the latter links Panda to the Federal Capital City (Abuja). These towns provide opportunities for unskilled or semi-skilled labouring work.

While the village HPAI status can capture different severities of HPAI event, the definition of the duration of an HPAI event faced by each household is uncertain.

In order to apply the literature, CRM strategies can be thought of as complementary or substitutable over time. For instance, it is possible for a household to borrow cash immediately after losing birds to HPAI/culling and wait until some months later to study the sequence of the event before using the cash to restock new birds. Hence, an aspect of the duration of event can be depicted in terms of the time period when a CRM strategy is adopted after the first HPAI outbreak occurred in the study area. Based on the initial pilot study and existing evidence available in the literature (e.g. Phillipson et al., 2004), the period of the HPAI event in the study area is assumed to be made up of approximately three stages[2] as follows:

i. Immediately after (1 – 30 days after) the first bird flu outbreak occurred in the village or nearby village

Immediate Strategies: These are *ex post* CRM decisions taken by households immediately after they first heard about the incidence of bird flu, or after their birds first became sick or were lost to HPAI/culling. The former is referred to as immediate period, t_1 and the latter as immediate period, t_2. Immediate responses could include the adoption of risk minimisation strategies (such as biosecurity investment).

ii. Three months after the first bird flu outbreak occurred in the village or nearby village

Early Strategies: These are *ex post* CRM strategies taken three months after households first heard about the bird flu incidence or first lost birds to bird flu (t_3). In terms of the continuum of coping reflecting event severity, this time period represents the moderately severe stage when households are expected to adjust their asset portfolio i.e. asset (dis)investment stage. At this stage, households may

[2] Other events such as flood that can wipe out household's entire physical assets may result in short time intervals between each stage of coping (Del Ninno et al., 2001).

dispose some of their remaining productive and non-productive assets and this might be motivated by three aims:

a. Disinvestment to maintain household's current consumption
b. Disinvestment for intensification of or re-investment in exiting livelihood strategies
c. Disinvestment for diversifying away from poultry business into new livelihood activities.

iii. Twelve months after the first bird flu outbreak occurred in the village or nearby village

Late Strategies: These are *ex post* CRM strategies taken at the later stage of the bird flu crisis (t_4). This period is taken as roughly twelve months after the bird flu crisis started in the village or in a neighbouring one. A strategy expected to be adopted by households failing to cope at this stage is distress migration.

[Table 2 here]

The data on household CRM responses according to the time period when each strategy was adopted are presented in Table 2. This shows a pattern consistent with some hypotheses in the literature on coping behaviour which proposes that at the initial stage of a crisis, households would adopt risk minimisation strategies to protect future livelihood security but as the crisis intensifies they can be forced to dispose of assets in order to cope with the short-term changes. At the later stage of a

crisis, households that have less capacity to cope may end up selling all of its productive assets in distress and a distress migration or dependence on external support could be the ultimate consequence (Adams et al., 1998).

As proposed above, the first thing which most households are likely to do when faced with any type of shock/stress will be to minimise risk of losses in order to protect long term consumption needs. Table 2 shows that the highest percentage of households surveyed (43%) sold their remaining birds immediately after they heard about HPAI- t_1 (in the market or in other villages) while about 35% adopted the same strategy at t_2 and no household adopted this strategy in the later stages of the crisis. The percentage of households needing to disinvest into their productive resource base for the purpose of bird restocking and diversification continued to increase with time (0% at t_1, 6% at t_2, 16% at t_3 and 20% at t_4).

As a result, the percentage of households that restocked poultry fully up to the *ex ante* levels increased with time alike. Interestingly, diversification is an early period strategy since no household adopted this strategy in later periods (Table 2). Similarly, as shown in Table 2 the proportion of households borrowing birds or cash for restocking/diversification increased with time. Migration was mostly adopted in the later periods. It is however surprising to see that some 2% of the households chose migration immediately after they heard about bird flu.

3. Conceptual Framework: An Asset-based Approach

In this study, we model the farm household's choice of coping and risk management strategies by employing an asset-based approach. Asset is usually referred to as the capacity to cope (Moser, 1998). The 'capacity to cope' represents the bridge between resilience and vulnerability. Both concepts are flip sides of the same coin; and they have received debatable definitions with the former being more vulnerable to numerous interpretations.

In words of Chambers (1989; 2006: 1), 'vulnerability refers to exposure to contingencies and stress, and the difficulty in coping with them…defencelessness meaning lack of means to cope without damaging loss'. Similarly, Adger (2000) refers to social resilience as the 'ability of human communities to withstand external shocks …and recover from such perturbations'. Moser (1998) also refers to asset ownership as the means of resistance to hardship or as the capacity to cope by mentioning that 'the more assets people have, the less vulnerable they are, and the greater the erosion of people's assets, the greater their insecurity'.

Hence, resilience can also be seen as the ability of a social unit to retain the same functions that its livelihood assets and strategies provide. For instance, a household that is able to restock poultry fully up to the *ex ante* levels can be assumed to be resilient to the HPAI shock. This links concepts of vulnerability and resilience to the sustainable livelihood literature, which defines a livelihood to be sustainable when it can cope with and recover from shocks and stresses while maintaining its capacity or livelihood assets (Scoones, 1998).

In view of these definitions, the analysis of factors influencing households' choice of coping and risk management strategies can be located within a sustainable livelihood approach (SLA) that emphasises the way people draw on a combination of livelihood assets (natural, human, physical, financial and social) to purse a variety of livelihood strategies (diversification, intensification, migration, etc) in order to achieve a range of livelihood outcomes (resilience, reduced vulnerability, income, food security, etc).

Although it is possible to quickly think of the SLA strictly as a policy tool, it has also become a focus of extensive research in rural development favoured by academics such as Scoones (1998) and Sneddon (2000). For example, Sneddon argued for the SLA over a broader term such as the 'sustainable development', which according to the author has not been conceptually helpful by mentioning that:

> *''An explicit focus on the livelihoods of different societies' marginalised peoples offers a much needed palliative to the more ethereal, national-level discussions typical of sustainable development discourses''* (Sneddon, 2000: 533).

