# LASER PULSE

## Long-term Assistance and Services for Research (LASER)
## Partners for University-Led Solutions Engine (PULSE)

# ENHANCING RESILIENCE IN CHICKEN VALUE CHAIN IN BANGLADESH: REDUCING MORAL HAZARD AND IMPROVING FOOD SAFETY STRATEGIES

**SUPPLEMENT TO AGREEMENT NO. AID-7200AA18CA00009**
**AOR Name: Brent Wells**

**, 2024**

## ABOUT LASER PULSE

LASER (Long-term Assistance and Services for Research) PULSE (Partners for University-Led Solutions Engine) is a $70M program funded through USAID's Innovation, Technology, and Research Hub, that delivers research-driven solutions to field-sourced development challenges in USAID partner countries.

A consortium led by Purdue University, with core partners Catholic Relief Services, Indiana University, Makerere University, and the University of Notre Dame, implements the LASER PULSE program through a growing network of 3,000+ researchers and development practitioners in 74 countries.

LASER PULSE collaborates with USAID missions, bureaus, independent offices, and other local stakeholders to identify research needs for critical development challenges and funds and strengthens the capacity of researcher-practitioner teams to co-design solutions that translate into policy and practice.

## ACKNOWLEDGEMENTS

We would like to extend our sincere gratitude to LASER PULSE for their generous funding support, which made this research project possible. Their commitment to fostering innovation and sustainable development in agriculture is truly commendable. We are deeply indebted to the poultry farmers and value chain actors in Bangladesh who graciously provided the necessary data for this study. Their cooperation and invaluable insights have been instrumental in enriching our understanding of the poultry industry and informing our research findings. We also wish to express our gratitude to policymakers, academicians, scientists, and poultry stakeholders who participated in our policy co-creation workshop. Their diverse perspectives, expertise, and collaborative spirit have been integral to shaping informed policy recommendations and fostering meaningful dialogue within the poultry sector. Special thanks are also extended to the Bureau of Socioeconomic Research and Training (BSERT), Bangladesh Agricultural University for their invaluable assistance with financial management throughout our project.

## SUGGESTED CITATION

Dey, M.M., Khan, M.A., Sudhakaran, P.O. Islam, M.S. and Chacrabati, R., 2024. Enhancing Resilience in Chicken Value Chain in Bangladesh: Reducing Moral Hazard and Improving Food Safety Strategies. West Lafayette, IN: Long-term Assistance and Services for Research - Partners for University-Led Solutions Engine (LASER PULSE Consortium).

# EXECUTIVE SUMMARY

**Purpose:** The purpose of the research project is to inform the policymakers on factors influencing unsafe meat production, processing, and sales to devise effective interventions across the poultry value chain in Bangladesh.

**Context:** Concerns about the quality of poultry meat have risen due to the presence of heavy metals such as chromium, cadmium, arsenic, and mercury in poultry feeds. Additionally, the use of antibiotics as growth promoters in poultry and the utilization of steroids, antibiotics, growth regulators, and vegetable oils for chicken fattening raise further health risks. These substances can biomagnify in food chains, leading to severe health hazards like heart attacks, blocked heart veins, cancer, piles, obesity, diabetes, eye problems, joint pain, kidney stones, liver problems, etc., in humans. Long-term health implications from consuming unsafe broiler meat have been documented.

**Methodology:** A comprehensive two-step methodology was employed for data collection, encompassing a systematic literature review and primary data acquisition from the field. The literature review, utilizing the PRISMA model, analyzed 142 papers to evaluate the heavy metal presence, microbial contamination, market structure, and government policies in Bangladesh's poultry sector. Primary data were collected from 412 producers and 393 value chain actors in seven key poultry-producing/marketing areas. Poultry producers were selected through simple random sampling from the Upazila Livestock Office's farmer list, while value chain actors were chosen through snowball sampling. Two interview schedules were tailored for data collection, covering socioeconomic characteristics; Knowledge, Attitude, and Practices (KAP); safe poultry production and selling status; factors influencing practices; moral hazard information; and resilience capacity. PLS-SEM was applied to establish cause-effect relationships for safe poultry production and selling practices, while OLS regression determined factors influencing moral hazard. Poultry producers' resilience capacity was measured using the USAID Resilience Framework.

**Key Findings:** Approximately 47.57% of respondents demonstrated good knowledge, while the remaining had poor knowledge regarding poultry production. Despite positive attitudes towards safe farm management and biosecurity, practical implementation was hindered by the marginal profitability of poultry farming. A considerable number of producers consistently used antibiotics without adhering to proper practices, such as using protective clothing, checking medicine expiration dates, burying dead chickens, and maintaining biosecurity measures. Younger producers exhibited better knowledge and practices of safer poultry production compared to their older counterparts. Education, access to extension services, and levels of knowledge and attitude significantly influence the adoption of safe poultry production. Training and education also play a vital role in reducing moral hazards. Cooperation gaps exist among farmers and other value chain actors, with power dynamics being asymmetric. Resilience capacity is notably low among poultry producers, but indicators like business

competition and evidence-based decision-making contribute to increased resilience. Among value chain actors, 38% exhibited poor knowledge of safe poultry handling, with only 22% possessing good knowledge. Nearly half were unaware of or unfamiliar with the "Poultry Slaughtering and Meat Control Act, 2011." Although three-fourths expressed a positive attitude towards safe poultry practices, only 32% implemented them, indicating a significant gap between attitude and action. Poor practices are prevalent, with 68% handling poultry inadequately. Hatcheries often supply substandard day-old chicks at elevated prices, and medicine company dealers promote indiscriminate and excessive use of antibiotics, vitamins, minerals, and growth promoters among producers.

**Recommendations:** The Department of Livestock Services (DLS), with the assistance of scientists, should develop a Standard of Procedure (SoP) on safer poultry production and marketing to ensure standardized and safe poultry production and marketing in Bangladesh. Based on the SoP, the DLS and other relevant development organizations should develop training manuals and conduct training among poultry producers and value chain actors to update their knowledge about standardized poultry production and marketing. The DLS should develop and design community market layouts and infrastructure that maintain hygiene for both producers and consumers. Wet poultry markets should be separated from other markets and local government should lead this initiative. Finally, prompt quality monitoring of feed and other inputs needs to be enforced by government agencies (including the DLS) to ensure safety through input control and quality improvement of inputs.

# TABLE OF CONTENTS

## LIST OF FIGURES



## LIST OF TABLES

# ACRONYMS

| | |
|---|---|
| BCR | Benefit-Cost Ratio |
| BLRI | Bangladesh Livestock Research Institute |
| BFSA | Bangladesh Food Safety Authority |
| BARC | Bangladesh Rural Advancement Committee |
| DLS | Department of Livestock Services |
| FCR | Feed Conversion Ratio |
| FAO | Food and Agricultural Organization |
| ICDDRB | International Centre for Diarrheal Disease Research, Bangladesh |
| KAP | Knowledge, Attitude and Practices |
| LBM | Live Bird Market |
| MHB | Moral Hazard Behavior |
| MoFL | Ministry of Fisheries and Livestock |
| NVD | Newcastle Disease Virus |
| PDN | Production and Distribution Network |
| PLS-SEM | Partial least squares structural equation modeling |
| PRISMA | Preferred Reporting Items for Systematic reviews and Meta-Analyses |
| SoP | Standard of Procedure |
| USAID | United States Agency for International Development |
| VCA | Value Chain Actors |
| WPSA | World's Poultry Science Association |

# PROBLEM STATEMENT

In Bangladesh, the poultry sector is regarded as important because of its increasing contribution to employment, food security, and the supply of nutritious food items for people across different socio-economic and demographic characteristics (Begum et al., 2011; Simons, 2009). Among Bangladesh's livestock sector, poultry is also one of the fastest-growing meat-based protein suppliers, with an annual growth rate of 28.23% during the last 5 years in Bangladesh (DLS, 2022). On the consumption side, poultry constitutes 80% of the country's total meat consumption with a per capita consumption of 6.3 kg per year (WPSA-Bangladesh, 2019). Poultry production and sales continue to grow due to higher consumer demand fueled by a lower price than other meat (Hamid et al., 2017). Women and educated young people find fewer barriers to entry due to higher profitability and easier husbandry. Women are directly and indirectly involved with different aspects of the business, including poultry rearing, feeding, waste management, etc. (MoFL, 2020).

However, recently, the quality of poultry meat has been a growing concern as heavy metals like chromium, cadmium, arsenic, mercury, etc. have been found in poultry feeds (Mottalib et al., 2018; Shoeb et al., 2016; Islam et al., 2007) and antibiotics have been notedly used as a growth promoter (Saud et al., 2019; Mottalib et al., 2018). Moreover, producers use steroids, antibiotics, growth regulators, vegetable oils, and the like for chicken fattening which can be biomagnified through bio-accumulating in the food chains and can lead to many life-threatening health hazards in humans (Mottalib et al., 2018) like heart attack, blocking heart veins, cancer, piles, obesity, diabetes, eye problems, joint pain, stones in the kidney, and liver problems. Research has shown a link between long-term injuries to human health and the consumption of unsafe broiler meat (Zhong et al., 2020; Mottalib et al., 2018; Macomber & Hausinger, 2011; Uluozlu et al., 2009)

The indiscriminate use of unsafe elements has been identified as a behavioral response to moral hazard. Actors in the poultry value chain, including producers, might be inclined to use these harmful materials due to different factors such as asymmetric market information or a lack of market information about product quality and prices. However, it is difficult to monitor and control the moral hazard activity of actors in the chain. The market does provide some small checks on poor behavior, or educates consumers to a small degree. Still, without a proper policy or market mechanism, value chain actors make decisions to maximize their own returns, while engaging in activities that harm the final consumer, which is considered as moral hazard behavior (MHB).

Therefore, this research works to answer the questions,

RQ1: *What factors are responsible for the MHB in unsafe poultry production?,*
*RQ1a: How can MHB be reduced through proper strategies and stakeholder involvement?*

Several previous types of research have investigated safe poultry meat production and consumer preferences in different countries, social, cultural, and economic contexts (MacRitchie et al., 2014; Venkitanarayanan et al., 2019; Wen et al., 2019; Komínková et al., 2020; Indrawan et al., 2021; Henke et al., 2021). However, there is a dearth of studies that have considered this designated research question.

# OBJECTIVES

This research aims to inform policymakers on factors influencing unsafe meat production, processing, and sales to help them devise effective interventions across the poultry value chain in Bangladesh. The specific objectives are as follows:

1. Evaluating the institutional framework (market, regulation, and policy) to explore the reasons for moral hazard across the poultry value chain;
2. Understanding knowledge, attitude, and practices (KAP) of safe chicken among poultry producers and other value chain actors in Bangladesh;
3. Examining the factors that incentivize the production of unsafe poultry to explain moral hazards poultry producers;
4. Exploring the resilience capacities to shocks of producers and other value chain stakeholders;
5. Develop and conduct training programs for socio-economic and gender-diverse farmers based on the outcome of objectives 1 and 2;
6. Organize national and regional policy dialogues, with the participation of various stakeholder groups and national policy planners.

# METHODOLOGY

A two-step method was employed for data collection, involving a systematic literature review and the acquisition of primary data from the field. The systematic literature review utilized the PRISMA model and scrutinized 142 papers to assess the presence of heavy metals, microbial contamination, market structure, and government policies in the poultry sector. Additionally, primary data were collected from 412 producers and 393 value chain actors across seven major poultry-producing/marketing areas: Dhaka, Gazipur, Rajshahi, Khulna, Satkhira, Cumilla, and Chattogram (Figure 1).

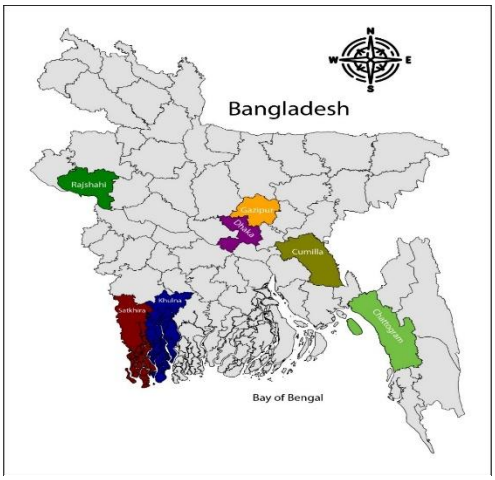



Figure 1: Study area.

Simple random sampling was employed to select poultry producers from a farmer list provided by the Upazila Livestock Office, while snowball sampling was done to select the poultry value chain actors. The poultry producers selection considered their gender, scale of operation and type of chicken reared. Two interview schedules were prepared for data collection, one tailored for producers and the other for value chain actors. The survey included the collection of socioeconomic characteristics, current KAP, factors influencing poultry production or sales, pricing decision factors, moral hazard information, and the resilience capacity. KAP measurement was done by using a scoring system in which all questions and statements were given on a 5-point Likert scale. Afterward, knowledge and attitude were classified as poor knowledge and negative attitude (scores "<50% out of total score"), moderate/fair knowledge and neutral attitude (scores "50%-74.99% out of total score), and good knowledge and positive attitude (score ">75% out of total score). Practices were divided into poor practices (marks below 50% of the total score) and good practice (score ≥50% out of the total score).

The partial least squares structural equation modeling (PLS-SEM) was applied to determine cause-effect relations for safe poultry production and selling practices. The moral hazard in poultry production was assessed by several questions related to production practices, the use of growth promoters and antibiotics, the presale antibiotic withdrawal period, and the like.


Figure 2: USAID resilience capacity measurement.

Finally, survey results were analyzed using the USAID resilience framework which has eight domains or nodes. Every node of the resilience framework has three sub-components such as absorptive, adaptive, and transformative capacity. **Absorptive** capacity indicates the ability to absorb the effects of a shock. **Adaptive** capacity implies the ways in which individuals, households, and communities adapt to shocks and stresses to minimize or contain their effects on well-being. **Transformative** denotes resilience capacities that create the enabling environment for long-term sustainability.

