Economic analysis of enhanced biosecurity practices in three types of chicken farms in Northern Vietnam

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Abstract

This paper describes the adoption of the Enhanced Biosecurity Practices (EBP) recommended by the Food and Agriculture Organization (FAO) and Vietnam's Department of Livestock Production (DLP) and compare profitability between adopters, who were supported by a project, and non-adopters in 5 provinces of Vietnam. On-farm interviews were conducted on 34 broiler farms, 20 chicken breeder farms, and 40 hatchery operations. The study found that all project supported model farmers were aware of proper biosecurity management and its role in chicken production. The percentage of farms that adopted EBPs differed widely between the two farms groups (model and control farms). Almost all biosecurity measures recommended by FAO-DLP were implemented by model farms, except for 2 measures: keeping daily farm records and spraying disinfectants on transportation vehicles and before entering the farms. In terms of antibiotic use, model farms use less antibiotic than control farms in both chicken broiler and layer production.

The results show that the recommended biosecurity practices in the chicken production chain substantially increase productivity, resulting in an increase in farms' profitability. In general, the profit markup of the model farms was higher than that of control farms in all types of chicken production. Model chicken breeder farms had highest profit markup (61.1%), followed by model chicken hatcheries (41.9%), and model chicken broiler farms (25.6%), while control chicken broiler farms had the lowest profit markup (6.31%). Based on the results of this study, it is recommended that the EBP should be promoted among chicken producers as a means to increase profits.

Keywords: biosecurity, chicken farms, profit mark-up

Introduction

The poultry industry is an important sub-sector in Vietnam's agriculture sector. In the past 10 years (2005-2014), the poultry population has increased faster than the average livestock species and has achieved the highest growth rate compared to other major meat subsectors (Tung 2017). In 2018, poultry accounted for 20.6% of domestic meat production in Vietnam (GSO 2018). Despite the increasing demand, poultry production faces numerous constraints. One of these is poor biosecurity status throughout the poultry value chain, which can significantly reduce productivity, product quality and profitability.

According to Permin and Detmer (2007), poultry biosecurity is a set of preventive measures designed to reduce the risk of disease transmission onto and from the farm. Biosecurity is key within the poultry industry in preventing the introduction and spread of disease and infections. Biosecurity is made up of three components: segregation, cleaning and disinfection (FAO 2008). There is growing evidence that biosecurity practices have the potential to increase farm

productivity, profitability and reducing disease risk in poultry farms. Despite to recognized importance of biosecurity, there is lack of or insufficient biosecurity measures practiced by poultry producers, leading to a decreased performance and profitability.

The Food and Agriculture Organization of the United Nations country office for Vietnam (FAO), through its Emergency Centre for Transboundary Animal Disease Operations (ECTAD), in collaboration with the Department of Livestock Production (DLP) has developed a minimum biosecurity package for poultry production. The FAO-DLP's Enhanced Biosecurity Practices (EBP) intends to prevent the introduction and spread of infectious diseases, improve the environment and protect the health of workers. There are four key components: (i) Improvement of farm/hatchery infrastructure; (ii) Improvement of farming conditions; (iii) Improvement of cleaning conditions; and (iv) Behavioral change. From 2012 to 2018, FAO-DLP supported the development of 17 broiler model farms, 10 chicken parent stock farms and 20 chicken hatchery models in five provinces with high chicken density in Vietnam: Ha Nam, Bac Giang, Thai Nguyen, Vinh Phuc and Hung Yen. There is limited information available on the adoption of EBP and its impact on poultry production in Vietnam. This study aimed to assess current status regarding adoption of the EBP and its impact on chicken production in the project provinces.