The SLA assumes that the agency of communities or the people are central in the development discourse, thus it is interested in their 'potential, competencies and capacities to organise their own realities', which can form the basis for maximising their strengths and minimising their weaknesses (Kirkby et al., 2001). SLA is a way of viewing how a social unit behaves under a specific context. Such context could be external or internal to the social unit and it may constitute an opportunity or a vulnerability.

[Figure 1 here]

While asset ownership or capacity is endogenous to households, it is also subjected to the influence of external forces that provide the context under which assets are combined and utilised. Based on this, differences in coping and risk management decision adoption among households in a community will not only depend on their asset endowments but also on the vulnerability contexts and a range of socio-economic and facilitating factors (such as income, gender, access, policy, etc) which may determine how they respond to the shock (Figure 1).

When a context increases the exposure of a livelihood system to failure, then it can be referred to as a vulnerability context. As shown in Figure 1, an occurrence of a shock in households' asset stock due to the HPAI outbreak would necessitate changes in livelihood strategies. The coping and risk management strategies emerging as a result of these changes mediate between the pre-outbreak livelihood strategies and subsequent livelihood outcomes. External contexts can also mean opportunities. The policy environment for example can provide access to assets required for fashioning out coping and risk management strategies. Lack of access can result in asset redundancy and this can make a household unable to generate a production or consumption flow required for resisting a hardship.

The literature on household responses to shock and stress suggest some key factors that are likely to influence household CRM decision making (Adams et al., 1998; Smuker and Wisner, 2008). Following this and the SLA (Figure 1), the choice of a CRM strategy, C in response to a shock or stress by a household, i, will depend on the level of event encountered (vulnerability context), E_i, duration of the event, D_i, type of resources available to the household (assets), A_i, household's socio-economic characteristics, S_i and other factors, Z_i such as facilitating factors (e.g.

intra-communal insurance, policy, market access, etc). As shown in Figure 1, facilitating factors such as the institution and policy (e.g. local government) can influence all elements in the framework. The government can respond to the crisis by providing food aids, credit facilities or insurance cover, which may have an overarching effect on other elements in the framework.

$$C_i = f(E_i , D_i , A_i , S_i , Z_i) \qquad (1)$$

4. Empirical Model

Existing studies on coping and risk management behaviours in Africa and other developing countries tend to estimate the determinants of CRM decisions under the assumption that the observed behaviours are subjected to a single causal factor (e.g. Takasaki et al., 2004). We assume that the choice of a CRM strategy is due to HPAI shock and stress and a vector of explanatory variables. Thus a rural household is subject to a binary decision of either adopting strategy, C_i (C_i=1) or not (C_i=0) subsequent to HPAI shock.

A distinguishing feature of the data presented in Table 2 is that some strategies were adopted immediately (t_1 or t_2), while others were adopted at early (t_3) and late (t_4) periods. A household which sold all its remaining birds at t_1 may not adopt any of the early/late strategies. If this were to be the case, then there is a need to correct for a self-selection bias in the empirical model. However, summary statistics shows that households that had adopted immediate strategy also adopted early and late strategies. 35% of those households that had sold their remaining birds immediately also restock poultry fully either at t_3 or t_4. It is possible that such

households after selling the remaining birds also have plans to use the cash to restock new birds later but first waited for a while in order to study the event before restocking. Similarly, 12% of those that borrowed also diversified into non-farm activities at t_3 (Table 3). This suggests that there are possible interdependencies in households' coping decision-making.

[Table 3 here]

Coping decisions can be complementary or substitutable over time and this may result in positive or negative correlations across CRM strategies (Belderbos et al., 2004; Nhemachena and Hassan, 2007). Therefore, estimating separate univariate probit model for each strategy adoption would omit these possible interdependencies. Such an approach is biased and may neglect unobserved correlated factors (Greene, 2007). However, Gillespie et al. (2004) argue that a multivariate probit model (MVP) is advantageous because it accounts for simultaneous correlation of the error terms and thus reduce bias.

Hence, a MVP is applied in jointly estimating the probabilities of adoption of multiple coping strategies listed (n = 5) in Table 3. In order to proceed, equation (1) is re-written as:

$$C_i = f(X_i) \qquad (2)$$

where X_i represents a set of factors (*A, D, E, S* and *Z*) expected to influence CRM decisions according to the literature reviewed under conceptual framework.

Following Choo and Mokhtarian (2008) and Velandia et al. (2009), the MVP model for n = 5 is specified as follows:

$$C_i^* = x'\beta_i + \varepsilon_i,\ i = 1, 2, \ldots . n \quad [3] \qquad (3)$$

where C_i^* refers to *n* unobserved binary dependent variables representing the latent utility of household *j*, *x'* is a vector of explanatory variables, β_i is a vector of unknown parameters to be estimated and ε_i is the random error term which is normally distributed with mean zero and a unitary variance. The probability of a household adopting a strategy is such that:

$$\Pr(C_i = 1) = \Phi\,(x'\beta_i), \qquad \text{for } i = 1, \ldots, n.$$

It may be re-written as:

$$c_i = \begin{cases} 1 \text{ if } x'\beta_i + \varepsilon_i > 0, and \\ 0 \text{ otherwise, } i = 1, 2, \ldots . n \end{cases}$$

In this case, *n* has a variance-covariance matrix of the error terms, *M* with a standard normal density $\phi\,(\varepsilon_1, \varepsilon_2, \ldots, \varepsilon_n; M)$.

$$M = \begin{bmatrix} 1 & \rho 12 & \cdots & \rho 1n \\ \rho 21 & 1 & \ldots & \rho 2n \\ \vdots & \vdots & \ddots & \vdots \\ \rho n1 & \rho n2 & \ldots & 1 \end{bmatrix}$$