# RESEARCH FINDINGS

## Existing contamination in the poultry value chain: A review

A total of 142 peer-reviewed papers were studied on contamination in poultry meat and feed in Bangladesh. Among them, 110 papers reported bacterial, viral, and fungal contamination in poultry. According to the previous literature, Salmonella spp. and E. coli. are found to be the major contaminants in chickens. Salmonella spp. prevalence was found in about 40% of samples from healthy-looking chickens collected from farms (Sarker et al., 2021). The presence of E. coli has been found in 63.5% of meat samples collected from Bangladeshi retail poultry shops (Rahman et al., 2020). These bacteria showed 80% to 100% resistance to erythromycin, tetracycline, and ampicillin antibiotics (Alam et al., 2020; Rabby et al., 2021; Rahman et al., 2020). The bacteria showed the most susceptibility towards Ciprofloxacin and Gentamicin antibiotics. Avian influenza and Newcastle Disease Virus (NDV) are the most prevalent viruses found in poultry. Fungi are mostly found in poultry feed materials and feeds.

About 15 peer-reviewed papers have reported the presence of heavy metals and trace elements in poultry feed and meat. Among the heavy metals, Chromium was mostly found to exceed the permissible level (Alam et al., 2021; Chowdhury et al., 2021; Korish and Attia, 2020; Tithi et al., 2020 ). Other heavy metals and trace elements like Lead, Cadmium, Arsenic, Nickel, Copper, Manganese, etc. are also found in poultry feed and in some cases in chicken meat and eggs (Korish and Attia, 2020). About 12 papers reported the presence of excess amounts of Chromium in poultry feed and meat (Hossain et al., 2022; Chowdhury et al., 2021). Six papers reported the presence of Lead, and 4 papers reported the presence of Cadmium, Copper, and Nickle in poultry feed and meat (Ullah et al., 2022; Hossain et al., 2022; Chowdhury et al., 2021; Korish and Attia, 2020).

## Institutional framework for the poultry industry in Bangladesh

Several institutions, both government and private organizations, are dedicated to ensuring safer food production in Bangladesh. The Department of Livestock Services (DLS) and the Bangladesh Livestock Research Institute (BLRI) operate under the Ministry of Fisheries and Livestock (MoFL), and focus on livestock welfare. BLRI conducts research, while DLS provides extension services to stakeholders, introducing innovations at the production level. The Bangladesh Food Safety Authority (BFSA), a relatively new agency, employs scientific approaches to ensure overall food quality. International organizations and development partners like the World Bank, FAO, USAID, ICDDRB, and BRAC collaborate with Bangladesh for poultry sector development. Despite these efforts, the lack of coordination and harmonization among these institutions leads to conflicts, overlapping laws, and confusion regarding food safety regulations for both regulatory bodies and the general public.

Beyond policy considerations, several operational challenges warrant attention, with regular monitoring being a critical issue. In theory, monitoring should encompass all stages of food production and marketing, but this is not the current reality. Due to the absence of a robust inspection framework, skilled manpower, adequate budget, and essential physical equipment such as laboratories and rapid test kits, regular monitoring falls short of achieving its intended goal of ensuring food safety.

The monitoring efforts undertaken by the Bangladesh Food Safety Authority rely on mobile courts activated only in response to complaints of food adulteration. However, this approach is limited to sample testing and judicial actions against shop owners upon detection of adulteration or contamination. Unfortunately, these measures do not include proactive steps or risk reduction measures through tracing the source of adulteration or contamination, a crucial aspect for effective prevention.

A significant drawback of these institutions lies in their top-down approach rather than a bottom-up strategy. A bottom-up approach would enable these institutions to address issues at the grassroots level and devise suitable solutions. Establishing a strong linkage between research and extension is pivotal to resolve this problem. A well-executed extension system can disseminate technology from research laboratories to farmers, identify ongoing production-level issues, and inform researchers for targeted problem-solving. Unfortunately, in Bangladesh, the connection between research and extension remains inadequately addressed, leading to a failure to ensure safer food for the populace.

## Policy and Regulations of Institutions:

The aforementioned institutions are governed by specific policies and regulations that delineate their operations in maintaining food safety. Effective implementation of well-defined policies at the field level holds the potential to prevent food adulteration and contamination. However, as Bangladesh transitions from a sole emphasis on production escalation to a more nuanced focus on safer food production, it becomes evident that certain policies and regulations lack clarity in their alignment with food safety objectives. Identifying and addressing the gaps in these policies and regulations is crucial for ensuring comprehensive food safety. Table 1 highlights specific policies, law, regulations, and their identified gaps, offering a systematic overview of areas requiring attention and refinement in the pursuit of enhanced food safety measures.

Table 1: Key findings of policy and regulations

| Policy, Law, and Regulations | Summary | Gaps |
|---|---|---|
| Food Safety Act, 2013 | Rules and regulations for producing safer food from production level to marketing | No documentation of the maximum allowable limits of food additives, growth promoter etc. |
| Regulation on food safety, 2017 | Mentions the maximum permissible level of heavy metals in foods including poultry | Only permissible level of lead in poultry meat is mentioned. |
| Animal slaughter and meat quality control act, 2011 | Animal slaughtering and environment, quality control, and licensing regulations | Does not mention detailed information |
| Animal Feed Rules, 2013 | Animal feed ingredients with standard quality | No regulation regarding heavy metal contamination in feeds |
| Safer food (Microbial contaminants identification and control) regulation, 2021 | Mentions maximum tolerable number of microbial presence in food | Details on Salmonella use and punishment level |

## Poultry Market Infrastructure

In Bangladesh, two predominant types of poultry markets exist: the Live Bird Market (LBM) and the supermarket facilitated through the processed poultry Production and Distribution Network (PDN). The LBM, often favored by the majority of customers, is a public marketplace where live chickens are directly sold, known as a wet market. However, the LBM is considered a potential hot spot for the spread of zoonotic diseases due to its inadequate management system. Live chickens, ducks, and other domestic birds are densely housed within these markets, with manual slaughtering and dressing occurring on-site according to customer requests. The absence of dedicated slaughterhouses makes maintaining hygiene in this open environment, devoid of proper regulations, a challenging task. Common issues include a lack of personal hygiene among poultry sellers, inadequate waste management, and improper cleaning of blood from the slaughtering area. Consequently, the LBM becomes a frequent site for bacterial and viral contamination. Additionally, the LBM is often interconnected with fresh vegetable and fish markets, further complicating the potential for cross-contamination. Therefore, contamination can easily transfer from LBM to fresh vegetable and fish markets and vice versa. Furthermore, the supply sources of chickens in LBMs vary, with birds coming from different small- and large-scale farms and sometimes from contract farms through varying supply chains. Hence, if there is an outbreak or contamination of diseases, it is hard to trace back the source of contamination in chickens in LBMs to

prevent it from spreading. There is no specific law or policy regarding LBM management or regular monitoring. Only one policy regarding the market is present, but that is only concerned with store and marketplace leasing.

Another type of poultry market is supermarkets through PDN. It's mostly regulated by the big poultry companies with their contract farms. There, chickens come from a specifically regulated supply chain and are always supervised from farms to processing plants to supermarkets by experienced staff and veterinarians. Although this pathway is comparatively safer than the LBM, customers prefer mostly fresh chickens from LBM to processed frozen chicken from supermarkets.

## Socioeconomic profiles and profitability

This section provides a brief overview of the current socioeconomic profiles and profitability of the selected poultry farmers and value chain actors. Understanding these factors is crucial for gaining insights into management practices, risk tolerance, and business positions across various farm sizes within the poultry industry. Disparities in socioeconomic circumstances between small and large-scale farmers can significantly influence how resources are utilized in the poultry production process. As such, factors like age distribution, education level, experience, and training among stakeholders are taken into account as key socioeconomic characteristics.

Approximately 44% of both producers and traders were found to be in the age range of 37 to 51 years old, while the second highest category was the young respondents' age range between 18-36 years. In addition to the limited representation of female producers among the respondents (approximately 7% of the total respondents), no female traders were found during the research. Nearly half of the poultry producers had educational qualifications ranging from secondary to higher secondary levels. In contrast, half of the traders had primary education as their highest level of educational attainment. Within the poultry production segment, 55% of producers had less than 5 years of farming experience, while 46% had more than 5 years of farming experience. In contrast, almost 78% of traders possessed over 5 years of poultry selling experience. A significant majority, comprising 83% of poultry producers and 93% of traders, lacked any formal training experience, which is strongly associated with poor practices during poultry production and selling (Appendix Table 1 & 2).

In terms of profitability, a 30-day production cycle for batches of 1000 birds, the calculated profit amounted to Tk. 38,403 (350.64 USD), with an estimated total cost of Tk. 298,116 (2,721.95 USD). Notably, 67% of the total cost was allocated to feed, while 22% was earmarked for the purchase of day-old chicks (Table 2). Also, 3% and 2.6% of the total cost were allocated to medicine and labor, respectively. The benefit-cost ratio (BCR) was determined to be 1.15, reflecting a positive outlook on the economic viability of the poultry production venture. The BCR of 1.15 implies that for every unit of cost incurred, there is a 15% additional benefit, indicating a favorable economic return on the investment in poultry production.

Table 2: Profitability analysis of poultry production (per 1000 birds/production cycle)

| Cost items | Values (Tk.) | % of total cost |
|---|---|---|
| • Feed cost | 175333 | 67.28 |
| • Day-old chick cost | 58500 | 22.45 |
| • Medicine cost | 7880 | 3.02 |
| • Litter cost | 1730 | 0.66 |
| • Labor cost | 6700 | 2.57 |
| • Electricity cost | 1550 | 0.59 |
| • Transportation cost | 750 | 0.29 |
| • Disinfection cost | 1340 | 0.51 |
| • Depreciation cost | 5765 | 2.21 |
| • Land use cost | 1065 | 0.41 |
| ➢ Total cost | 260613 | |
| ❑ Return from live broiler sell | 298116 | |
| ❑ Return from empty feed bag sell | 900 | |
| **Net return** | 38403 | |
| **FCR** | 1.41 | |
| **BCR** | 1.15 | |

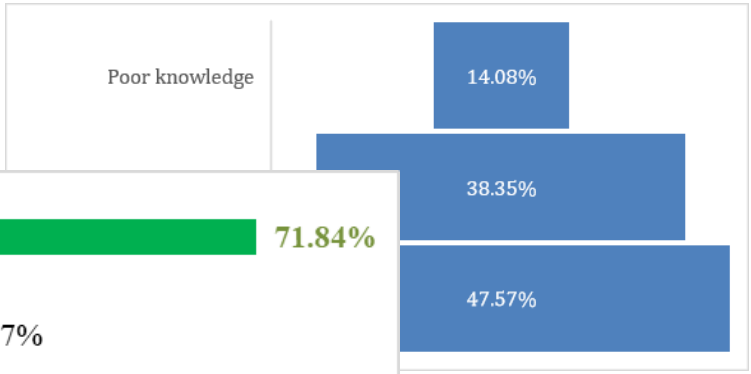
# Knowledge, Attitude, and Practices

## Poultry Producers

The poultry sector in Bangladesh is pivotal for food security and economic stability. U nderstanding the KAP of producers is essential for implementing strategies that enhance the overall health and productivity of the poultry industry. Producers exhibit commendable knowledge in fundamental aspects of input use, showcasing expertise in feeding and brooding rules for new chicks, maintaining vaccination records, and implementing appropriate water change practices. However, during research, only 40% of

respondents displayed good knowledge of the proper use of farm equipment, litter management, space requirements, and biosecurity measures (Appendix Figure 1)

A positive trend is found in disease management practices, with a significant proportion of producers demonstrating adequate knowledge of




roducers' knowledge.

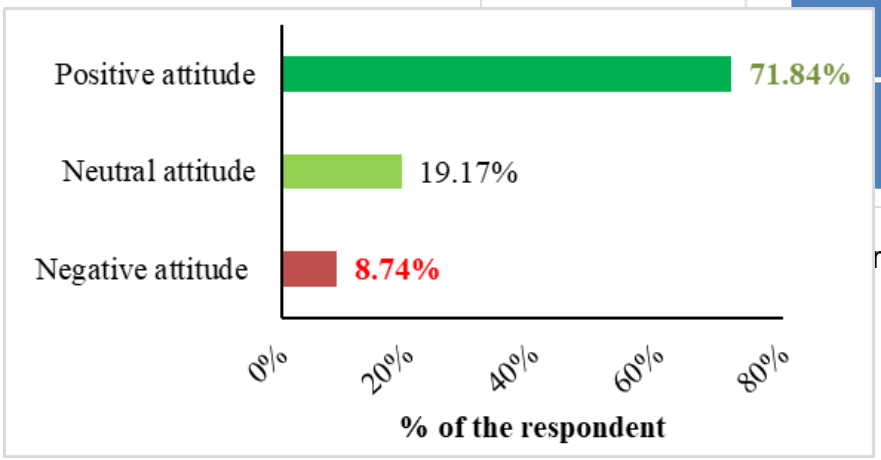



Figure 4: Overall attitude of poultry producers.

banned antibiotics, showing an understanding of disease-infected farm cleaning, and actively seeking suggestions from registered veterinary doctors. The study reveals that almost half of the respondents exhibited an overall good knowledge of poultry production practices. However, concerns arise as 14% displayed a deficiency in understanding safe poultry production (Figure 3). The observed variations in knowledge levels can be attributed to several societal factors, including educational disparities among producers, accessibility to advanced training programs, and the impact of regional variations on information dissemination. Scientifically informed interventions should be tailored to address these specific factors, ensuring targeted and effective knowledge enhancement.

In the context of the poultry sector in Bangladesh, producers' attitudes play a pivotal role in shaping the industry's practices and outcomes. Encouragingly, many poultry producers in the region demonstrate a positive attitude towards good farm management and adherence to robust biosecurity measures (Figure 4). This positive inclination reflects a commitment to maintaining high standards in poultry production. However, a noteworthy aspect is the discerned negative attitude towards growth promoters, with producers expressing concerns about the potential harm to human health associated with their usage. This anxiety is reflected in the highest negative attitude shared among the respondents. Approximately

72% of producers exhibit a positive attitude, highlighting an overall inclination towards responsible and health-conscious practices, while only 9% express a negative attitude.