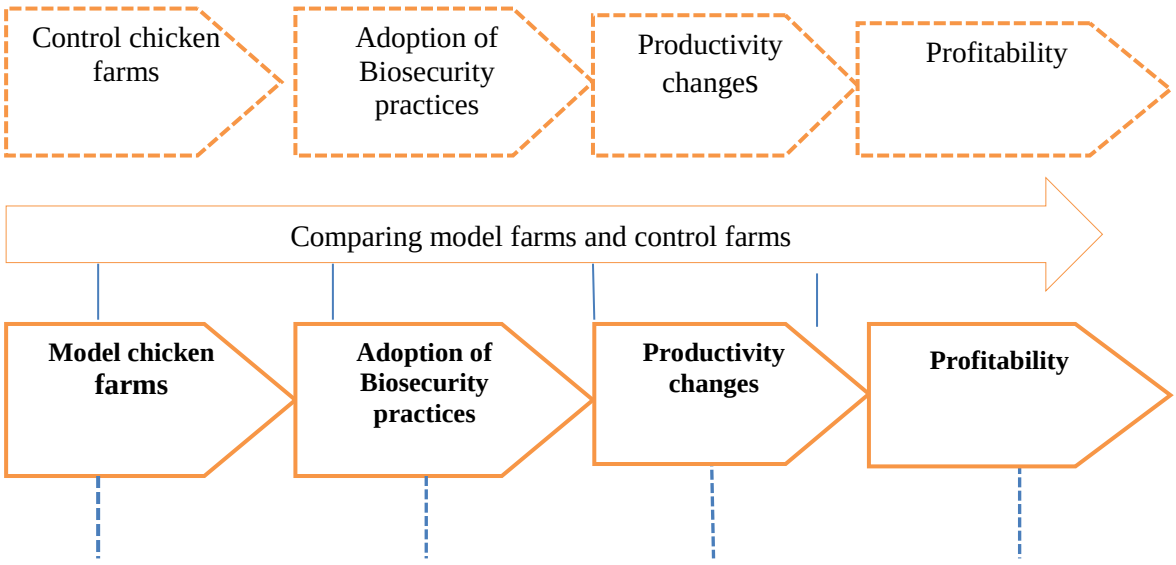
The specific objectives of the study were to determine the adoption level of EBP and to conduct a comparative profit analysis for adopters and non-adopters in five provinces of Vietnam. The results of this analysis can be used to raise awareness among stakeholders in the poultry value chain and advocate for the adoption of the EBP and support policy makers in promoting the EBP by showing its impact on farm profitability.

Methodology

Conceptual framework

The impact of any intervention is commonly assessed through (i) the comparison of the situation before and after the intervention and (ii) the comparison of the situation with and without the project intervention at the end of the project. Due to a lack of baseline information, in this case, the second approach was adopted.

Figure 1 presents the analytical framework of the study



- Broiler farms - Breeder farms - Hatchery farm	- Improvement of farm infrastructure - Improvement of farming conditions - Improvement of cleaning conditions - Behavior change	Adoption of biosecurity practices leading to changed mortality rate/% of dirty eggs/% of non-embryos egg/hatching rate, etc.	- Reduced production cost (variable +fixed cost) - Increased benefits (revenue)

Figure 1. Analytical framework of the study

Data collection

This study was conducted in five provinces of Northern Vietnam: Ha Nam, Bac Giang, Thai Nguyen, Vinh Phuc and Hung Yen. These are provinces where FAO-DLP collaborative projects supported the development of piloted chicken hatcheries and parent-flock-farm and broiler farm models.

A mix sampling method was used for this study, where purposive sampling techniques were adopted to identify respondents. The first stage involved the selection of all model farms supported by FAO. In the second stage, other farms were selected as controls if they were located in the same district with similar production type (broiler or layer), housing, flock size and breed.

A sample of 47 model farms of chicken broilers, hatcheries and chicken parent flocks were chosen for the study. The same number of control farms in these five project provinces was selected and visited. The study used direct observations and structured interviews based on pre-designed semi-structured questionnaires with the 94 chicken producers, to assess biosecurity implementation, management practices, and the profitability of adoption of these biosecurity practices.