Thus, the joint probability that a household chooses a particular CRM strategy such that $C_i = c_i$, conditioned on parameters β_i, *M*, and x'; can be derived from *n*-variate standard normal distribution. Let $y_i = \omega_i(x'\beta_i)$ where $\omega_i = 2C_i - 1$, for $i = 1, 2, \ldots, 5$. Solving the following integral will give us the multivariate standard normal probability of $C_i = c_i$:

[3] Note that the observation subscript *j* is suppressed to avoid unnecessary complexity.

$$\Pr(C_i = c_i, i = 1, \ldots, 5 \mid y_1, y_2, y_3, y_4, y_5) = \Phi_5\,(y_1, y_2, y_3, y_4, y_5; \rho 12, \rho 13, \ldots, \rho 45)$$

$$= \int_{-\infty}^{(2c_i-1)x'\beta_1} \int_{-\infty}^{(2c_i-1)x'\beta_2} \ldots \mathrm{x} \int_{-\infty}^{(2c_i-1)x'\beta_5} \phi_5\,(\varepsilon_1, \varepsilon_2, \varepsilon_3, \varepsilon_4, \varepsilon_5;$$

$$\rho 12, \rho 13, \ldots, \rho 45)\; d\varepsilon_1 d\varepsilon_2 \ldots d\varepsilon_5, \qquad (4), \text{ where}$$

$\Phi_5\,(\cdot)$ and ϕ_5 respectively denote multivariate normal distribution function and probability density function (Young et al., 2006), $\omega_i(x'\beta_i)$ is the index value corresponding to each CRM strategy i.e. $(-\infty, x'\beta_i)$ is the interval if c_i =1 and $(x'\beta_i, \infty)$ is the interval if c_i = 0 (Chib and Greenberg, 1998; Greene, 2007).

4.1 Explanatory Variables and Hypotheses

A review of relevant studies (e.g. Lay et al., 2009) and the conceptual framework adopted in Figure 1 informed the composition of a list of explanatory variables included in the MVP model (Table 6). These variables are organised into four groups following the conceptual framework.

Household Asset Endowments

Household asset endowment variables are grouped into physical, financial, human, social and natural assets (Scoones, 1998). Physical assets can be referred to as 'man-made' capital required in production processes (Ellis, 2000b) and these include poultry housing, livestock, etc. Indices were created to represent the number of livestock species and the type of poultry housing units owned by the household. Following Brown et al. (2006), the total livestock unit is calculated as shown in Table 4. Livestock other than poultry may serve as an alternative source of income generation for diversifying into non-farm activity. Households with more livestock species other than poultry may depend less on borrowing as a coping strategy after the HPAI shock. Poultry is the commonest livestock type owned by the majority of households surveyed. 83% owned poultry, 43% owned goats, 16% owned sheep, 14% owned pigs and only 7% owned cattle.

[Table 4 here]

About 20% of households surveyed did not provide any housing for their birds and thus the birds rest on the tree or in the bush at night. This represents a zero level of housing-biosecurity input. The level of poultry housing biosecurity input can therefore be assumed to increase from tree/bush (0), open floor (1), floored backyard (2), raffia basket (3), mud house (4), wooden cage (5), a room within the owner's house (6) to poultry farm (highest level of investment: 7). About 35% of households kept birds in a mud house, 19% kept birds in a room within their homes while only 1% owned a backyard 'poultry farm'.

Some households owned multiple types of poultry housing in the study area. As a result, a poultry housing index was created for each household by averaging ranks for all poultry housing units owned. It is hypothesised that those households that have better housing investments such as a small-scale 'poultry farm' would have been more likely to keep a higher number of birds before the outbreak and thus more likely to restock.

Scoones (1998) defines natural asset as 'the natural resource stocks and environmental services from which resource and services useful for livelihoods are derived'. Total size of land owned and farmed by households is considered as an indicator of natural asset ownership. It is expected that the greater the area of land

farmed by a household, the less likely such household would be to diversify or migrate in search of off-farm employment.

Human capital refers to health status, skills, education, knowledge and age. Following Sesabol and Tol (2005) and Lay et al. (2009), it is expected that the number of years that a household head had been keeping poultry (poultry experience) would have a positive relationship with the adoption of a bird restocking strategy. The household head age is also hypothesised to be negatively correlated with the adoption of diversification and 'immediate bird sale' strategies. With more drive and aspirations in young people, young household heads are more likely to sell their remaining birds and diversify into non-farm petty trading.

Financial capital is represented by access to credit. Investment barriers due to lack of access to credit may limit a household's capability to diversify into non-farm trading activities or restock new birds (Barrett et al., 2001a). In contrast, lack of access to credit is expected to increase the likelihood of a household adopting a migration-based strategy and it may also serve as a push factor for the poor to sell their remaining birds or borrow in order to restock.

The definition of social capital has been the most controversial. Ellis (2000b) noted Moser (1998)'s idea of 'reciprocity' in which families spend time and resources in establishing trust or social networks which could be sought for future assistance. In the study area, the common social capital is represented by participation in community impacts sharing system in which households provide mutual assistance and contribute to help others during a crisis. An ownership of such asset might assist affected households to secure help for restocking new birds. Likewise, memberships

of a poultry sellers' associations is also expected to increase the adoption rate of 'restocking' and 'borrowing' strategies.

Household Characteristics (Gender, Household Size and Income)

Coping strategy adoption could vary across households depending on the household head gender, household size and income levels (Adams et al., 1998; Eriksen et al., 2005). Particularly if per capita income is lower, larger households are more likely to sell their remaining birds at immediate periods since a total loss without recurring any payment could mean more pressure on family resource base (Obi et al., 2008). In a situation where poultry is lost, an income poor household may need to depend on borrowings for restocking purposes. Also, a larger household size could increase the likelihood of a family member migrating in search of off-farm employment subsequent to the loss of poultry or poultry income (Lay et al., 2009).

At the initial stage of a crisis, women have been found to be most involved in adopting coping strategies while men participates more actively as the crisis becomes more acute (e.g. Campbell and Trechter, 1982). However, results of a recent household study in north-eastern Nigeria which show that a majority of birds are owned by male household heads (Abubakar et al., 2007) suggest that gender of the household head may be positively correlated with the adoption of 'bird restocking' and 'immediate bird sale' strategies. Women are generally known in Nigeria for their participation in petty trading and credit groups (Udry, 1990; 1995), thus gender of the household head may have a negative relationship with the adoption of 'borrowing' strategy.