The poultry production practices revealed through a survey depict a concerning scenario within the industry. A significant portion of participants, approximately 36%, neglects the crucial step of sterilizing equipment, potentially contributing to the spread of diseases (Appendix Figure 7). Additionally, 37% of respondents do not adhere to regular cleaning of farm waste, raising sanitation issues (Appendix Figure 8). Although 47% follow age-appropriate feeding practices for chicken, a worrisome 43% fail to properly disinfect visitors, posing a biosecurity risk (Appendix Figure 9). Disturbingly, 42% do not isolate sick chickens, potentially facilitating the transmission of illnesses. Moreover, a majority of 62% do not provide proper working clothes for farm employees, compromising hygiene standards (Appendix Figure 10). The inadequate burial of dead chickens is reported by 38% of respondents, further emphasizing the need for improved biosecurity measures (Appendix Figure 11).

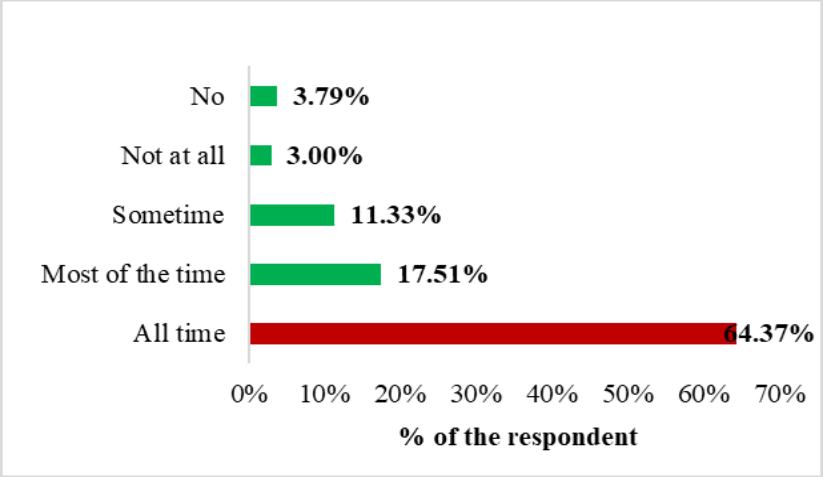



Figure 5: Frequency of antibiotic use by producers.

Regarding medicine, almost half of producers neglect to check the expiration dates of antibiotics and medicine, which could compromise the efficacy of treatments. 43% utilize growth promoters, and 94% employ antibiotics to some extent, raising concerns about antimicrobial resistance (Appendix Figure 12). Among them, about 64% of producers use antibiotics in all production batches (Figure 5). Furthermore, the neglect of proper vaccine doses by almost half of the respondents underscores the overall lack of adherence to safe production practices, with nearly 69% failing to meet recommended standards. Urgent attention and education are imperative to address these alarming trends and promote sustainable and safe poultry production. However, when it comes to overall practices in poultry production, only 31% of producers

follow safe practices, which is concerning for the poultry industry given the issue of foodborne illness and public health (Figure 6). Nearly 70% of producers did not follow safe production practices.

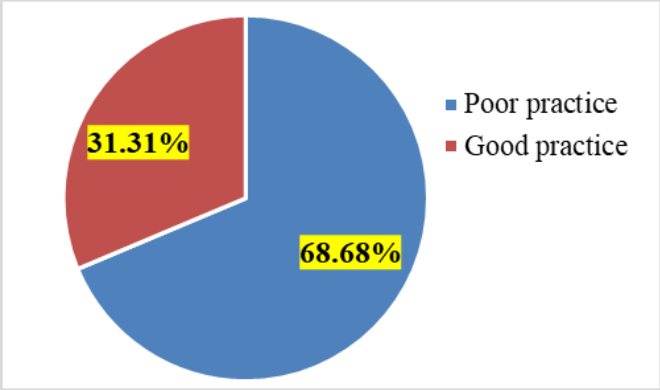



Figure 6: Level of safe poultry production practice.

In summary, while approximately half of the producers have a commendable understanding of safer poultry production, the majority have a good attitude toward implementing these practices. Despite this optimistic outlook, many producers are reluctant to adopt safer production procedures due to concerns about higher production and financial risks. This emphasizes the importance of focused interventions and support systems to bridge the gap between knowledge, attitude, and practice, ensuring that safer poultry farming becomes more widely adopted across the industry.

## Poultry Value Chain Actors

The survey findings reveal significant gaps in scientific knowledge and practices among poultry value chain actors. 37% of respondents exhibit a poor understanding of safe poultry handling and selling, pointing towards a need for educational interventions to enhance their knowledge base (Appendix Figure 13). A lmost half of the respondents lack awareness about the slaughtering act, indicating potential lapses in ethical and hygienic practices during the poultry processing and selling phase. A pproximately three-fourths of the respondents express a positive attitude towards safe poultry handling and selling, which can be leveraged for educational campaigns to reinforce good practices. Furthermore, concerning practices emerge in the post-mortem handling of chickens. Nearly half of the respondents admit to discarding sick or dying chickens, a practice that can exacerbate disease transmission. Additionally, 39% of the poultry value chain actors sell these compromised birds at a lower price to low-income people, hospitals, and prisons, potentially introducing substandard products into the market (Appendix Figure 15). 52% of survey value chain actors consume unhealthy chickens themselves, while 34% sell them at reduced prices, raising questions about the safety of such products for both personal and public consumption (Appendix Figure 15).

Another noteworthy observation pertains to the sales timing for chicken leftovers such as liver, leg, and skin sales. Forty-five percent of respondents sell chicken leftovers within an hour, demonstrating a proactive approach to food safety. However, XX% delay sales, with some extending up to five hours, potentially compromising product freshness and safety. The overarching analysis indicates that about 68% of value chain actors fall into the category of poor practice, highlighting the urgent need for

targeted interventions to address knowledge gaps, reinforce positive attitudes, and improve overall practices within the poultry production and selling sector (Appendix Figure 16). Scientifically informed training programs and awareness campaigns can play a crucial role in elevating industry standards and ensuring the safety and quality of poultry products for both producers and consumers.

## The relationship of poultry producers' and VCAs' practice level and their socioeconomic variables, knowledge, and attitude level

In Bangladesh, the dynamics of poultry production practices are heavily influenced by socioeconomic factors, presenting a complex interplay between age, education, access to resources, and farm size. These factors not only shape the knowledge and attitudes of poultry producers but also impact the adoption of safe production practices, thus bearing economic implications. Firstly, the correlation between age and poultry production knowledge underlines the role of experience in shaping producer behavior. Older producers may have accumulated practical knowledge over time, leading to a better understanding of safe poultry production practices. This highlights the economic significance of experience as an intangible asset that contributes to the efficiency and productivity of poultry operations. Secondly, education emerges as a critical determinant of poultry production knowledge. Higher levels of education equip producers with the analytical skills and capacity to grasp technical information related to safe poultry practices. Educated producers are better positioned to make informed decisions regarding inputs, technologies, and management practices, which can ultimately enhance productivity and profitability in poultry farming enterprises.

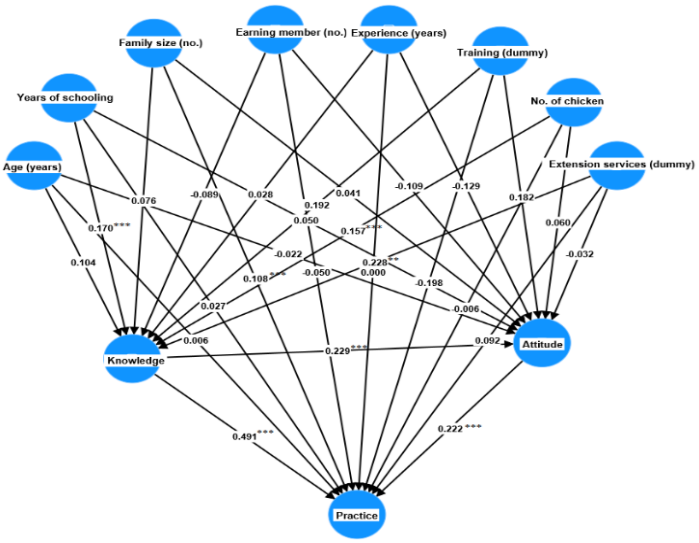



Figure 7: Factors affecting producers' practice level.

Furthermore, access to extension services is identified as a key facilitator of safe poultry practices. Extension services provide valuable resources and information to producers, enabling them to stay updated on the latest developments and best practices in poultry production. This highlights the economic importance of investing in extension services as a means of promoting knowledge dissemination, technology transfer, and capacity building within the poultry sector. Moreover, the association between farm size and knowledge of safe poultry production suggests economies of scale at play. Larger poultry operations may have access to greater resources, expertise, and infrastructure, enabling them to invest in training programs, technology adoption, and quality assurance measures. This

underscores the economic advantage of scale in poultry production, wherein larger farms are better positioned to implement efficient and sustainable production practices. Overall, the positive relationship observed between knowledge levels, attitudes, and safe poultry production practices highlights the economic benefits of investing in producer education, extension services, and experience-building initiatives (Figure 7). By equipping producers with the necessary knowledge and skills, policymakers and stakeholders can promote sustainable growth, improve food safety standards, and enhance the competitiveness of the poultry industry in Bangladesh.

The implementation of safe handling practices within the poultry value chain in Bangladesh is influenced by numerous socioeconomic factors, each playing a crucial role in shaping the behavior and practices of value chain actors. From an economic perspective, understanding these factors sheds light on the mechanisms through which knowledge, education, and experience impact the efficiency and safety of poultry handling and selling practices. Education emerges as a significant determinant of safe poultry handling practices among value chain actors. Individuals with higher levels of education are better equipped to comprehend and adhere to safety protocols, thus reducing the risk of contamination or foodborne illnesses. Moreover, education fosters a culture of continuous learning and adaptation, enabling value chain actors to stay abreast of evolving safety standards and best practices, which in turn contributes to the overall quality and reputation of poultry products in the market.

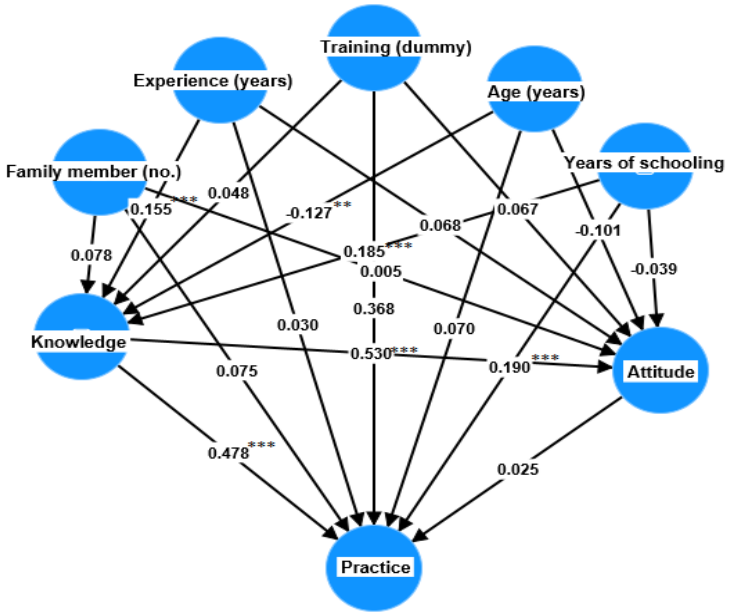



Figure 8: Factors affecting the practice level of value chain actors.

The business type also influences the adoption of safe handling practices within the poultry value chain. Formalized businesses with structured processes and quality control measures are more likely to prioritize safety and hygiene standards, driven by the imperative to protect brand reputation and consumer trust. In contrast, informal businesses may face greater challenges in implementing and enforcing safety protocols due to resource constraints and limited regulatory oversight, underscoring the need for targeted interventions and capacity-building initiatives tailored to the specific needs of small-scale actors. Furthermore, experience in the poultry business, coupled with factors such as age and education, shapes the knowledge levels of value chain actors regarding safe poultry handling and selling practices. Seasoned practitioners often possess tacit knowledge and practical insights accumulated over years of exposure to the industry, which complement

formal education and training programs. This highlights the economic value of experience as a driver of efficiency and innovation within the poultry value chain, reinforcing the importance of fostering a supportive ecosystem that encourages knowledge sharing and mentorship among industry stakeholders. The positive correlation observed between knowledge levels and attitudes underscores the role of information dissemination and awareness-raising campaigns in promoting a culture of safety and compliance among value chain actors (Figure 8). By enhancing understanding and buy-in from stakeholders, policymakers and industry stakeholders can create an enabling environment for the adoption of safe handling practices, thereby safeguarding public health and consumer confidence while unlocking new opportunities for market growth and competitiveness and fostering a resilient and sustainable poultry value chain that meets the highest standards of safety, quality, and consumer satisfaction.

## Moral Hazard and Factors Affecting Moral Hazard of Poultry Producers

This section investigates the phenomenon of moral hazard within the poultry sector, specifically focusing on the use of different inputs, growth promoters, and antibiotics by poultry producers. Moral hazard, in this context, is delineated by the actions of poultry producers that may pose increased risks or negative consequences for others, particularly in the long-term implications for human health, given the indiscriminate use of antibiotics. The study assesses moral hazard through various dimensions, namely market, institutional, and personal. The market dimension, accounting for 33% of the index value, signifies the potential risks introduced into the market due to certain practices. The institutional dimension, with an index value of approximately 50%, highlights the risks associated with non-compliance with established guidelines and withdrawal periods for antibiotics (Appendix Table 5). The personal dimension, also with an index value of around 50%, underscores the individual decisions and practices of poultry producers. The empirical findings also revealed that 43% of respondents intentionally use growth promoters to make their chickens gain weight, demonstrating a market-oriented moral hazard. Furthermore, 28% of producers violate the recommended presale antibiotic withdrawal period of 7 days by selling chickens within six days of application. This indicates an institutional and personal dimension of moral hazard. The average antibiotic application start time and frequency, along with growth promoter usage patterns, provide a nuanced understanding of the complexities within the poultry sector, shedding light on the multifaceted nature of moral hazard in poultry production practices. Specifically, the study discovered that 53% of the surveyed poultry producers began administering antibiotics to chickens as early as 0–3 days old. Furthermore, the typical age at which antibiotics are given to chicks is around two days on average. Nonetheless, 76% of the surveyed poultry producers stated that they use antibiotics only once or twice per production batch. Across all respondents, the average antibiotic use per batch is approximately 2 times per production period (Appendix Figure 18a). Regarding the use of growth boosters, 69% of the poultry farmers said they use boosters at least once every batch production cycle, while the remaining 31% of the respondents use growth promoters more than once per batch production cycle (Appendix Figure 18b).