Table 1. Number of respondents by farm types

Types of farms	**No. of model farms**	**No. of control farms**
Chicken broiler farms	17.0	17.0
Chicken breeding farms	10.0	10.0
Chicken hatcheries	20.0	20.0
Total	47.0	47.0

Framework for comparative economic analysis

Data collected was analyzed by using descriptive statistics and farm budgeting figures. Descriptive statistics were used to describe socio-economic characteristics of the surveyed farmers, level of adoption of biosecurity practices, and benefits as well as problems associated with the adoption of the enhanced biosecurity practices.

The adoption rate of each component was calculated by dividing the number of EBP adopters by the total number of surveyed farmers in the project areas.
AR=(A/N)*100

Where AR represents the percentage of adopters, A is the number of adopters and N is the total number of surveyed farmers in the project area.

The farm collected variables that were used to compute the benefit and cost parameters. Cost included all the cost required during the whole production stage. All cost were converted into monetary value using their respective quantities and market prices. Benefits in this study refer to all the outputs generated from poultry production that have a value. The benefits were also converted into monetary values by multiplying their respective quantities by their market value.

(i) Calculating cost for poultry production (C)
The cost of production is the sum of the fixed cost and the variable cost of the enterprise. That is C= V + F, where C is the total cost to produce 100 lwkg of broilers, 100 eggs, or 100 Day-Old-Bird (DOB) depending on the type of chicken farm; F represents the fixed cost and V is a variable cost.
Variable cost includes all the different inputs that are needed for operating poultry production or hatchery operation such as feed, labour, water, electricity, and others.

Fixed cost includes the cost of poultry houses and equipment. The cost of housing was calculated taking into account the depreciation cost, interest on the value of housing, and maintenance cost. Cost of equipment was calculated by taking into accounts the depreciation cost and interest on the value of the equipment.

The total cost of production is calculated by using the following formula:
TC=TFC+TVC, where, TC is total cost of production; TFC is total fixed cost and TVC is Total variable cost.

(ii) Calculating benefit from poultry production (B)
The main outputs of poultry production are eggs and birds. In some farms, as birds are reared in a closed system, the poultry litters are also considered as revenue sources of the poultry enterprises.
Revenue is computed as TR=P*Q, where TR is total revenue, P is the price per bird or egg and Q is the number of birds or eggs.

(iii) Net income (NI)
Net profit (NP) = TR-TC

(iv) Profit mark-up as an indicator for analysis
In this case, profit mark-ups were used to measure the profitability of the farms, which produce broilers (broiler farm), breeding eggs (parent stock breeding farm) or day-old chicks (hatchery). The profit mark-up were computed accordingly to the type of the farm.
Profit mark-up was calculated by subtracting the total cost of production to the total revenues and dividing such difference by total cost, as in the following equation

Profit mark-up percentage = (R-C)/C;

where R is revenue, C is the cost to produce a product.
In order to quantify and measure the indirect benefits from participating in the project as a model farm, the Likert Scale was used to measure farmer's perception on indirect benefits identified by the investigator. This scale assessed the perception towards a topic by asking model farmers to indicate how important each of the indirect benefits were on a five-point

scale, where 1 indicates insignificant importance and 5 indicate substantial importance. The mean score was used to rank indirect benefits.

Results and discussions

Socio-Economic Characteristics of Adopters and Non- Adopters of Enhanced Biosecurity Practices

Socio-economic characteristics of model farmers (adopters) and control farmers (non-adopters) of Enhanced Biosecurity Practices (EBP) which directly or indirectly affect their chicken production are presented in Table 2.

Table 2. Key characteristics of studied chicken broiler farms in Project provinces