Access and facilitating factors

Market access (that is whether or not a household needs to obtain permission before selling in the village market) and distance to the nearest town market (measured in minutes walk from the household) are considered as access factors. Households that are closer to the market may have better opportunity to dispose of their remaining birds while those that do not have access to the village market may be forced to adopt a 'migration' strategy. The HPAI control policy involves compensation payments. It is expected that compensation payments to those households whose birds were culled would provide immediate cash for restocking new birds or diversifying.

[Table 5 here]

Household-specific vulnerability context (Level of HPAI Event)

CRM adoption decision would vary depending on the level of HPAI event encountered by households (Adams et al., 1998). The level of HPAI event can encompass the HPAI status of the village in which a household is located and whether or not the household lost poultry to HPAI/culling. The need to cope with HPAI shock is expected to be higher in those villages where outbreaks have been recorded and thus would increase the strategy adoption. As shown in Table 5, the village HPAI status variable and that representing whether or not a household lost poultry are not included in the model because they are strongly correlated with the compensation variable. We found that those households that were compensated are

located only in villages with outbreaks, thus the compensation variable can also represent the village status variable to some extent.

[Table 6 here]

5. Results and Discussion

The determinants of the choice of CRM strategies were estimated in STATA using a smooth recursive simulator commonly called Geweke-Hajivassiliou-Keane GHK simulator, which is a method of simulated maximum likelihood (SML) (Young et al., 2006). The SML estimator yields efficient estimates that approaches those of a maximum likelihood as ratio of the square root of sample size to number of replications tends to zero. As a result, in the MVP literature the model specification is usually assessed based on Cappellari and Jenkins (2003)'s recommendation that the number of draws (i.e. number of simulations from distributions of each of the probit equations in order to calculate the joint probability, P_i) should be greater than the square root of the sample size, $\sqrt{N}$. Adopting this rule of thumb we observed 300 draws, which is greater than 16.49 (the square root of 272 observations).

Correlation Coefficients

The claim that there are correlated unobserved disturbances in the utility of CRM strategy bundle, C^*_i, can be verified based on the pairwise correlation coefficients across the five CRM strategy adoption equations, which are presented in

Table 7. These are the coefficients of pairwise correlation between equation error terms after which the effects of the observed factors have been accounted for in the MVP model (Green, 2003). Some of the correlation coefficients are statistically significant and the log-likelihood ratio test rejects the null hypothesis of a lack of significant interdependencies (χ^2 (10) = 33.0451 Prob > χ^2 = 0.0003). This supports our initial hypothesis that the equation error terms are correlated and that the MVP model is appropriate for estimating the determinants of CRM strategy adoption.

[Table 7 here]

Signs on the correlation coefficients reveal complementarities and substitutions in the adoption of CRM strategies. There is a significant negative correlation between household decisions to borrow and fully restock poultry. This may reflect that those households which borrowed birds or cash for restocking were unable to restock birds fully up to the *ex ante* levels, which could be due to the fact that they were either unable to borrow enough or constrained by their *ex ante* poverty levels. Using a wealth index created through factor loadings on the asset variables it was found that the majority of households that borrowed birds for restocking (about 30%)[4] are in the poorest wealth category (lowest 25%) while none of those households in the highest wealth category (top 25%) borrowed birds.

This asset poverty is probably the reason why there is also a significant positive correlation between the decision to sell the remaining birds at immediate periods and the decision to borrow or migrate at later periods. These positive

[4] Of those that lost birds (n = 128)

correlations may reflect that poorer households disposed of their remaining birds immediately after the HPAI shock and utilised the cash to maintain their consumption without re-investment, which is why they needed to borrow birds for restocking later on. In addition, it could perhaps mean that members of poorer households that had depended on borrowings adopted migration as a risk averse strategy to seek alternative income source for smoothing consumption. Meanwhile, the positive correlation between the decisions to sell the remaining birds at immediate periods and diversify later on probably reflect that some households might have reinvested the cash secured from immediate bird sales.

Since the CRM strategies adopted could have uncertain implications on household livelihood outcomes in the longer term, it is quite difficult to categorically understand factors that enhance household coping capability considering that we utilise cross-sectional data. As such, for instance it will be inconclusive to assume that the adoption of migration is a bad or good strategy neither will it be complete to consider borrowing as having a negative implication on household resilience. Further, on one hand, the disposal of productive assets for reinvestment in another livelihood activity may have positive effects on household resilience in the future. On the other, such strategy can also expose livelihoods to future failure especially if the return on the asset disposed of is not re-invested. While we recognise this aspect of dynamics, there is a lack of longitudinal or panel data. However, the parameter estimates obtained in this study allow us to describe the characteristics of those households that adopted each type of CRM strategy with a focus on implications of the results for disease control and impact reduction policies.

Parameter Estimates

The parameter estimates from the MVP model are presented in Table 8. In each of the five adoption equations, there are various significant determinants. Variables that have significant effect on the choice of restocking birds fully up to the *ex ante* level include the household head poultry experience, poultry association membership, access to village market, distance to town market, poultry housing index and household size. As expected, households with access to the village market and with a membership of poultry sellers' association, *ex ante* ownership of higher biosecurity investment, as well as more years of poultry keeping experience, are more likely to restock birds fully.

[Table 8 here]

Similarly, those households that are closer to a nearby town tend to restock fully since they can easily get access to poultry markets and also be aware of changes in price and consumer preferences. Likewise, there is a higher likelihood that smaller households would choose to restock birds up to the *ex ante* level in the aftermath of HPAI shock. The explanation here may be that with fewer household members there is less pressure on family's resource base and thus making more capital available for restocking. The negatively significant parameter estimate on credit access, however, is contrary to expectation.