It's clear that regulatory interventions and awareness programs are needed to mitigate the identified moral hazards, safeguard public health, and promote responsible practices within the poultry industry.

This research delves into the intricate relationship between accountability, the rule of law, transparency, and the knowledge and practice of safe poultry production as well as some other socioeconomic factors in influencing the moral hazard exhibited by poultry producers. Accountability, as a key determinant, is gauged through several parameters such as the producer's sense of societal liability for producing safer chicken, their concern for providing safe meat to consumers, considerations for consumer welfare, encouragement of unmotivated farmers, and the extent of supervision exercised in day-to-day operations. Rule of law is assessed by the producer's knowledge of food safety laws, compliance with regulations, adherence to the FAO code of hygiene, compulsion to produce safe food, and the effectiveness of government enforcement against the sale of unsafe chicken. Transparency, another critical dimension, is measured by factors such as the addition of harmful ingredients to feed, the impact of monitoring deficiencies on unsafe practices, engagement in unsafe practices due to a lack of information, and the recognition of the importance of consumer awareness about farming procedures.

Furthermore, surveys evaluated the knowledge of producers concerning factors such as safe chicken feed and meat production; farm location in relation to commercial establishments or homesteads; required space for each chicken; farm biosecurity measures; chicken diseases and vaccines; prohibited antibiotics; and the importance of a registered veterinary doctor's advice. Producer practices were recorded, encompassing aspects like:

- farm ventilation
- regular cleaning
- the use of meat enhancers
- monitoring of expiration dates for feeds, antibiotics, and other medicines
- quarantine measures for sick chickens
- daily health monitoring
- data recording
- prompt disposal of dead chickens.

These factors exhibit a negative relationship with the moral hazard index value, suggesting that controlling and improving these aspects can potentially reduce moral hazard among poultry producers. This study underscores the importance of targeted interventions and regulatory measures to enhance accountability, adherence to the rule of law, transparency, and knowledge and practice of safe poultry production. Ultimately this work is contributing to the reduction of moral hazard in the poultry industry.

Table 3: Factors affecting moral hazard

| Variable | Coef. | p-value |
|---|---|---|
| Accountability | -0.269 | 0.00 |
| Rule of law | -0.256 | 0.00 |
| Transparency | -0.298 | 0.00 |
| Knowledge level of safe poultry production | -0.025 | .063 |
| Level of safe poultry production practice | -0.017 | 0.00 |
| Attitude toward safe poultry production | -0.014 | .331 |
| Training received | -0.007 | .982 |
| Education level | -0.008 | .793 |
| Gender (Dummy; Male =0, Female=1) | 0.007 | .757 |
| Constant | 15.665 | 0.00 |

## Resilience Capacities of Poultry Producers

Poultry farmers' ability to withstand shocks was assessed using the resilience capacity framework established by USAID. This framework consists of eight components that demonstrate the resilience capacity of value chain stakeholders. We applied this model specifically to poultry farmers, who are particularly susceptible to various climatic, natural, and man-made disruptions because of the fragile nature of their business and market environment. On top of that, each component has three sub-components: Absorptive, Adaptive, and Transformative.

The first element of resilience architecture is cooperation, which involves market participants working together to achieve a shared goal or function, particularly to increase profits or get higher prices for their poultry products. Poultry producers are more adaptable than absorptive and transformational, with transformative showing the lowest performance. Poultry farmers cannot transfer their risk within the framework of cooperation with the help of other poultry producers, or producers' associations, or any national-level poultry producer's society during the shocks. Competition, which is characterized as conflict between multiple businesses to obtain a larger market share, is the second element of the resilience architecture. In the context of competition, poultry farmers exhibit a greater ability for transformation, but they also have a greater capacity for resilience when it comes to the adaptation of competitive sub-components. For the component of evidence-based decision-making, comparable

outcomes were also recorded. Evidence-based decision-making, as a field for comprehending the resilience of market systems, describes how much data or evidence based on facts is applied to solve problems during any shocks. In order to find a solution for any issue, poultry producers are therefore more likely to accept and assimilate fact-based data than to shift the risk to other stakeholders or market participants. The business strategy, which focuses on how a business operates, makes up the fourth component. It can involve selling phony or adulterated goods, manipulating weights and measurements, misleading customers, or using other power-wielding tactics to obtain an instant financial advantage in a transaction. This component of the research yielded an intriguing finding: rather than absorbing or embracing the risk that naturally exists in markets, poultry producers choose to transmit their risk to other stakeholders through quick sales of their chickens to wholesalers or retailers, making a quick profit, and maintaining their own capacity.

Connectivity, or the definition of the relationship between the market participants, is the sixth element of the resilience structure. Poultry producers in this situation have the lowest resilience capacity across all three sub-components—absorptive, adaptive, and transformative—which indicates that they have a low degree of network connections, particularly with other farmer groups and with governmental and non-governmental organizations. This might be explained by the significant obstacles that exist, both actual and perceived, to forming reliable business relationships between groups. The sixth component, diversity, tries to measure how well a poultry producer can spread out their risks if a shock to the market system—whether natural or man-made—occurs.

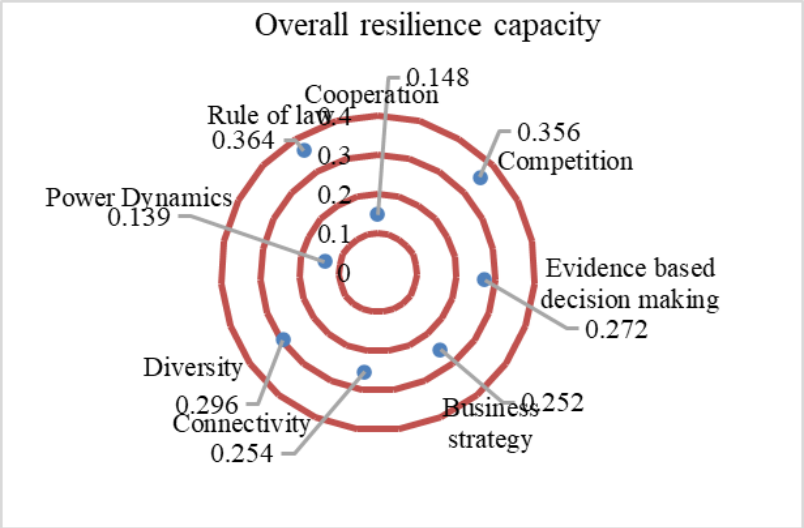



Figure 9: Resilience capacity of poultry producers.

According to the findings, there is little expertise and limited diversity among poultry producers, which means they are unable to expand their business beyond the poultry industry in the event of a shock. The transformative and adaptive sub-components in this domain had the lowest scores, whereas the absorptive sub-component had a slightly better score. This suggests that to increase their capacity for resilience, poultry producers may be more likely to absorb diversified business, such as off-farm income and jobs held as migrants.

The seventh component is power dynamics which quantifies the concentration and exercise of power in a system that means if the large farms and other dominant market players force the poultry producers

to obey their over exercised market regulations and act accordingly while the small poultry producers have less power to act in the market and sell their products. In all the sub-components in this domain, poultry producers receive the lowest score. They are essentially controlled by the other major companies in the market because they lack transformational resilience in the dynamics of power. They occasionally aggressively accept and assimilate certain market laws, such as requiring them to sell to dealers who supplied the feed used in production or awarding wholesalers a specific proportion of the revenues from the sale of poultry in the market. The rule of law, which is the final element of the resilience structure, focuses on institutionalized access to a comparatively fair judiciary amid shocks. This implies that all people and farms operating in the market are subject to the same set of regulations. The findings showed that the transformative resilience score in this domain is higher than that of the other two sub-components. This suggests that when market laws are enforced, such as through market taxation policies or the development of trust among rival groups, poultry producers would prefer to transfer these legal protections to other market participants rather than assimilating or adopting them.

Overall, from the empirical analysis, this project found that among the resilience dimensions, cooperation, business strategy, connectivity, and power dynamics have the lowest scores which means they have less resilience in terms of these indicators. Therefore, greater policy interventions will need to be made in the future to enable poultry farmers to collaborate and interact with other key players during the shock, including farmer's associations, government agencies, suppliers of feed and medications, and other non-governmental organizations. Additionally, in order to unite everyone under one roof, a more formalized structure for overseeing and managing the poultry producers' business strategies has to be developed. On the other hand, among the other domains, competition, rule of law, and evidence-based decision-making show better resilience capacity of poultry producers.

## Capacity Development and Policy Co-creation

The capacity development objective of this project is based on the idea that a better education program centered on the sound identification of training needs among poultry industry participants will lead to improved safety outcomes. Therefore, the research team conducted different training programs to promote safe poultry production and marketing across the value chain. There were eight batches of 2-day training courses/programs for 200 farmers and value chain actors. Research translation partner MATI Bangladesh organized these training programs. One group was 4 batches of 2-day training courses entitled "Enhancing Resilience & Reducing Moral Hazard in Poultry Production" for 100 (37% women) poultry producers and another group was 4 batches of 2-day training courses entitled "Enhancing Resilience and Reducing Moral Hazard in Poultry Value Chain" for 100 (27% women) value chain actors. The training participants were selected from 38 villages of 4 sub-districts of Mymensingh and Sherpur districts. The participants were either small-scale producers, feed manufacturers, medicine sellers, or live bird sellers.

Bangladesh Organization of Marginal Poultry Farmers & Marginal Poultry Professionals, along with the gender specialists, played a vital role in designing and delivering the training programs.

The curriculum of the training program was tailored based on the findings from KAP analysis, moral hazard analysis, and resilience capacities analysis. It included participatory discussions, group work, and presentations. The producer's training module included content on moral hazards & KAP in poultry, effects on human health and environments, steps to reduce hazards & improve resilience in the establishment and operation of poultry farms, and the like. On the other hand, the subject matter of training for the value chain actors included the existing unsafe practices in the poultry value chain, causes and effects on human health & environment, best practices in the safe hatchery and day-old chick transportation management and controlling hazards in chick trading, ways to reduce hazards in poultry feed & medicine trading, best practices in matured poultry bird transportation and trading, and the best practices in safe poultry slaughterhouse management etc.

Figure 11: Policy co-creation with different stakeholders at Dhaka, Bangladesh. Credit: Md. Emran Hossain

Two co-creation meetings were conducted for formulating policy, one was on 19th July/2023 and another was on 14th February 2024. In the first co-creation program, approximately 140 participants consisting of farmers, value chain actors, participants from various universities, research institutes, high government officials, and media persons were present and provided their valuable feedback about the research and help in formulating appropriate policy implications from their respective positions. Farmers and value chain actors explained different problems that they are facing during production and marketing levels. And explained why moral hazards are happening throughout the value chain. They also suggested some moral hazard mitigation strategies to the policymaker. In contrast, academicians and researchers from different universities and research institutions suggested some policies from their own experience and research findings. Furthermore, policymakers and relevant govt. officials also mentioned the different limitations of the existing policies and the lack of implementation of the existing rule of law,

transparency, and accountability. Some legitimate policy directions have been handed over to the respective government officials.

A roundtable discussion meeting was held on the 14th of February 2024 at the Conference Hall of the daily "Samakal" a leading newspaper of Bangladesh on the issue of "Improving Food Safety Strategies in Chicken Value Chain of Bangladesh". Different participants such as industry people, farmer representatives, journalists, academics, the Director of the Bangladesh Food Safety Authority, researchers from the Bangladesh Livestock Research Institute, etc. were present in the roundtable meeting. After a long discussion some policy recommendations came out such as: (i) all stakeholders in the poultry industry including production, processing, marketing, supply, and consumers must work together to keep people healthy and ensure safe food; (ii) the existing laws and regulations should be properly implemented; (iii) farmers who are following the guidelines for antibiotic use should be praised. Besides, those who ignore guidelines should be punished under the law, and a poultry board should be formed that includes a full range of stakeholders.

Figure C 12: Roundtable discussion with different stakeholders/expert for policy validation and finalization. Credit: MATI, Bangladesh

# Recommendations

This study identifies that there should be a three-way approach to address the safer poultry production issue in Bangladesh – Producer-Oriented, Value Chain-oriented, and Enforcement and implementation-oriented.

## Producer-oriented

- The Department of Livestock Services (DLS), with the assistance of scientists, should develop a Standard of Procedure (SoP) for safer poultry production.
- Based on the SoP, the DLS along with relevant development organizations, needs to prepare a training curriculum for safer poultry production, biosecurity measures, and marketing.
- The DLS, along with relevant development organizations, needs to conduct training among poultry producers and value chain actors.
- The DLS should initiate motivational activities such as TV advertisements, leaflet distribution, seminars, and workshops that make the public aware of the harmful effects of unsafe poultry production and marketing to enhance their safer practices.

## Value Chain Actor-oriented

- The DLS needs to develop and design physical market infrastructure to maintain hygiene for both value chain actors and consumers.
- The DLS, with the assistance of scientists, needs to develop a (SoP) on safer handling and processing of poultry products.
- Poultry markets should be separated from the other markets and local government should take this initiative.

## Enforcement and Implementation-oriented

- The DLS should develop transparent and stringent enforcement and implementation of food safety policies in poultry production and value chains.
- The DLS needs to create a technically trained workforce to ensure stringent implementation of inspection programs throughout the country.
- The DLS's regular feed testing and monitoring will ensure safety in the sale of these inputs, which are critical for safe poultry production.
- A poultry development board with strong stakeholder participation needs to be formed.

## REFERENCES

Alam, K. S., Hossain, S. M., Naher, K., Islam, M. A., Khan, M. R., Das, S., & Akramuzzaman, M. M. 2021. "Analysis of fish, poultry, feeds and sediments using NAA for assessment of arsenic and chromium contamination". *In Journal of Physics: Conference Series* (Vol. 1718, No. 1, p. 012017). IOP Publishing.

Alam, S. B., Mahmud, M., Akter, R., Hasan, M., Sobur, A., Nazir, K. N. H., ... & Rahman, M. 2020. "Molecular detection of multidrug resistant Salmonella species isolated from broiler farm in Bangladesh". *Pathogens*, 9(3), 201.