Indicators	Unit	Broilers (n=34)		Parent stocks (n=20)		Hatcheries (n=40)	
		Model farmers	Control farmers	Model farmers	Control farmers	Model farmers	Control farmers
n	Farms	17.0	17.0	10.0	10.0	20.0	20.0
Age of farm owners	Years	44.8	46.5	47.4	45.2	46.1	46.6
Education							
-Primary school	%	5.90	5.90	-	-	-	-
-Secondary school	%	64.7	70.6	50.0	60.0	50.0	50.0
-High school	%	23.5	23.5	40.0	40.0	45.0	50.0
-Technical school	%	5.90	-	10.0	-	5.00	-
Poultry raising experience	Years	9.90	9.60	10.1	8.70	11.2	14.5
Family size	Persons	4.70	4.40	4.80	4.90	4.90	4.90
Workers/farms	Workers	2.60	2.60	2.90	3.00	2.60	3.10
Family labor working in poultry enterprise	Workers	1.90	1.60	2.30	2.20	2.00	2.20
No. Hired laborers	Workday	630	360	1,210	1,632	405	1,050
Total agricultural land area/farm	m^2	11,061	8,193	13,504	6,209	10,932	5,379
Living land area	m^2	553	575	538	579	447	435
Raising area/incubatory area	m^2	4,650	2,881	3,572	2,566	135	116
Poultry housing area/hatchery area	m^2	698	503	1,602	1,660	34.3	17.3

Source: Field survey.

Chicken farm owners' age was reasonably consistent across the 3 farm types. The average age of the owners of chicken breeder farms (47) was higher than chicken hatchery farms (46) and broiler farms (44). The largest proportion of chicken broiler farmers falling in the 35 to 49 age category. The parent stock farmers tended to be older, with 60% falling between 45 to 55 years of age. The largest proportion (55%) of hatchery operators fell in the 45 to 55 age group. This may suggest that the ages of farmers for all thee farm types were fairly in their active years.

The most common level of education for farm heads was the secondary school with almost half of the respondents having completed middle school. The mean educational level is consistent across farm types. Percentage of farm owners having completed the technical school of model farms is higher than for control farms. This could be a reflection of the increased managerial skills required to operate a model farm operation.
Labor available to chicken producers include family members and temporarily employed workers. The most common type of labor used for chicken production purposes is family member. The result shows that over 30.8 % percent of the producers indicated that they used hired labor for chicken production purposes, varied from 14.7% of chicken breeder farms and 50% for hatcheries.

The broiler housing was mainly open-cages with opening on the side blocked by iron nets or bamboo curtains. The model farmers have rolling canvas operated by hand winch, ventilated ceiling and industrial suction fans at the end of the cage (when pulling down a canvas, turn on the fan to keep the cage close), automatic drinking water system. Whereas, the chicken breeder shelters are mainly windowless in both model and control farms.

Table 3. Meat production in studied chicken broiler farms

Indicators	**Model farmers**	**Control farmers**
n	17	17
Number of chicks (chicks/farm)	3,029	2,458
Growing period of chick (week)	14.9	16.1
No. of batches/year	3.31	3.32
Mortality rate (%)	3,51	6.82

Source: Field survey

The average number of chicks per farm was 3,029 in model group and 2,458 in the control group. There was no significance difference between the farm groups in terms of the chick growing period. The average chick growing periods were 14.9 weeks in model group and 16.1 weeks in the control group (Table 3).

The number of production cycles or batches per year varied among the survey farms; although, the average number of batches per year was the same for both, model and control farms (3.3 batches per year). A majority (71%) of the model farmers raised less than 3 batches per year, whereas 35.3% of the control farmers raised at least 4 batches per year.
Some control farmers reared broilers in multiple batches of brooding and rearing of broilers at the same time in the year. The model farms practiced the all-in-all-out system of rearing broilers have shorter growing period and lower number of batches per year. In term of mortality, model farms had lower mortality (3.5%) compared to control farms (6.8%).

Table 4. Flock and layer performance of studied chicken breeding farms

Indicators	Model farmers	Control farmers
n	10	10
No. of layers	4,245	5,190
Production period (months)	16.1	13.6
Laying period (days)	301	225
Mortality rate (%)	13.4	16.2
Average laying rate (%)	51.8	49.6
No. of eggs/layer /laying period	149	113
Percentage of dirty eggs (%)	2.10	3.20
Percentage of non-embryos egg (%)	9.10	11.0

Source: Field survey

Model breeding farms (Table 4) had smaller flock size (4,245 laying hens, ranged from 900 to 16,000 layers) compared to control farms (5,190 laying hen, ranged from 800 to 31,000 layers). The production or keeping period of laying hens was found to be 16.1 months in model farms and 13.6 months in control farms respectively. Time for depopulation depends not only on the laying rate, but also on the price of eggs and the price of spent hens.