In the migration strategy adoption equation there are six significant variables. Generally, the signs on parameter estimates indicate that at least one member of

larger households with less farm land, less market access, and that lack social capital (poultry association membership) is more likely to quit poultry farming and/or trading and migrate in search of off-farm work. This result probably suggests that poorer households with fewer assets are less likely to be resilient to the impact of HPAI shock and stress.

For instance, lack of access to the village market through which alternative livelihood activities (such as off-farm trading) can be devised would limit the extent to which a household member that depends on poultry-based livelihood can cope without resorting to external opportunities. In addition, lack of association membership (which can serve as a source of help) is more likely to limit coping capability and probably push a migration decision. Similarly, the significant and positive coefficient on farm land size shows that landlessness can also 'push' the decision to migrate. An ownership of small area of farm land would motivate the decision to search for employment elsewhere perhaps because labour has a higher opportunity cost in nearby towns.

However, migration can also be a risk averse strategy to protect future livelihoods. Since a participation in communal sharing reflects a household's attempts to insure against perceived risk *ex ante*, those households that usually receive assistance from others during a crisis are likely to be more risk averse. As shown in Table 8, this probably explains the reason why the variable is positively associated with the adoption of 'immediate bird sale', diversification and migration-based strategies. Surprisingly, we obtain a positive and significant coefficient on compensation variable in the 'migration' equation, which shows that those households that were compensated are more likely to have at least a member adopting migration. This is probably due to the fact that the Nigeria's compensation

scheme initially suffered from insufficient government funding resulting in prolonged delays between the times when birds are culled and when the owners get compensated (up to one year in some cases) (AICP, 2007: 38).

Again, since the compensation variable also represents the village HPAI status, it can be inferred from the signs on the parameter estimate that those households that encountered higher levels of HPAI event (i.e. those that are located in a village with outbreaks) are more likely to adopt a migration-based strategy. However, the fact that those households that lost birds to culling and were compensated also tend to adopt the 'immediate bird sale' strategy suggests that some households might have hidden infected birds from the government officials during the bird culling exercise.

The decision to sell the remaining birds immediately after the emergence of the HPAI outbreak is significantly affected by age of the household head, poultry housing index, participation in community sharing, household size, distance to town market as well as by the level of the HPAI event encountered. The result shows that closeness to a town market is a significant determinant of the adoption of 'immediate bird sale' strategy. Households that are closer to town markets might be better aware of sales points and quickly be able to take advantage of the initial lack of consumer awareness about HPAI in the local area.

As expected, the significant and negative coefficient on household head age implies a higher likelihood for younger household heads to sell their remaining birds immediately. Owing to the fact that young people are more agile, younger heads may have more social networks in the nearby towns than their older counterparts through which sales opportunity could be identified. Consistently with our hypothesis,

larger households are more likely to sell their remaining birds immediately as a risk minimisation strategy since total loss may mean more pressure on their resources than those with fewer family members. Intuitively, the result confirms that those households with higher *ex ante* poultry housing investments are more likely to keep more birds and thus there is more likelihood that they will sell their remaining birds immediately. Again, the positively significant coefficient on compensation variable may suggest that those households located in the villages with outbreaks are more likely to dispose of their birds immediately after an outbreak, which is as expected.

Livelihood diversification has been identified in some ecological-related studies as a risk spreading strategy while others consider it as contributing significantly to resilience building in rural areas (Marschke and Berkes, 2006). The parameter estimate obtained on 'participation in community sharing' variable in the diversification equation indicates that those households that usually receive assistance from others during a crisis are more likely to quit poultry and diversify into non-farm petty trading in the aftermath of HPAI outbreak, perhaps making this decision as a risk spreading strategy. In contrast, the decision to diversify or change investment portfolio could have also been influenced by the level of event encountered (Del Niñno et al., 2001).

The positively significant coefficient on compensation variable indicates that those households that lost birds to culling and were compensated are more likely to diversify into non-farm activity. The compensation payment could have assisted some households in diversifying as it would have provided access to some fund during the crisis. Since the compensation variable also represents the village HPAI status, this result implies that a diversification strategy may be particularly adopted

by those households that faced higher levels of HPAI event i.e. those located in a village with outbreaks.

Beside these factors, poor asset endowment seems to be important in influencing the decision to diversify. Although weakly significant, the result indicates that those households that lack poultry association membership and with less farm land are more likely to diversify. In the livelihood diversification literature, there is a general assumption that the poor are more likely to engage in diverse livelihood activities as way of minimising their livelihood risks (Ellis, 2000a). While our result is consistent with this, there are contradictory evidences over the relationship between wealth status and livelihood diversification. Under changing policy conditions, poor households in rural areas may be unable to take advantage of emerging opportunities or face constraints to enter into profitable activities (Dercon, 2000; Barret et al., 2001b).

Finally, in the 'borrowing' strategy equation, variables significant are the number of livestock owned, household income and compensation. Households that are more likely to depend on borrowing are income poor. The result implies that even though some households were compensated, they still depended on borrowing for coping suggesting that the pre-existing level of income poverty is an overarching factor. This reflects that the compensation fund were not invested but rather utilised to maintain survival, thus the reason why some households had to borrow birds for restocking. Since the compensation variable represents the event severity, the result shows that households which depended on borrowing during the HPAI crisis faced higher levels of HPAI event, which is consistent. A fairly recent study by Del Niñno et al. (2001) also showed that households that faced more severe conditions of the 1998 flood in Bangladesh borrowed more in order to cope with the shock.

The weakly statistically significant coefficient on TLU shows that households that keep more of livestock species other than poultry are more likely to depend on borrowing as a coping strategy, which is surprising. Small animals are usually regarded as an insurance asset in rural areas of Africa (McPeak, 2004). Perhaps, the result suggests that the income poor households may perceive the disposal of small ruminants as constituting a higher level of risk to their future livelihoods. Thus they would prefer to seek external sources of support rather than disposing of other livestock species as a coping strategy. In addition, people may not necessarily utilise income from livestock sales for purchasing poultry (Muhammad-Lawal and Balogun, 2007).