Begum, I.A., S. Rahman, M.J. Alam, J. Buysse. 2011." Bangladesh Poultry Sector: Growth, Competitiveness and Future Potential. In *Livestock: Rearing, Farming Practices and Diseases Animal Science, Issues and Professions*, ed. M.T. Javed, 81–104. New York: Nova Science Publishers Inc.

Chowdhury, M. A. Z., Abir, M., Nesha, M., Fardous, Z., Rahman, H., & Bari, M. L. (2021). Assessment of toxic heavy metals and trace elements in poultry feeds, consumer chickens and eggs in Bangladesh. *Asian-Australasian Journal of Bioscience and Biotechnology*, *6*(3), 128-141.

DLS, 2022. Department of Livestock Services, Annual Report, Ministry of Fisheries and Livestock, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

Hamid, M. A., Rahman, M. A., Ahmed, S., & Hossain, K. M. 2017. "Status of poultry industry in Bangladesh and the role of private sector for its development". *Asian Journal of Poultry Science*, 11(1), 1-13.

Henke, K. A., Alter, T., Doherr, M. G., & Merle, R. 2021. "From stable to table: Determination of German consumer perceptions of the role of multiple aspects of poultry production on meat quality and safety Consumer perception of poultry production's influence on meat quality". *Journal of Food Protection*.

Hossain, S., Farid, F. B., Hasan, M. N. B., Rahman, S. A., Muztaba, M. A., & Rahman, M. M. (2022). Assessment of Heavy Metal Contamination in Liver, Gizzard, and Brain of Parent, Broiler, Layer, and Domestic Poultry Chickens in Dhaka, Bangladesh: A Threat to Bangladeshi Chicken Consumers. *Indonesian Journal of Social and Environmental Issues (IJSEI)*, *3*(2), 159-166.

Indrawan, D., Christy, A., & Hogeveen, H. 2021. "Improving poultry meat and sales channels to address food safety concerns: consumers' preferences on poultry meat attributes". *British Food Journal*.

Islam M.S., M. A. I. Kazi, M. M. Hossain, M. A. Ahsan & A. M. M. M. Hossain. 2007. "Propagation of heavy metals in poultry feed production in Bangladesh". *Bangladesh Journal of Scientific and Industrial Research*, 42(4): 456-474.

Komínková, A., Vavřina, J., & Polák, J. (2020). "Breaking food safety and quality standards in the EU: Financial aspects within poultry products manufacturers in Visegrad 4 countries". *Journal of International Studies* Vol, 13(3).

Korish, M. A., & Attia, Y. A. (2020). Evaluation of heavy metal content in feed, litter, meat, meat products, liver, and table eggs of chickens. *Animals*, *10*(4), 727.

Macomber L, Hausinger RP. (2011). Mechanisms of nickel toxicity in microorganisms, *Metallomics* ;3(11):1153–1162, doi: 10.1039/c1mt00063b.

MacRitchie, L. A., Hunter, C. J., & Strachan, N. J. C. (2014). "Consumer acceptability of interventions to reduce Campylobacter in the poultry food chain". *Food control*, 35(1), 260-266.

MoFL, 2022. Ministry of Fisheries and Livestock, Annual Report, Chapter 10, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh.

Mottalib, M. A., G. Zilani, T. I. Suman, T. Ahmed, S. Islam. 2018. "Assessment of Trace Metals in Consumer Chickens in Bangladesh". *Journal of Health and Pollution* 8 (20). doi: https://doi.org/10.5696/2156-9614-8.20.181208

Mund, M. D., Khan, U. H., Tahir, U., Mustafa, B. E., & Fayyaz, A. (2017). "Antimicrobial drug residues in poultry products and implications on public health: A review". *International Journal of Food Properties*, *20*(7), 1433-1446.

Rabby, M. R. I., Shah, S. T., Miah, M. I., Islam, M. S., Khan, M. A. S., Rahman, M. S., & Malek, M. A. (2021). "Comparative analysis of bacteriological hazards and prevalence of Salmonella in poultry-meat retailed in wet-and super-markets in Dhaka city, Bangladesh". *Journal of Agriculture and Food Research*, 6, 100224.

Rahman, M. M., Husna, A., Elshabrawy, H. A., Alam, J., Runa, N. Y., Badruzzaman, A. T. M., ... & Ashour, H. M. (2020). "Isolation and molecular characterization of multidrug-resistant Escherichia coli from chicken meat". *Scientific Reports*, 10(1), 21999.

Sarker, B. R., Ghosh, S., Chowdhury, S., Dutta, A., Chandra Deb, L., Krishna Sarker, B., ... & Mozaffor Hossain, K. M. (2021). "Prevalence and antimicrobial susceptibility profiles of non-typhoidal Salmonella isolated from chickens in Rajshahi, Bangladesh". *Veterinary Medicine and Science*, 7(3), 820-830.

Saud, B., G. Paudel, S. Khichaju, D. Bajracharya, G. Dhungana, M.S. Awasthi, and V. Shrestha. 2019. "Multidrug-Resistant Bacteria from Raw Meat of Buffalo and Chicken, Nepal." *Veterinary medicine international* 2019.

Shoeb, M., A. Mahim, M. I. R. Mamun, N. Nahar. 2016. "Organochlorine pesticide residues in poultry meats of Bangladesh". *Croatian Journal of Food Science and Technology* 8(1): 30-33. https://doi.org/10.17508/CJFST.2016.8.1.04

Simon PC. 2009. "Commercial egg and poultry meat production and consumption and poultry trade worldwide". Proceedings of the 6th International poultry show and seminar, Dhaka, Bangladesh.

Tithi, N. H., Ali, M. A., & Khan, M. B. (2020). Characterization of heavy metals in broiler and fish feeds from some selected markets of Mymensingh and Tangail districts.

Ullah, A. A., Afrin, S., Hosen, M. M., Musarrat, M., Ferdoushy, T., Nahar, Q., & Quraishi, S. B. (2022). Concentration, source identification, and potential human health risk assessment of heavy metals in chicken meat and egg in Bangladesh. *Environmental Science and Pollution Research*, 1-12.

Uluozlu, O. D., Mustafa, T., Mustafa, S. (2009). Speciation and separation of Cr(VI) and Cr(III) using coprecipitation with Ni2+/2-Nitroso-1-naphthol-4-sulfonic acid and determination by FAAS in water and food samples, *Food and Chemical Toxicology*, 47 (10):2601-2605.

Venkitanarayanan, K., Thakur, S., & Ricke, S. C. (Eds.). (2019). Food Safety in Poultry Meat Production. Springer.

Wen, X., Sun, S., Li, L., He, Q., & Tsai, F. S. (2019). "Avian influenza—Factors affecting consumers' purchase intentions toward poultry products". *International journal of environmental research and public health*, 16(21), 4139.

WPSA (2019). World's Poultry Science Association-Bangladesh. https://wpsa-bb.com/

Zhaog, Y., Yu, X., Xiao, Y., Cai, Z., Luo, X., & Zhang, F. (2020). "Netizens' Food Safety Knowledge, Attitude, Behaviors, and Demand for Science Popularization by WeMedia". *International Journal of Environmental Research and Public Health*, 17(3), 730.

# Appendices:

**Appendix-Table 1: Socioeconomics profile of producers**

| Variables | Value |
|---|---|
| Age (% of respondents) | |
| Youth (<36 years) | 32.90 |
| Middle aged (37 to 51 years) | 43.87 |
| Old aged (>51 years) | 23.23 |
| Gender (% of respondents) | |
| Female | 6.80 |
| Male | 93.20 |
| Farming experience (% of respondents) | |
| More than 5 years | 44.54 |
| Less than 5 years | 55.46 |
| Education (% of respondents) | |
| Up to primary | 35.88 |
| Secondary to higher secondary | 45.75 |
| Graduation or above | 18.37 |
| Training received on safe poultry production (%) | |
| Yes | 16.50 |
| No | 83.50 |

**Appendix-Table 2: Socioeconomics profile of value chain actors**

| Variables | Value |
|---|---|
| Age (% of respondents) | |
| Youth (<36 years) | 40.88 |
| Middle aged (37 to 51 years) | 44.66 |
| Old aged (>51 years) | 14.46 |
| Business experience (% of respondents) | |
| Less than 5 years | 22.34 |
| More than 5 years | 77.66 |
| Education (% of respondents) | |
| Up to primary | 52.55 |
| Secondary to higher secondary | 43.98 |
| Graduation or above | 3.47 |
| Training received on safe poultry handling (%) | |
| Yes | 6.9 |
| No | 93.1 |
| Average commission/profit (per kg) | 13.81 |

**Appendix-Table 3: Relationship among poultry producers' socioeconomic characteristics, knowledge and attitude level**

| Variables | Practice level (%) | | $\chi 2$ | P value |
|---|---|---|---|---|
| | Poor | Good | | |
| Gender | | | | |
| Male | 25.45 | 74.55 | 0.452 | 0.534 |
| Female | 37.15 | 62.85 | | |
| Age group | | | | |
| Youth (<36 years) | 22.67 | 77.33 | 2.891 | 0.091 |
| Middle aged (37 to 51 years) | 30.88 | 69.12 | | |
| Old aged (>51 years) | 40.55 | 59.45 | | |
| Farming experience | | | | |
| More than 5 years | 36.15 | 63.85 | 0.881 | 0.453 |
| Less than 5 years | 26.45 | 73.55 | | |
| Education level | | | | |
| Up to primary | 36.6 | 63.4 | 3.562 | 0.054 |
| Secondary to higher secondary | 34.9 | 65.1 | | |
| Graduation or above | 22.45 | 77.55 | | |
| Extension service | | | | |
| Yes | 23.35 | 76.65 | 6.902 | 0.006 |
| No | 39.25 | 60.75 | | |
| Knowledge level | | | | |
| Poor | 54.75 | 45.25 | 12.022 | 0.000 |
| Moderate/fair | 26.8 | 73.2 | | |
| Good | 12.45 | 87.55 | | |
| Attitude level | | | | |
| Poor | 61.7 | 38.3 | 14.932 | 0.000 |
| Moderate/fair | 23.2 | 76.8 | | |
| Good | 9.1 | 90.9 | | |

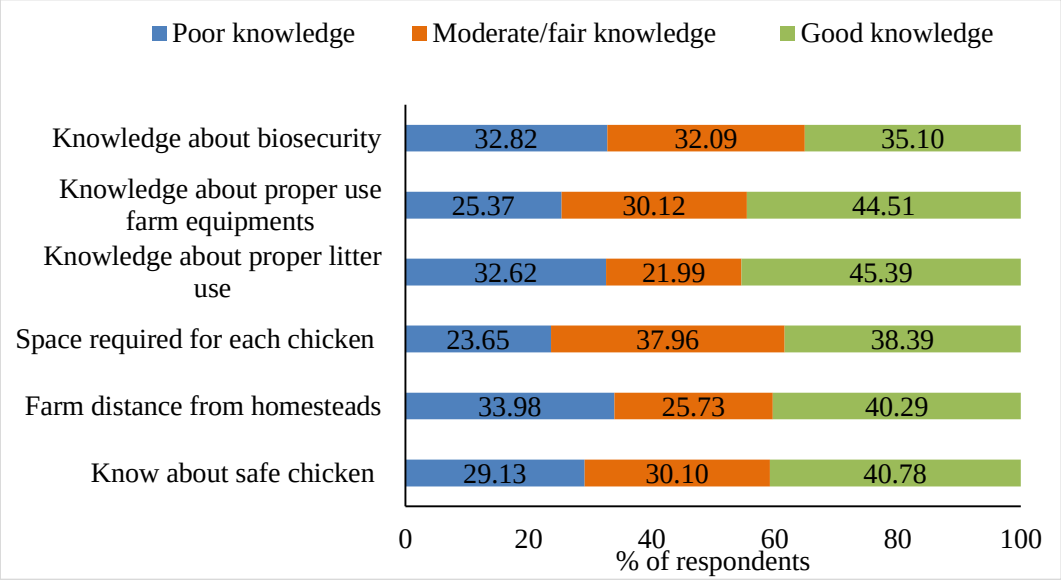
**Appendix-Table 4: Relationship among value chain actors' socioeconomic characteristics, knowledge and attitude level**

| Variable | Practice level (%) | | χ2 | P value |
|---|---|---|---|---|
| | Poor | Good | | |
| **Education level** | | | | |
| Up to primary | 38.3 | 61.7 | 0.671 | 0.054 |
| Secondary to higher secondary | 33.2 | 66.8 | | |
| Graduation or above | 25.15 | 74.85 | | |
| **Poultry business type** | | | | |
| Retailers | 48.6 | 51.4 | 3.876 | 0.075 |
| Dealers | 37.8 | 62.2 | | |
| Wholesalers | 19.8 | 80.2 | | |
| Bepari | 22.7 | 77.3 | | |
| Training on poultry handling in safer way | | | | |
| Yes | 18.85 | 81.15 | 12.901 | 0.006 |
| No | 45.6 | 54.4 | | |
| **Knowledge level** | | | | |
| Poor | 59.75 | 40.25 | 10.932 | 0.000 |
| Moderate/fair | 26.98 | 73.02 | | |
| Good | 9.96 | 90.04 | | |
| **Attitude level** | | | | |
| Poor | 60.3 | 39.7 | 9.091 | 0.000 |
| Moderate/fair | 27.47 | 72.53 | | |
| Good | 8.92 | 91.08 | | |