The number of eggs per hen per laying period was lower in the control group than in the model group. The average number of eggs per layers was 149 per laying period in model farms and 112 eggs in control farms.

Table 5. Capacity of the studied chicken incubators

Items	Unit	Model farmers	Control farmers
n	Farms	20	20
No. of incubators	Incubators	4.10	4.10
Capacity (egg)	Eggs/batch	51,850	61,250
No. of eggs incubated per month	Eggs	47,790	35,641
Total no. of eggs incubated during 12 months	Eggs	510,778	409,012

Source: Field survey

Table 5 showed that the average number of incubators owned by model hatcheries is almost the same as the control hatcheries. The average capacity of the studied incubators owned by model hatcheries was lower than that of control hatcheries. However, the number of eggs incubated per month was higher in model farms/hatcheries than control farms/hatcheries.

Table 6. Adoption of biosecurity measures in studied chicken broiler farms in the project province (%)

Biosecurity measures	Broilers		Parent stocks		Hatcheries	
	Model farmers	Control farmers	Model farmers	Control farmer	Model farmers	Control farmer
1.Improvement of farm infrastructure						
Repair/upgrade/build animal house (for hatchery: Separation of hatchery from living area)	94.1	-	90.0	70.0	95.0	20.0
Repair/upgrade/build perimeter fence	100	88.2	100	90.0	100	90.0
Repair/upgrade/build drainage system	88.2	11.8	90.0	60.0	90.0	30.0
Repair/upgrade/build feed storage (for hatchery: Improve hatchery infrastructure by lifting the roof and making new windows to promote ventilation and reduce the temperature during summer time)	100	47.1	100	70.0	65.0	5.00
Repair/upgrade/build egg storage			70.0	10.0	55.0	10.0
Buy egg fumigation cabinet			90.0	10.0	90.0	15.0
2. Improvement of farming conditions						
Buy/install a drinking system	100	23.5	90.0	40.0		
Buy/install laying nests		-	100	90.0		
Make new hatching machines with relevant equipment for separating egg incubation from hatching (now egg incubation and hatching in the same machines)					90.0	35.0
3. Improvement of cleaning conditions						
Purchasing new slippers/boots	94.1	23.5	100	40.0	95.0	20.0
Installing place and equipment for hand washing	100	35.3	90.0	70.0	95.0	60.0
Purchasing waste bin/waste treatment	35.3	-	50.0	20.0	75.0	40.0
4. Behavior change						

Table 6. Adoption of biosecurity measures in studied chicken broiler farms in the project province (%)

Biosecurity measures	Broilers		Parent stocks		Hatcheries	
	Model farmers	Control farmers	Model farmers	Control farmer	Model farmers	Control farmer
Use the right dose of the vaccine	70.6	23.5	100.0	10.0		
Raise one flock or isolate two flocks follow the principle: "all-in and all-out" (For hatchery: eggs must be originated from healthy herds)	94.1	58.8	90.0	90.0	95.0	90.0
Cleaning, correctly hanging drinker and feeders, wash feeders and drinkers daily, keep the floor dry, add probiotics (for hatchery: Clean the hatchery including surrounding area)	88.2	29.4	100	30.0	95.0	20.0
Cut off trees, clear the garden, open drainage for dry and airy gardens	100	41.2	90.0	10.0	95.0	5.00
Use chemical disinfectant properly, do not spray disinfectant to poultry	88.2	-	90.0	10.0	95.0	25.0
Spray disinfectants on transportation vehicles and before entering the farms	52.9	-	20.0	10.0	10.0	-
Daily recording	29.4	-	20.0	10.0	10.0	5.0
Rearrange the facilities to make one-directorial movement.					65.0	30.0

Source: Field survey

Adoption of Biosecurity practices by farm types

Different components of the Enhanced Biosecurity Practices (EBP) recommended for chicken producers and the percentage of adoption of each practice are given Table 6. Adoption level was expressed as a percentage of a single measure adopted by farms. Across all farm types, model layer farms had a better understanding of biosecurity.