6. Conclusion

Folke, Elinor & Co. in their 2002 seminar paper on sustainable development argued that a 'management that builds resilience can sustain socio-ecological systems in the face of surprise'. As a result, there is a rising interest in understanding elements that enhance coping capacity or that build resilience (Daskon, 2010). In the event of a livelihood shock, farm households do not remain passive but adopt a number of strategies to cope with the shock and to manage subsequent risks. This aspect of household responses during a crisis and its relevance to the context of resilience building is usually investigated using ecological-related shocks such as drought and flood. We however examined household responses using an unusual context of the case of shock and risks created by HPAI outbreaks in Nigeria as an avenue for identifying factors that enhance coping and adaptive capacities in the rural area.

Adoption of coping and risk management strategies is dependent on a number of factors including whether an affected household have capacity to cope or have access to the factors facilitating livelihoods, as well as the goal of the household. The model utilised in this paper allowed us to take into account the potential simultaneity in coping and risk management decision making. Using a multivariate probit approach we jointly examined the determinants of households' adoption of immediate bird sale, borrowing, bird restocking, diversification and migration decisions, which are the five commonly adopted coping and risk management strategies in response to HPAI shock and risks in the study area.

In the literature on coping behaviour in rural Africa, it is often assumed that households do not respond to crisis in a haphazard manner but rather in a logical sequence. Results obtained from the multivariate probit approach reveal that there are substitutions and complementarities in the strategy adoption decisions, which reflect the coping sequence assumption even in an unusual context of the HPAI shock. Although it is difficult to identify the coping dynamics, the estimation results allowed us to describe the characteristics of households that adopted each strategy type.

The result reveals that poorer households with fewer assets are more likely to be less resilient (or more vulnerable) to livelihood shock. Generally, poor asset endowment and lack of access to assets (e.g. less market access, less social capital) create significant barriers to the poorer households in adopting potentially livelihood-improving coping strategies such as bird restocking or diversification into non-farm activities. The household's ability to restock poultry up to the *ex ante* level reflects a capacity to cope or become resilient to the HPAI shock. It was found that

those households that were able to restock poultry fully have smaller family size, a poultry association membership and an access to the market.

Leaving the village to search for an alternative source of income to poultry may in some respect reflect a lack of capacity to cope and our results indicate that this may be driven by poor asset endowment. We found that those households that adopted the migration-based strategy have smaller area of farm land, lack access to market and lack poultry association membership. Although an outward migration of a household member in search of off-farm employment may provide means of coping and an opportunity to build resilience against future shock, the extent to which this can be relied upon as a policy strategy is unclear. This is particularly because town and cities in Nigeria are already faced with growing problems of insecurity, unemployment and increasing slum congestion.

Similarly, those households that diversified away from poultry trading have smaller area of farm land and lack memberships of poultry association. Other ecologically-related studies in general have established that the nature of asset endowment affects the way in which households cope or adapt to changes (Takasaki et al., 2004; Eriksen et al., 2005). However, the fact that some households attempted to diversify signals an avenue for policy intervention for enhancing households' own capacities to adjust. This is also applicable to disease control. Several alternative approaches have been proposed for managing the HPAI risk in Africa and Asia. Lfft et al. (2007) and Roland-Holst et al. (2007) favoured a market-based approach where consumers' demand can be relied upon for reducing the risk of HPAI infection and transmission.

Meanwhile, in less developed countries especially in Africa where rural scavenging poultry accounts for a significant share of the poultry sector, a world in which many governments will encourage markets and regulatory approaches to shift poultry supply towards the commercial sub-sector can be envisaged. A particular strategy for achieving such scenarios would be by reducing poor people's dependence on scavenging poultry keeping and enhancing their capacities to diversify into other sectors. As a result, other non-market approaches involving poultry sector restructuring (such as biosecurity upgrading and livelihood-enhancement through diversification) can serve as an effective complementary disease control strategy. A cross-country analysis of livelihood impact of HPAI by Birol et al. (2010) also shows that diversification may be a policy tool in itself for minimising HPAI risks in Africa.

It was also found that a considerable proportion of the villagers sold their remaining birds during the implementation of bird culling policy in the area. This finding suggests that the 'immediate bird sale' strategy adoption decision is not only influenced by livelihood factors but also by household goals, which could be risk minimisation. Since younger households closer to a town market tend to adopt this strategy, government officials can quickly target this population during the implementation of the bird culling and compensation policy in order to reduce the risk of virus spread.

Apart from asset poverty, household size seems to be an overarching factor limiting coping and adaptive capacities. It was found that households with larger family size tend to dispose of their remaining birds immediately after the emergence of HPAI outbreak in the local area and depend on borrowings thereafter. Our findings suggest that poorer and larger households can be targeted during the

implementation of HPAI impact reduction and compensation policies. It is however surprising to find that compensation payments to those households whose birds were culled does not seem to enhance the adoption of 'bird restocking' and 'diversification' strategies. It probably reflects the long delays in compensation payments during the initial periods of HPAI outbreaks in Nigeria. Consistently with the coping behaviour literature, it was found that the level of HPAI event is a significant determinant of coping and risk management decision making.

In general, the study provides information on those areas of asset poverty that can be improved upon for reducing the impacts of HPAI outbreaks on rural livelihoods as well as for enhancing household's resilience to future livelihood shocks. These include physical capital (improving ownership of better poultry housing), natural capital (farm land area), and improving access to market and social capital (enhancing poultry association membership).