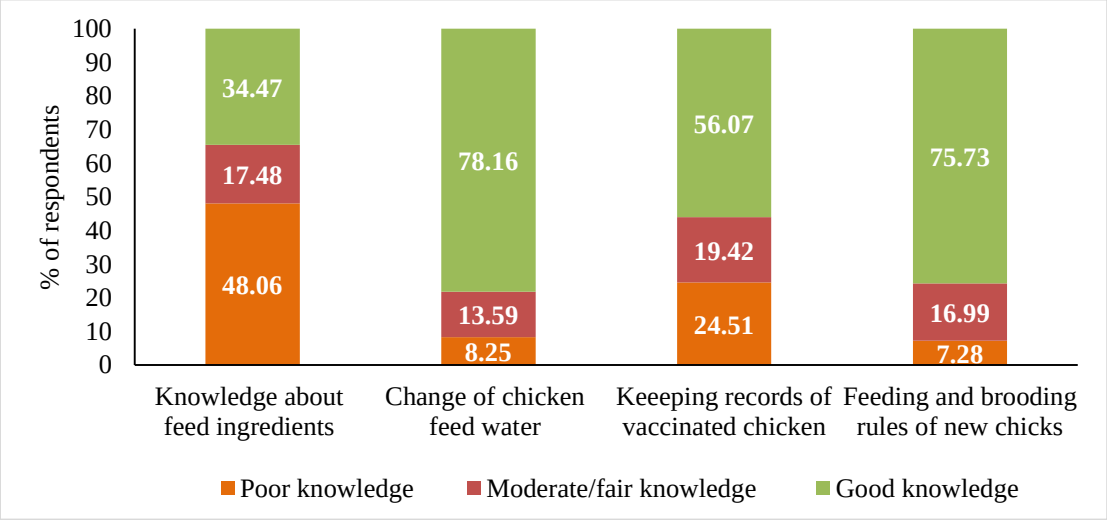
**Appendix-Table 5: Dimensions of moral hazard**

| Dimensions of moral hazard | Indicators | Value of indicators | Index value |
|---|---|---|---|
| Market | Influence of feed and medicine company's representative to increase chicken weight fast | 0.383 | 0.334 |
| | Feeding the chickens anything other than food (e.g., sugar or salted water) before selling | 0.296 | |
| | Unpermitted doings if market price goes high swiftly | 0.324 | |
| Institutional | Absence of proper enforcement and proper policies | 0.550 | 0.574 |
| | Knowledge about FAO code of hygiene for meat production | 0.598 | |
| Personal | Unpermitted doings when chickens are sick/dying during rearing | 0.465 | 0.504 |
| | Immediate pushing of injections medicine before selling | 0.410 | |
| | Knowledge about selling of chicken infected with any infectious disease | 0.729 | |
| | Practice regarding the dyed chicken | 0.413 | |
| Overall Moral Hazard Assessment Index Value | | | 0.463 |

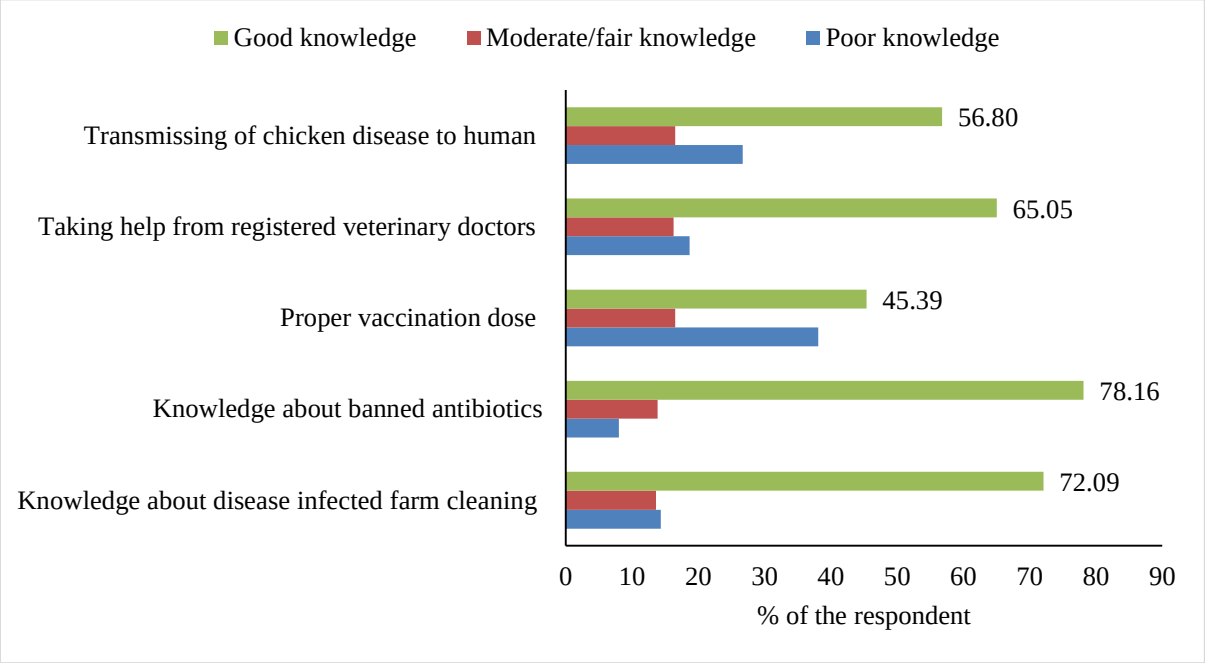
**Appendix-Figure 1: Safe farm management knowledge of producers**



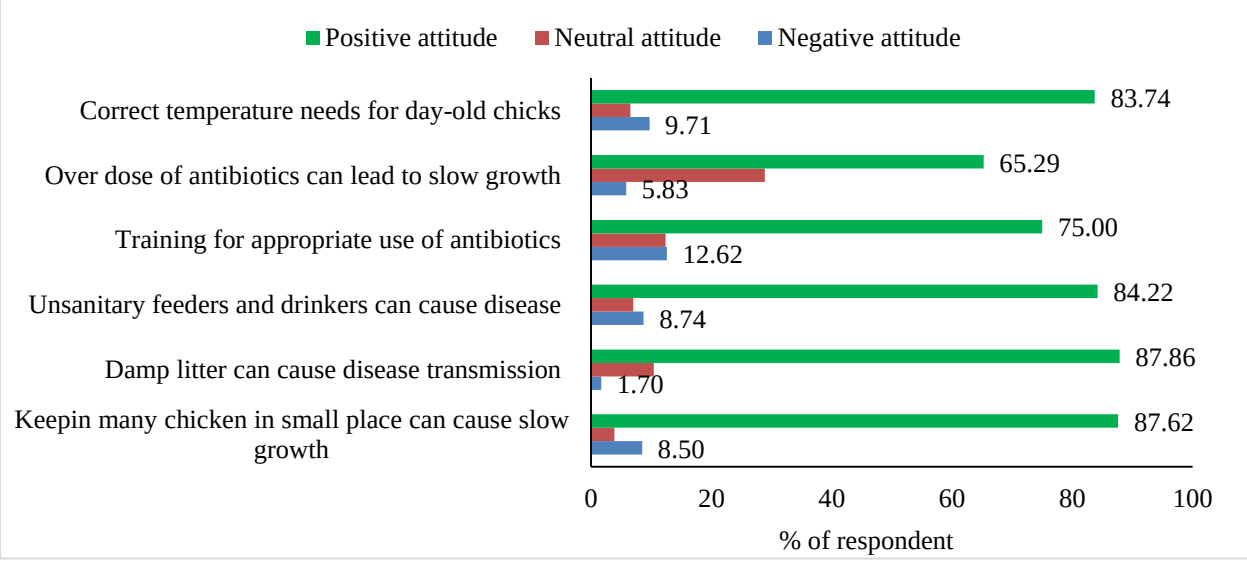

**Appendix-Figure 2: Proper input use knowledge of producers**



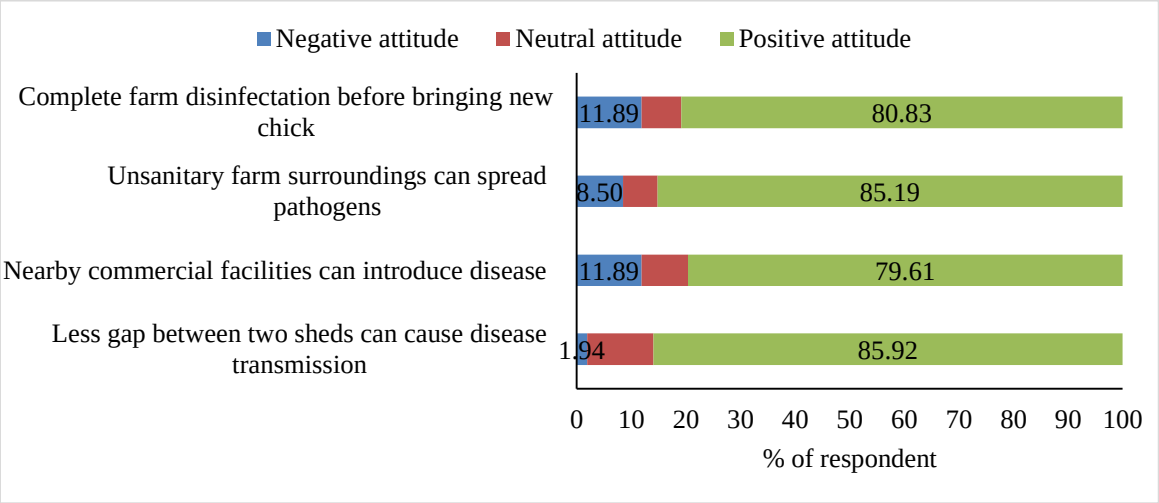
**Appendix-Figure 3: Producers' disease management knowledge**