Farmers who participated in the FAO-DLP projects appreciated almost all recommended practice and they mentioned that those measures were relevant for their chicken production. There was a significance variation in the adoption of different measures of the EBPs between the two groups of farms. Almost all EBP were implemented by the model farmers, while a few EBP were adopted by the control farms.

The two recommended practices that stand out as the most widely implemented by all model farm types are: upgrading or building a perimeter fence, at 100% adoption; Installing place and equipment for hand washing, at nearly 100%. Improvement of farming conditions is an important factor that reduces disease risk. The results showed that buying and installing drinking system practiced more commonly on broiler chicken model farms (100%) than layer farm models (90%). Only 23.5% of broiler control farms had bought and installed new drinking systems. Three least adopted biosecurity measures for the model farms were the use of the right dose of the vaccine, spraying disinfectants on transportation vehicles and before entering the farms, and daily recording.

Spraying disinfectants on transportation vehicles and before entering the farms adoption was low at 52.9 percent compared with zero percent in broiler control farms. The limited availability of these disinfectants was an important reason for their low adoption. Keeping farm records is one of the most important recommendations for managing poultry farms. The practice was adopted by 29.4 percent of model farmers, while zero percent for broiler control farmers, 10% breeder farms and 5% control hatchery operation adopted this practice.

Productivity changes

The results for a comparison of chicken productivity in the model farms before and after intervention are shown in Table 7. Evidence from farm records of the model farms showed that the implementation of the EBPs in all three types of chicken farms can substantially benefit the farmers in term of increased productivity.

Table 7. Change in productivity after the intervention

Items	Unit	Before intervention	After intervention	% changed
Broiler farms	Farm	13*	13*	
Daily weight gain	Gram/day	18.7	20.8	11.2
Slaughter weight	Kg/head	2.00	2.20	10.0
Mortality rate	%	6.60	4.90	-25.8
Breeder farms	Farm	7*	7*	
Drop-out rate	%	16.0	13.4	-16.3
Laying rate	%	45.6	47.9	5.00
Egg yield (Av. number of eggs/hen)	Egg/hen	148	155	4.70
Dirty or cracked eggs	%	2.80	1.30	-53.6
Rate of fertile eggs	%	16.3	10.0	-38.7
Hatchery operations	Farms	7*	7*	
Rate of fertile eggs	%	83.3	88.8	6.60
Rate of rotten eggs	%	0.70	0.30	-57.1
Hatching rate	(%)	71.6	77.6	8.4
Rate of quality I/DOB	(%)	97.0	98.1	1.1

Mortality rate after hatching	(%)	0.50	0.20	-60.0

**Not all surveyed farms had recorded this kind of information*

Comparative economic analysis of model and control farms

The economic analysis of chicken production on production cost and revenue among the the sample farmers of three farm types with and without the participation of the FAO-DLP projects are presented in Table 8 and Table 9.

Table 8. The production cost in studied chicken farms

Cost items	**Broilers** (000VND/(100 kg live weight)		**Parent stocks** (000VND/(100 breeding eggs)		**Hatcheries** (000VND/(100 DOC)	
	Model farms	**Control farms**	**Model farms**	**Control farms**	**Model farms**	**Control farms**
I.Total variable cost	4,299	4,897	366	487	718	792
Chick purchase cost	567	559	135	203	627	684
Feed	2,978	3,419	186	218		
+ Complete feed	2,784	3,419	186	216		
+ Other feed	194	0.0	-	1.4		
Electricity	52.8	53.1	9.00	14.2	12.3	22.2
Veterinary/ medication	328	484	14.5	16.5		
Of which, antibiotics	136	295	9.10	6.80		
Cleaning/disinfecting	7.70	14.9	1.20	0.70	1.20	1.50
Labour	307	331	19.0	32.3	34.8	49.4
Other cost	58.3	33.9	0.60	2.20	42.0	35.6
II.Fixed cost	188	248	30.0	56.9	7.91	15.8
Building depreciation*	439	375	17.6	5.81	5.82	10.2
Building repair cost	0.81	1.92	0.11	0.43	0.62	0.71
Machinery depreciation	16.3	0.84	1.45	8.31	0.21	0.32
Others	0.0	0.0	-	-	1.3	4.7
Total cost (I+II)	4,488	5,146	396	544	725	808