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Tables and Figure

Table 1: Percentage of Total Households Surveyed Adopting CRM Strategies in Response to HPAI Shock and Stress by Village

Strategy	Hayin Gada (n = 25)	Angwan Mayo (n = 70)	Panda (n = 195)	Kubang (n = 44)	All households (n = 337)
Immediate sale of the remaining birds to avoid loss due to HPAI/culling *(Immediate bird sale)*	50.0	71.4	75.4	61.4	71.0
Seek support through social network (borrow birds or cash) *(Borrow bird or cash)*	34.8	22.9	33.3	11.36	28.3
Restock poultry fully up to the *ex ante* level *(Restock full)*	34.8	30.0	23.1	54.6	29.5
A household member quit poultry trading/rearing and diversified into non-farm village petty trading of manufactured items *(Diversify into non-farm)*	33.3	37.1	9.3	38.6	20.7
A household member quit poultry trading and migrate to seek employment in a nearby town *(Migrate)*	4.4	2.9	25.1	0.0	15.7

Table 2: Sequence in Household Responses: Percentage of Households Adopting CRM Strategies by Time Periods after the initial Incidence of HPAI (n = 334)

Strategy	**Immediate1 (t_1)**	**Immediate 2 (t_2)**	**Early (t_3)**	**Late (t_4)**	**All Responses**
	After first hearing about HPAI	After bird first became sick/dead due to HPAI/culling	Three months after first hearing about HPAI/after bird first became sick/after first losing bird to HPAI/culling	Twelve months after first hearing about HPAI/after bird first became sick/after first losing bird to HPAI/culling	Overall (All Periods) [5]
Immediate bird sale	43.3	34.9	0.0	0.0	71.0
Borrow birds or cash	0.0	4.2	14.8	17.5	28.2
Restock full	0.0	0.3	4.2	28.0	29.5
Diversify into non-farm	0.0	0.0	20.7	0.0	20.7
Migrate	1.8	0.9	8.8	8.7	15.7

[5] The sum of columns 2 - 5 does not equal to the figures under column 6 because while some households took the same strategy more than once, their responses are only counted once. As a result, the figures in column 6 represent whether or not the household took a strategy over a period of 12 months.

Table 3: Percentage of Households that adopted 'Immediate Bird Sale' and 'Borrowing' Strategies and that also adopted each of 'restock full', 'migration' and 'diversification' Strategies.

CRM Strategies	Sold remaining birds immediately (n = 235)	Borrow (n=94)
Restock birds fully	34.90	23.40
Diversification	11.49	11.70
Migration	20.00	22.34

Table 4: Average Number of Livestock Owned by Village

Variable	***Angwan Mayo***	***Hayin Gada***	***Kubang***	***Panda***	***All sampled households (n = 337)***
No of birds	18.3	89.3***	15.4	19.0	23.2
Cattle	2.0	0.0	0.02	0.3	0.6
Pig	1.7	1.3	0.3	0.2	0.6
Goats	1.8	2.9	1.9	2.2	2.2
Sheep	0.9	0.00	0.0	1.3***	1.0
Total Livestock Unit (excluding birds)*	2.4	0.4	0.3	0.7**	1.0

*TLU = 1 Cattle = 10 sheep = 10 goats = 10 pigs;

***1% significance level; **5% significance level (paired t-test)

Table 5: Pearson Correlation Coefficients

Variable Combination	**Correlation Coefficient**
'Compensated' (Yes = 1, No = 0) and 'Lost Poultry to HPAI/culling' (Yes = 1, No = 0)	0.7126
'Compensated' (Yes = 1, No = 0) and 'Village HPAI Status' (Yes = 1, No = 0)	0.4006
'Village HPAI Status' (Yes = 1, No = 0) and 'Lost Poultry to HPAI/culling' (Yes = 1, No = 0)	0.5621

Table 6: Summary Statistics of Explanatory Variables

Variable	*All households* *Mean (std. error)* *N = 337*
Human Capital	
Household head poultry experience (years)	4.50 (5.26)
Household head age (years)	43.95 (12.72)
Level of Crop farming	
Total hectares of land farmed (Ha)	6.51 (44.61)
Physical Capital	
Total Livestock Unit (TLU)	0.97 (4.75)
Poultry housing index	3.37 (3.00)
Social Capital/Community Sharing	
Participate in community sharing (receive assistance from others during a crisis, Yes = 1; No = 0)	0.81
Poultry seller's association membership (Yes = 1; No = 0)	0.22
Financial Capital: Credit access (Yes = 1; No = 0)	0.23
Household Characteristics	
Household size	5.52 (2.94)
Household head gender (male = 1; female = 0)	0.90
Log Income (Household average monthly income in the past 12 months; range: ₦500 – 288,333)	9.84 (0.99)
Access to facilities	
Market access (Yes = 1; No = 0)	0.89
Distance to town market (minutes walk from home)	355.34 (622.13)
Facilitating Factor/Level of HPAI Event	
Compensation (Yes = 1 No = 0) - represents households located in village with outbreak and whose birds were culled	0.24

Table 7: Coefficients of Correlation between Equation Error terms

Equations for CRM Decisions	***Coefficient (std. error)***
Restock full and Migrate	-0.0979 (0.1437)
Restock full and Immediate bird sale	0.1100 (0.1344)
Restock full and Diversify	0.0113 (0.1567)
Restock full and Borrow	-0.2542 (0.1138)**
Migrate and Immediate bird sale	0.4372 (0.1660)***
Migrate and Diversify	0.2103 (0.1663)
Migrate and Borrow	0.3177 (0.1350)**
Immediate bird sale and Diversify	0.5940 (0.2126)***
Immediate bird sale and Borrow	0.4181 (0.1255)***
Diversify and Borrow	0.1334 (0.1535)

***1% significance level, ** 5% significance level, *10% significance level

Table 8: Parameter Estimates from the Multivariate Probit Model of Factors Affecting the Adoption of HPAI Coping and Risk Management Strategies