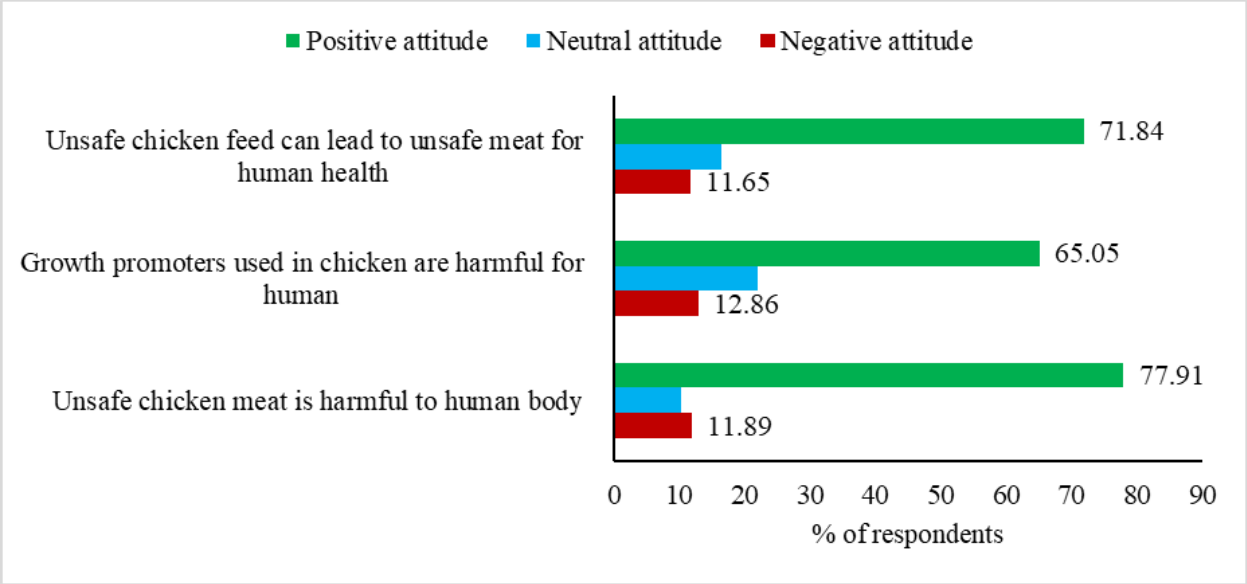

**Appendix-Figure 4: Producers' attitude towards good farm management**



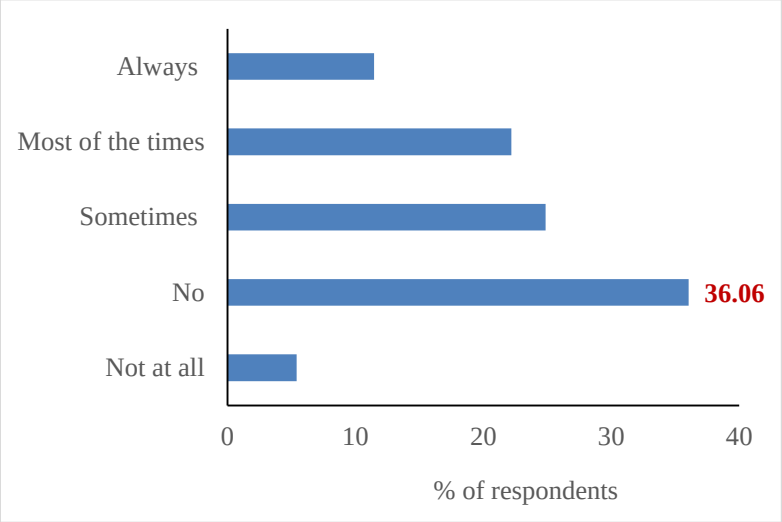

**Appendix-Figure 5: Producers' attitude towards farm biosecurity**



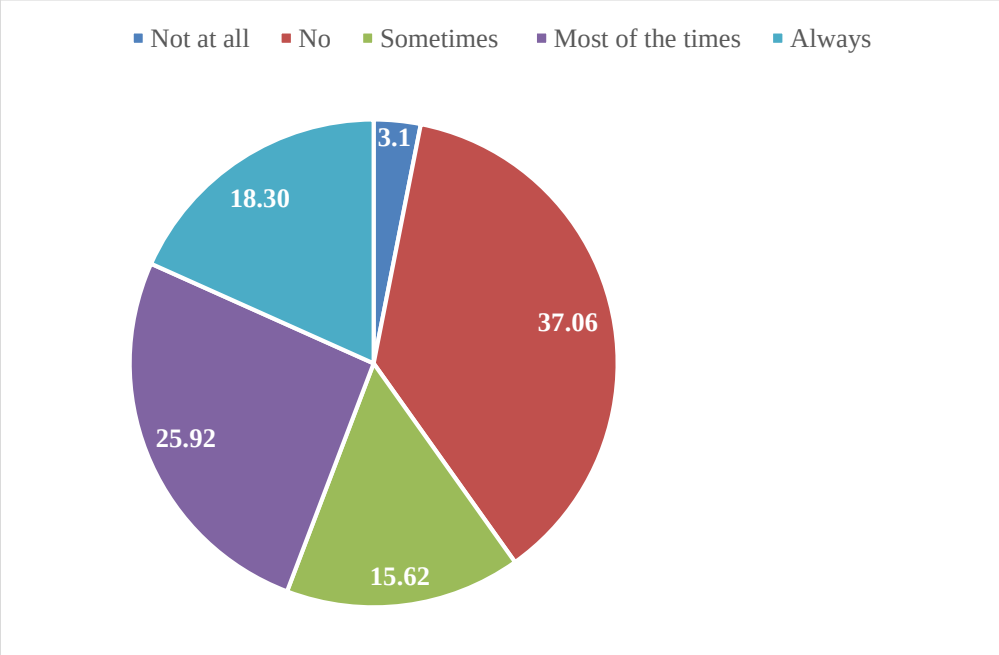

**Appendix-Figure 6: Producers' attitude towards human health**



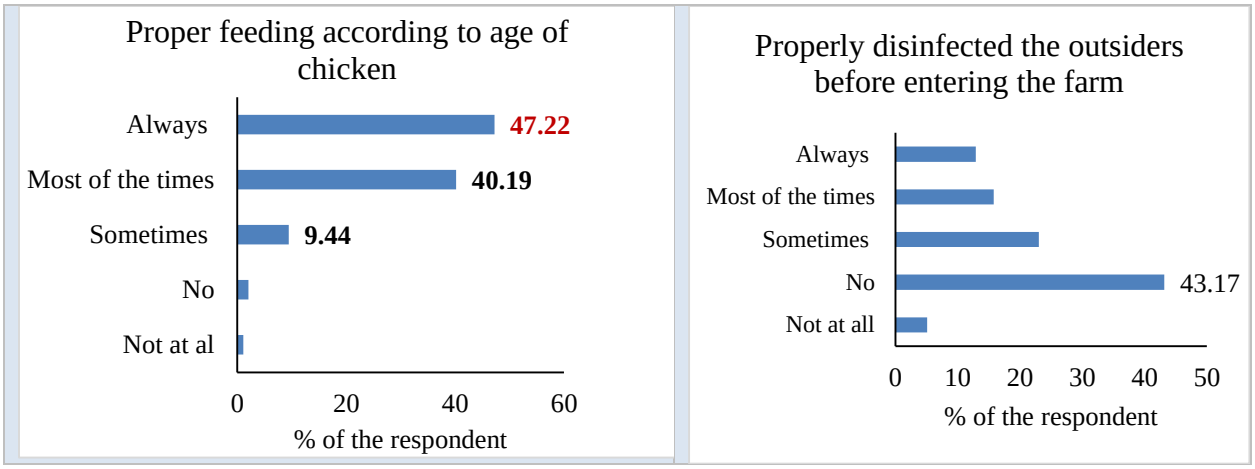
**Appendix-Figure 7: Producers' practices on sterilize the equipment brought from outside**



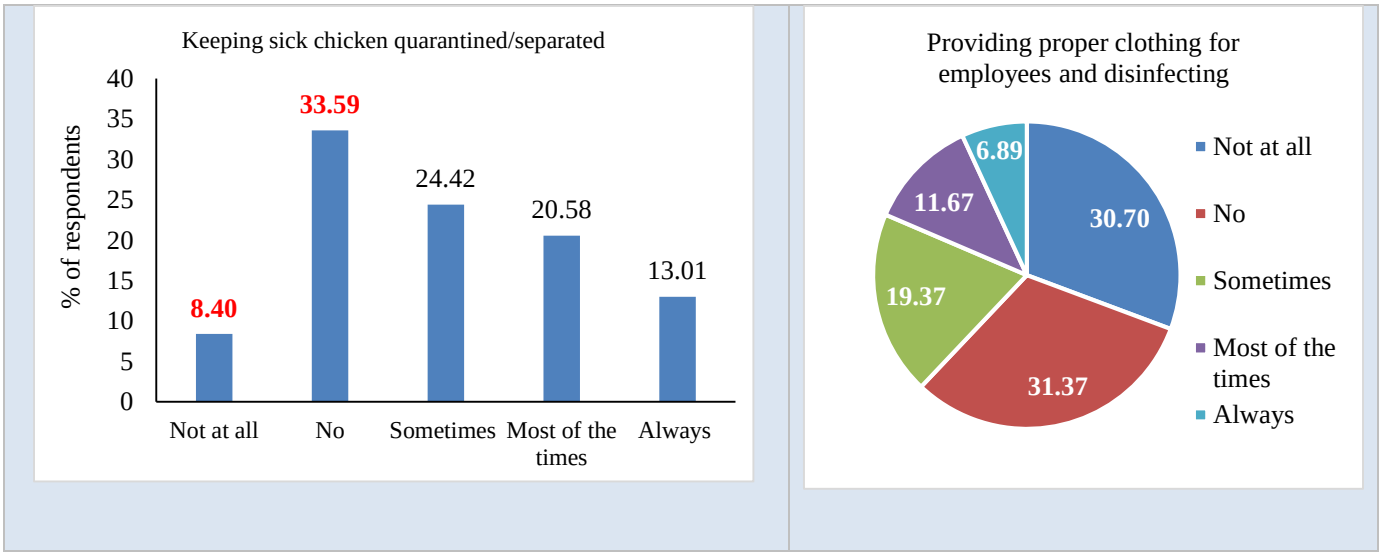

**Appendix-Figure 8: Producers' practices on regularly cleaning farm waste**



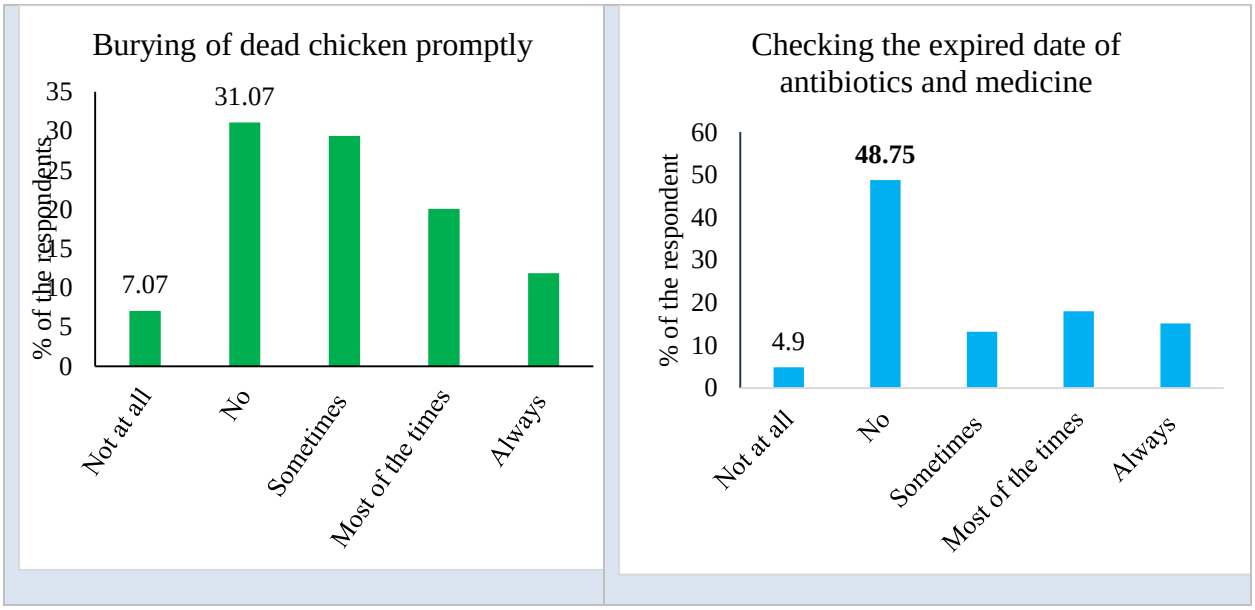
**Appendix-Figure 9: Producers' practices on proper feeding and disinfection**



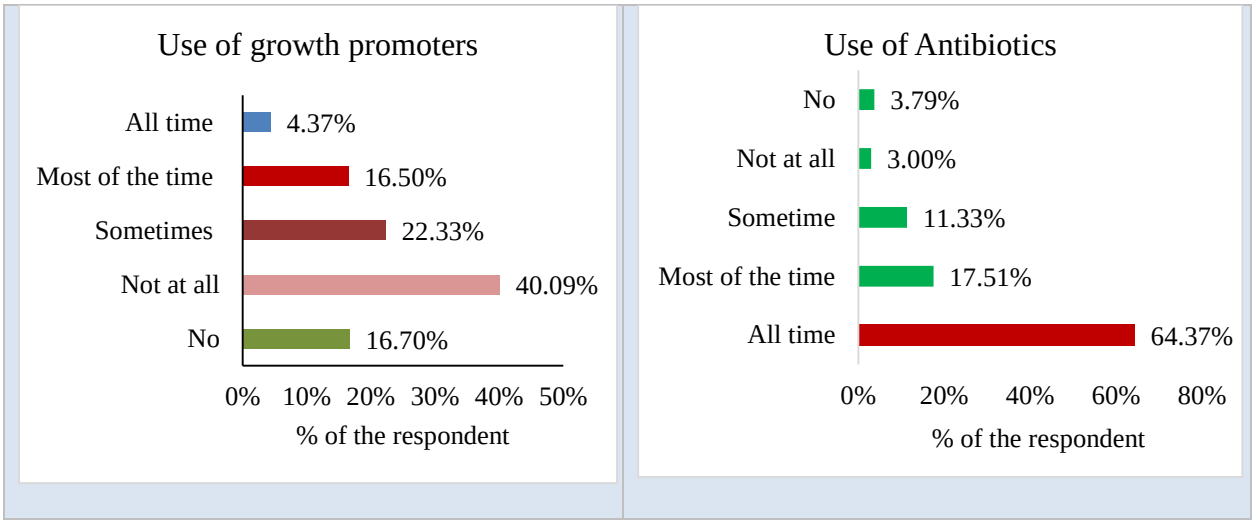

**Appendix-Figure 10: Producers' practices on separating sick chicken from the flock and providing proper clothing for employees**



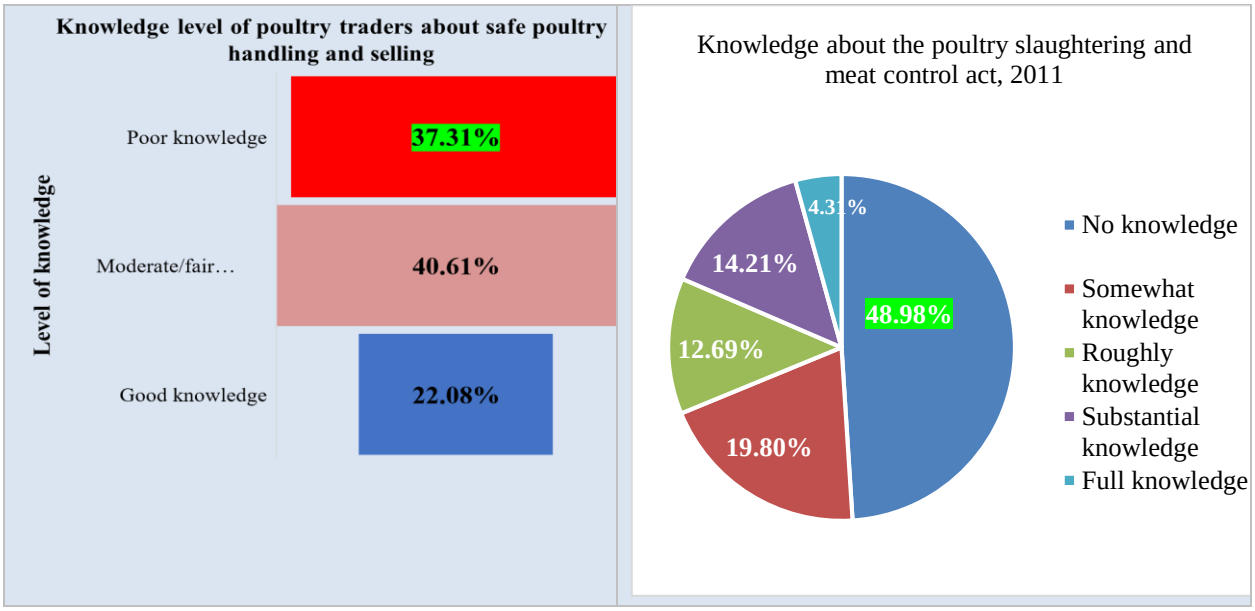
**Appendix-Figure 11: Producers' practices on burying chicken and checking expiration date of antibiotic and medicine.**