Source: Field survey

**Depreciation cost were calculated for buildings only, excluding land value, since land cannot be depreciated as the value of land appreciates with time.*

The cost of production of the broilers, breeding eggs or day-old-chicks is the total expenses incurred in obtaining the final product. These cost include the cost of breeding chicks/eggs,

expenditure on of feeds and medicine, labor cost, housing depreciation, etc. Variable cost varies with the changes in the number of outputs produced, while the fixed cost remains constants over time and does not vary within then changes in the level of output. The total production cost of model farms was lower than control farms across all farm types. Among the component of the total cost, feed cost occupied the highest share in both broiler and breeder farms. Variable cost constituted a significant part of total cost. The share of variable cost in the total cost varied from 89.6% in control breeder farms to 98% in control hatchery operations. Interestingly, the cost of antibiotics of model broiler farms was almost two times lower than in control farms. However, this observation is not consistent with breeder farms.

Table 9. Comparison of economic performance between two groups of farms

No.	***Items***	**Broilers (**000VND/(100 kg live weight)		**Parent stocks (**000VND/(100 breeding eggs)		**Hatcheries (**000VND/(100 DOC)	
		Model farms	**Control farms**	**Model farms**	**Control farms**	**Model farms**	**Control farms**
A	Gross production	5,636	5,470	638	647	1,029	922
B	Variable cost	4,299	4,897	365	487	717	792
C	Total production cost	4,488	5,146	395	543	725	808
D	Net value benefit (A-B)	1,336	573	272	161	312	129
E	Profit mark-up ((A-C)/C))*100	25.6%	6.3%	61.1%	19.1%	41.9%	14.1%

Source: Field survey

With the limited support, chicken producers experienced a great reduction in their cost of production as well as an increase in productivity. The profit markup of model farms was higher than that of control farms in all types of chicken production. Model chicken breeder farms (61.1%) had the highest profit markup, followed by model chicken hatcheries (41.9%), model chicken broiler farms (25.6%). The control chicken broiler farms (6.3%) had the lowest profit markup. The results are relatively consistent with the finding of the study carried out by on Economic analysis of broiler production in Peninsular Malaysia (Abdurofi et all 2017) where profit rate varied from 9% in Northern to 23% in Central region. The profit markup of chicken was found to be 43% for traditional system and 46% for integrated farming system in Can Tho by Nghi et al (2017).

Based on our finding, it is strongly recommended that FAO-DLP should continue to disseminate biosecurity management practices to chicken hatcheries. Although there is a positive correlation between the adoption of biosecurity practices and economic performance, this study may not provide valid evidence for a formal cause-effect relationship. This is due to the lack of data from model and control farms before the intervention for prospective comparison.

Table 10. Indirect benefits participating in the model of studied chicken broiler farms

Items	**Broilers**		**Parent stocks**		**Hatcheries**	
	Mean scores	Ranks	Mean scores	Ranks	Mean scores	Ranks
Improve the working	4.88	I	4.63	I	4.50	II

environment of farmers						
Save working time: hours/working day	4.24	III	3.54	III	3.80	III
Improve farmer health	4.64	II	4.45	II	4.60	I

**scale is rated 0 to 5, where 0 means NOT a value/benefit, 1 means very low value/benefit, and 5 means very high value/benefit.*

Table 10 shows the extent of the chicken producer's knowledge regarding the indirect benefit of minimum biosecurity adoption. Two indirect benefits such as "Improve the working environment of farmers" and "Improve farmer health" were ranked highest by all three farm types. These were two of the important indirect benefits of model participation, according to the perception of the farmers.