Explanatory Variable	***Restock birds fully up to the ex ante level***	***A household member migrate to seek employment in town***	***Immediate Sale of Remaining Birds***	***Diversification into Non-farm Activity***	***Borrowing cash or birds to buy food, diversify or restock***
	Coeff. (Std error)	Coeff. (Std. error)	Coeff. (Std. error)	Coeff. (Std error)	Coeff. (Std. error)
Human Capital					
Head poultry experience	0.0812*** (0.0229)	-0.0293 (0.0332)	-0.0041 (0.0222)	0.0316 (0.0320)	0.0097 (0.0174)
Head age	0.0037 (0.0079)	0.0022 (0.0098)	-0.0231*** (0.0077)	-0.0134 (0.0114)	0.0020 (0.0072)
Level of Crop farming					
Total hectares of land farmed	-0.0047 (0.0091)	-0.1669** (0.0733)	0.0077 (0.0101)	-0.1381* (0.0803)	0.0021 (0.0019)
Physical Capital					
Total Livestock Unit	-0.0402 (0.0648)	-0.0644 (0.0907)	0.0219 (0.0169)	-0.1110 (0.1387)	0.0335* (0.0178)
Poultry housing index	0.1317*** (0.0321)	0.0057 (0.0401)	0.1940*** (0.0378)	0.0178 (0.0443)	0.0283 (0.0304)
Social Capital/Community Sharing					
Participate in community sharing (receive assistance from others during a crisis)	0.3489 (0.2584)	1.4524*** (0.4251)	0.6821*** (0.2406)	0.7032* (0.3787)	0.1962 (0.2319)
Poultry Association	0.3752* (0.2068)	-0.6280** (0.2773)	0.0781 (0.2403)	-0.5815* (0.3404)	0.1703 (0.2052)
Financial Capital:	-0.3734*	-0.3949	-0.3186	-0.1926	-0.0786
Credit access	(0.2109)	(0.2707)	(0.2256)	(0.2817)	(0.1996)
Household Characteristics					
Household size	-0.0757* (0.0377)	0.0810* (0.0453)	0.1446*** (0.0415)	0.0618 (0.0506)	0.0700** (0.0342)
Head gender	0.2691 (0.3258)	-0.0688 (0.3885)	-0.4834 (0.3393)	0.4039 (0.5256)	-0.3468 (0.2981)
Log Household Income	0.0465 (0.1033)	0.1985 (0.1360)	0.1000 (0.1026)	0.0229 (0.1540)	-0.2930*** (0.0995)
Access to facilities					
Market access	0.6952** (0.3262)	-0.5523* (0.3111)	0.0360 (0.3025)	0.1076 (0.4025)	-0.1467 (0.2628)
Distance to town market	-0.0007** (0.0003)	-0.0005 (0.0004)	-0.0004** (0.0002)	-0.0002 (0.0003)	-0.0002 (0.0002)
Facilitating Factor/Level of HPAI Event					
Compensation	-0.2020 (0.2055)	0.9409*** (0.2319)	0.4823** (0.2377)	0.4314 (0.2619)	0.4646** (0.1940)
_Constant	-2.4391** (1.0646)	-3.7267*** (1.3731)	-0.8158 (0.9696)	-2.1947 (1.5152)	1.7958* (0.9377)

Log likelihood = -545.1522; Wald χ^2 (70) = 170.95; Prob > χ^2 = 0.0000; No. of obs = 272

Log likelihood ratio test of $\rho 21 = \rho 31 = \rho 41 = \rho 51 = \rho 32 = \rho 42 = \rho 52 = \rho 43 = \rho 53 = \rho 54 = 0$: $\chi^2(10)$ = 33.0451 Prob > χ^2 = 0.0003

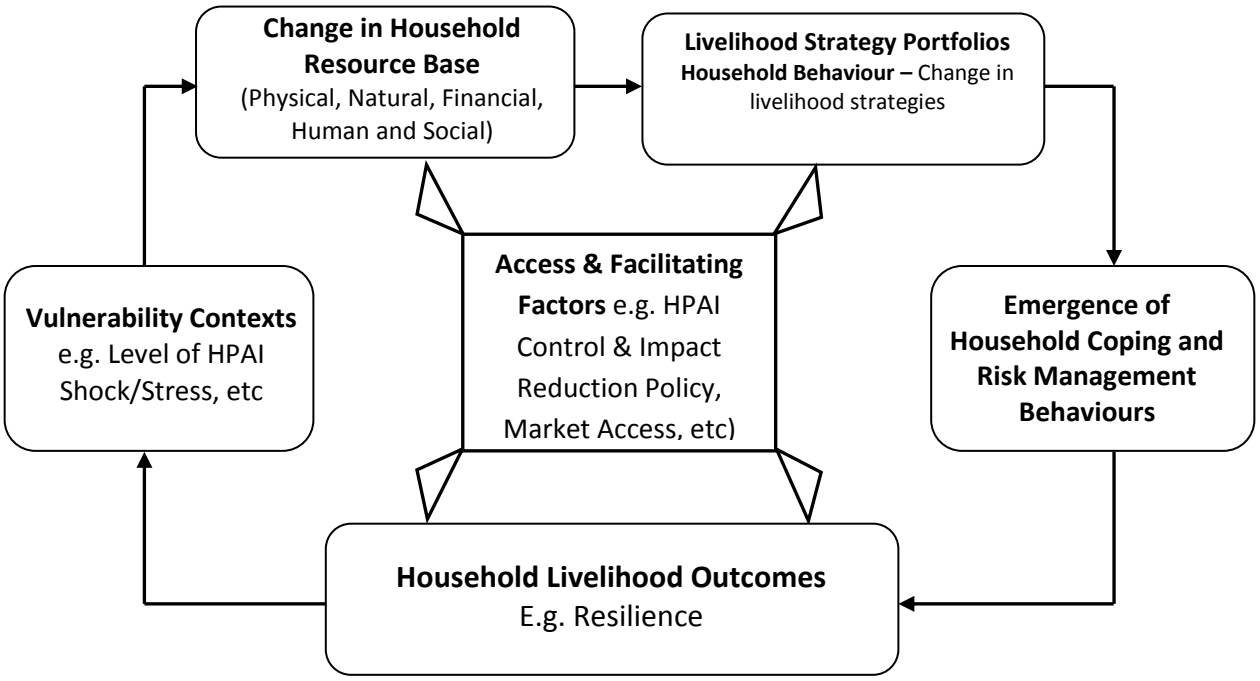

Figure 1: A Sustainable Livelihood Framework Adapted to Capture Household Coping and Risk Management Behaviour

Source: Adapted from Oparinde and Birol (2008)