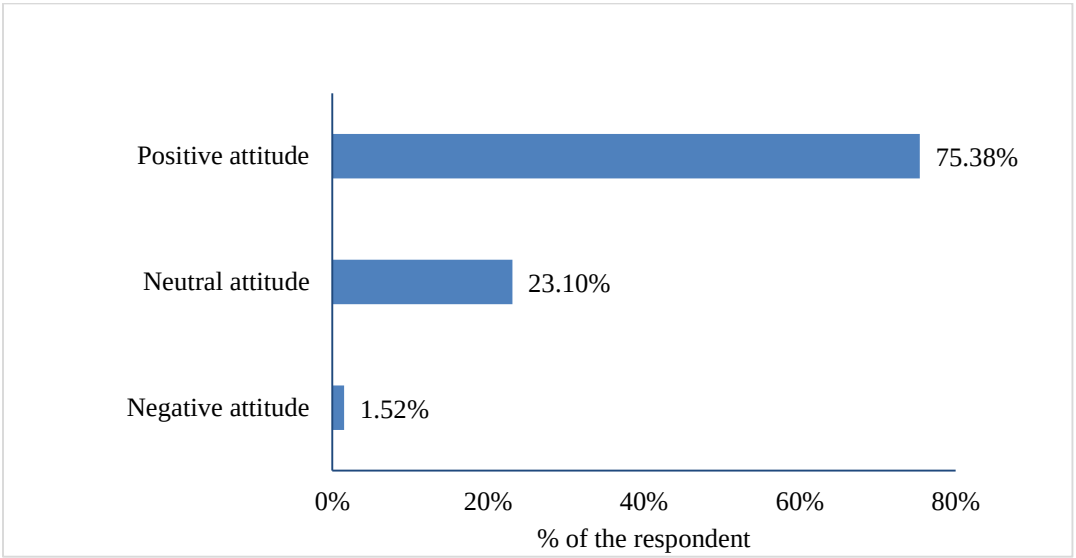

**Appendix-Figure 12: Producers' practices on use of growth promoters and antibiotics**



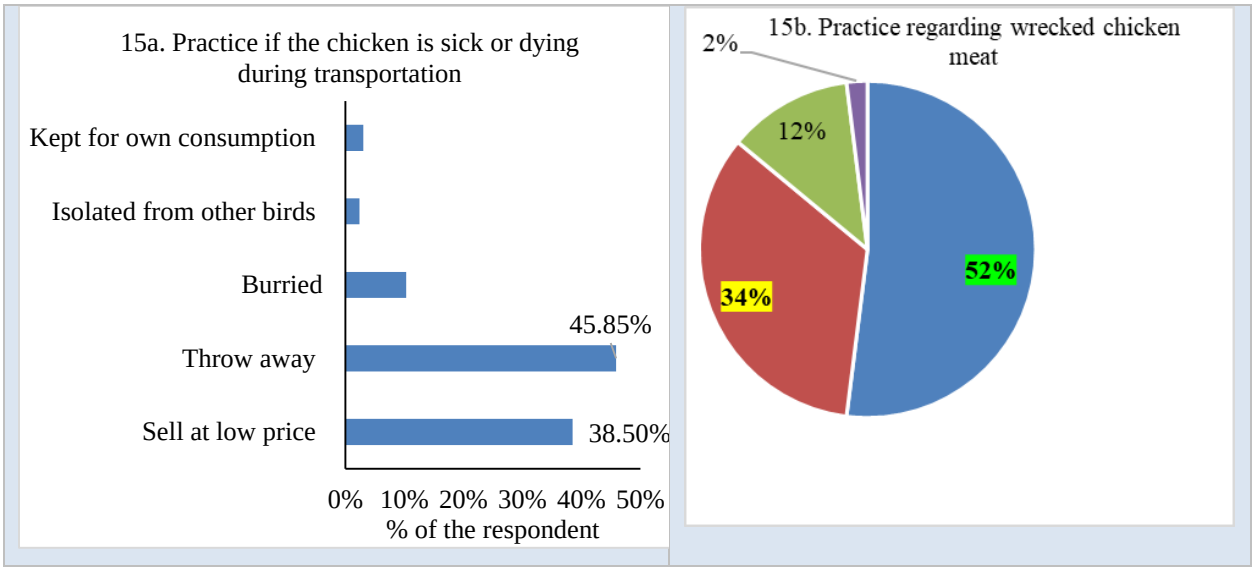
**Appendix-Figure 13: Value chain actors' knowledge on safe poultry handling and selling, and The Poultry Act of 2011**




**Appendix-Figure 14: Attitude level of poultry traders towards safe poultry**

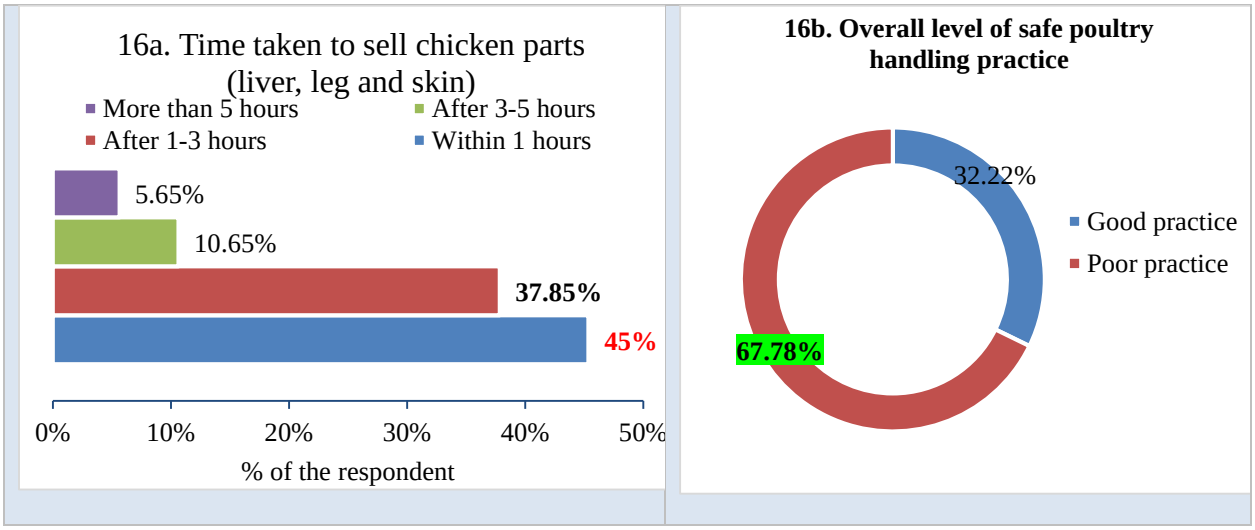


**Appendix-Figure 15: Practices around transportation and handling of spoiled chicken meat**

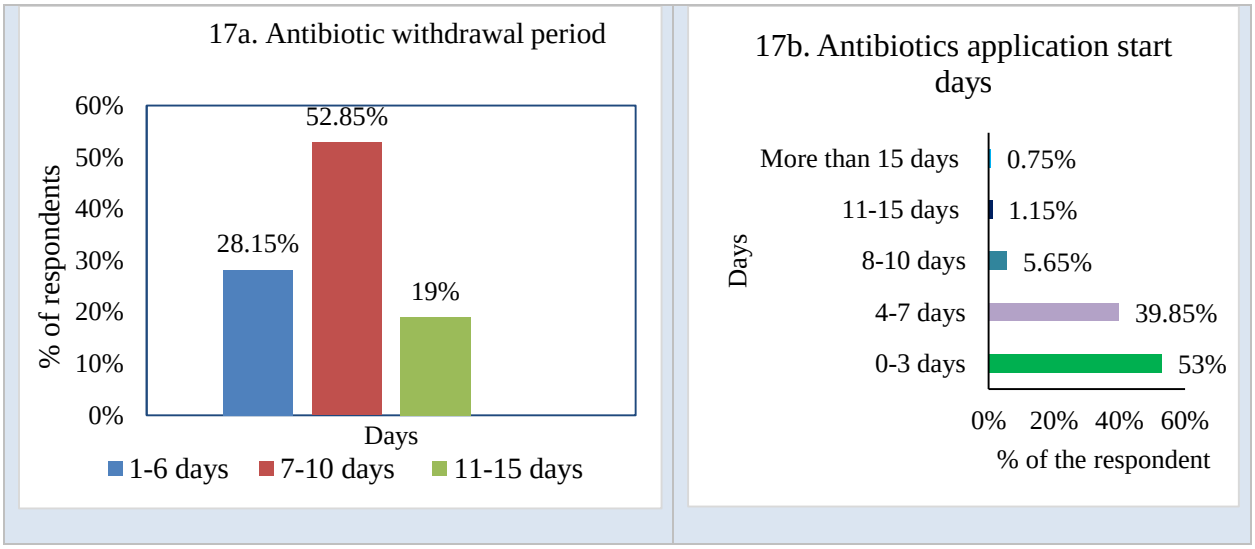



Legend for 15b: Blue: Farmers remove damaged meat and consume at their home. Red: sell at reduced price. Green: Discard/throw away. Purple: Immediately change and do not sell

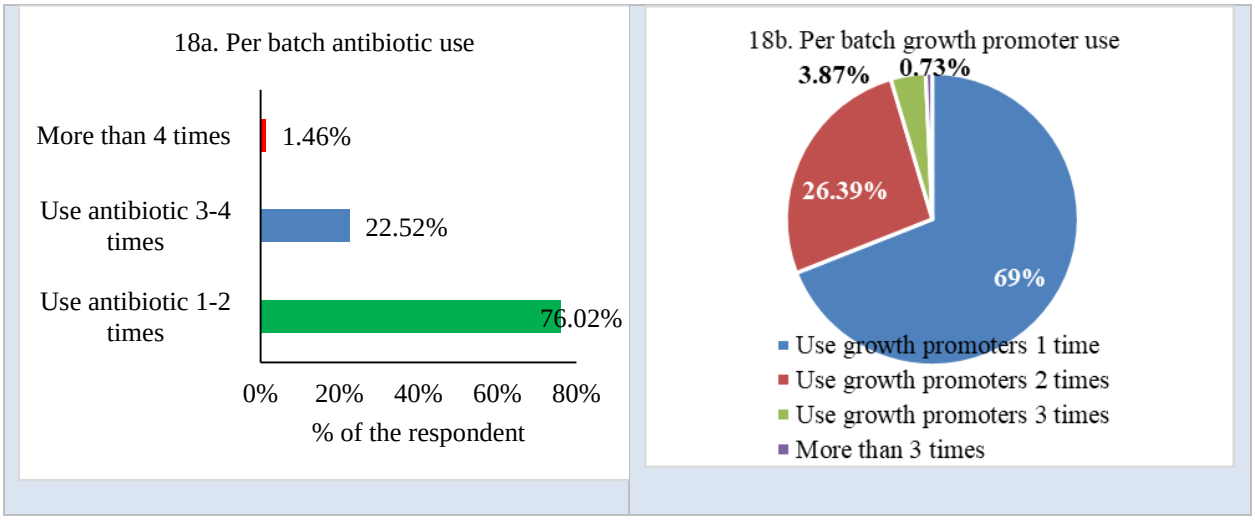
**Appendix-Figure 16: Practice level of poultry traders on sell of chicken parts and the overall practices**



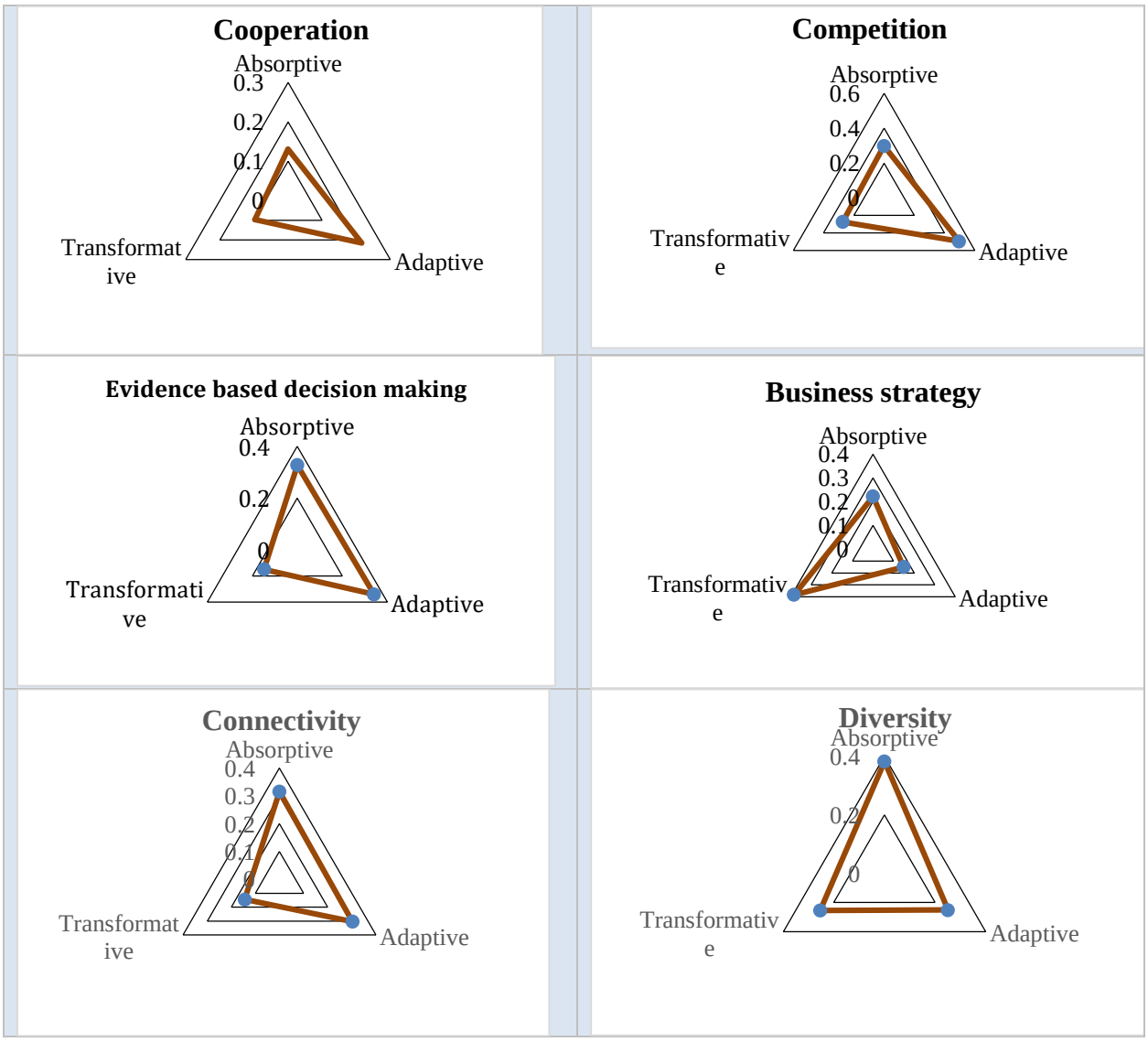
**Appendix-Figure 17: Antibiotic withdrawal period and application starts days.**

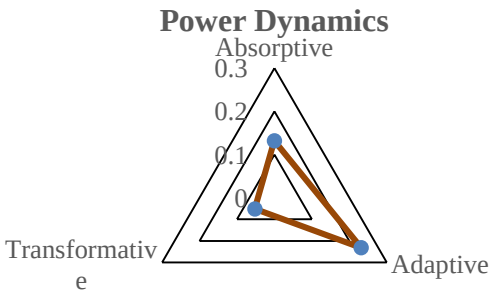


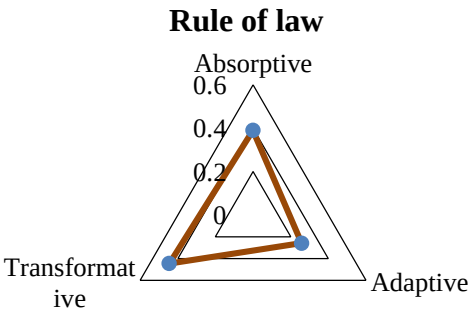

**Appendix-Figure 18: Per batch antibiotic and growth promoter use**



**Appendix-Figure 19: Per batch antibiotic and growth promoter use**




Power Dynamics
Absorptive
0.3
0.2
0.1
0
Transformativ
e
Adaptive


Rule of law
Absorptive
0.6
0.4
0.2
0
Transformat
ive
Adaptive