Chicken producers were asked to rank the environmental-social benefits of the minimum biosecurity practice adoption. Reducing environmental pollution was cited to be the most important environmental benefit of this biosecurity strategy. "Having access to new knowledge/technology" were the second most important factor.

Table 11. Environmental-social benefits of the model participant/compared to before participation in the model

Items	**Broilers**		**Parent stocks**		**Hatcheries**	
	Mean scores	Ranks	Mean scores	Ranks	Mean scores	Ranks
Contribution, the participation of women	4.17	III	4.27	II	4.50	I
Having access to new knowledge/technology	4.41	II	4.27	II	4.35	II
Reducing environmental pollution	4.64	I	4.45	I	4.40	II
Effective use of waste	3.52	IV	3.54	III	3.45	III

**scale is rated 0 to 5, where 0 means NOT a value/benefit, 1 means very low value/benefit, and 5 means very high value/benefit.*

Constraints associated with scaling up the adoption

Poultry farmers recognized that one of the most important barriers to replicating the model in the community was lack of additional capital. The land shortage was identified as the second-largest barrier by 70% of the survey breeder farmers and 60% of the survey hatcheries. Limited access to breeding chicks/eggs were perceived as the third biggest problem. Whereas limited access to supplies, equipment age was perceived as a major problem.

Table 12. The reason the model was not replicated in the community (%)

Items	**Broilers**	**Parent stocks**	**Hatcheries**
Lack of additional capital	91.2	95.0	77.5
Lack of land area	18.7	70.0	60.0
Labor shortage	21.5	10.0	12.5

Limited access to breeding chicks/eggs	39.9	40.0	47.5
Limited access to supplies, equipment	9.05	25.0	32.5

Source: Field survey

Conclusions and recommendations

- The results of the study found that all of the model farmers were aware of the need for proper biosecurity management and its role in poultry production. The percentage of farms that adopted EBPs differed widely between the two farms groups (model and control farms). Almost all biosecurity measures recommended by FAO were implemented by model farms, except for 2 measures such as spraying disinfectants on transportation vehicles and before entering the farms and keeping daily farm records.
- Although there is a positive correlation between the adoption of biosecurity/good practices and economic performance, formal causality cannot be proved since there was no baseline data before the intervention available in both model and control farms. The study reveals that with limited support, poultry farmers experienced a great reduction in their cost of production as well as an increase in productivity. In general, the profit markup of model farms was higher than that of control farms in all chicken enterprises. The highest profit markup was found for model chicken breeder farms (61.1%), followed by model chicken hatcheries (41.9%), model chicken broiler farms (25.6%) and the lowest was found by control chicken broiler farms (6.3%).
- The adoption of recommended poultry-production-farm biosecurity and management could bring several indirect benefits to poultry producers as improving the working environment of farmers and improving farmer health.
- Regarding acceptability and replicability, the lack of additional capital was one of the major problems faced by the chicken producers in the study areas for not replicability of the models in the community. Limited access to breeding chicken and eggs were perceived as the second biggest problem by most of the studied farm households. Whereas, limited access to supplies and equipment was perceived as a minor problem by most of the studied farm households.
- Extension organizations and private sector can play an important role in making the benefits of minimum biosecurity measures accessible to more farmers in the province by assisting poultry producers to implement minimum biosecurity measures at farms under close supervision by experienced extension advisors. Farmers could be organized into cooperative groups through which they can be helped to establish sustainable market linkage and enhance their capacity to access competitive prices in both output and input markets. There is evidence suggesting that farmers who use egg fumigation encounter problems, such as formaldehyde gas leaking out of the cabinet which may cause health problems for farmers. In this context, accurate information and introducing a detailed guideline are key factors for maintaining egg fumigation practice. Based on the results of this study, DLP can consider replicate the study in a larger scale to have more statistical power and collecting baselines data for pre and post intervention comparison in both model and control farms.

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