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Study on Animal Health Improvement & AMR Reduction in the Indian Poultry sector

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Study on Animal health improvement & AMR reduction in the Indian poultry sector

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LARIVE INTERNATIONAL

Executive summary

The Indian poultry sector

Poultry is one of the most important and advanced segments of the livestock sector in India, making it interesting for both domestic players and foreign investors. Over 5 MN people are directly engaged in the sector. Currently, India is the third-largest egg producer in the world (after China and the United States of America (USA)) and ranks fourth in terms of chicken meat production volumes, (after China, Brazil and the USA). Over the last six years, the per capita consumption of eggs in India has gone up from 30 to 70 eggs per year, and the consumption of poultry meat went up from 400 grams to 3.4 kg per year. As the consumption volumes are below the global rates, the consumption of eggs and poultry meat is expected to increase in the near future.

Anti-Microbial Resistance

In India, the use of antimicrobials in the livestock sector is expected to double between 2010 and 2030, which is significantly higher than the global trend. The use of antimicrobials in animal feed in India is currently an abundant and common practice. Antimicrobials are preventively applied to reduce disease risks, as growth promoters (in feed) or as sub-therapeutic treatment (in drinking water). The use of antimicrobials is effective and cheap, however, over-application of antimicrobials poses a lot of risks. Anti-Microbial Resistance (AMR) among animals, caused by over-application, causes animals to require increased doses of antimicrobials and/or other types of antimicrobials to have the desired effect. Secondly, antibiotic resistance amongst humans, caused by the consumption of products with antibiotic residues, pose serious health hazards for humans as antimicrobials to treat a disease become ineffective.

The COVID-19 pandemic, and previous poultry disease outbreaks (e.g. avian influenza), negatively impacted the reputation of the Indian poultry sector which in turn lowered the demand for poultry products. Consumers became more aware of food safety, antimicrobial usage and animal welfare concerns connected to the sector. Moreover, at the beginning of the pandemic, rumours were spread about poultry birds transferring the virus, causing a drastic drop in demand. The poor reputation poses a serious threat to the sectors' development as well as their global poultry position. And above all, the awareness regarding antimicrobials and the threat of resistance amongst animals and humans demands the Indian poultry sector to switch towards antimicrobial usage reduction and health improvement innovations and practices.

AMR reduction challenges

Although antimicrobial usage and animal health are mentioned as important topics by all poultry sector stakeholders (e.g. The Department of Fisheries, Animal Husbandry & Dairying, Food Safety Authority of India, Venky's, to name a few), not enough significant improvements are feasible yet. The current market situation, the (financial) performance of poultry farms, the high prices for antibiotic alternatives and the lack of alignment between public and private poultry sector stakeholders do not contribute enough to the reduction of AMR and/or the improvement of poultry health. In addition, there is currently no enabling environment, supporting investments and initiatives towards AMR and poultry health.

Another factor hampering AMR reduction is the lack of farmer awareness amongst medium and small scale farmers of potential measures and investments to achieve AMR reduction and improve poultry health. While large farmers, (international) integrators and their contract farmers aim to reduce their antimicrobial usages by switching to alternatives and increasing biosecurity levels. Medium and small-

scale independent farmers, raising 37% of the countries broilers and 32% of the layers, have limited knowledge, making them unaware of measures to take and investments to make to reduce their antimicrobial usage. Besides, antimicrobial alternatives are still referred to as expensive by these farmers. Additionally, the farmers do not have any incentives to implement AMR reduction and animal health improvement practices to make the necessary investments.

While the lack of farmer awareness is key concerning the AMR problem, the sub-optimal regulatory environment is equally important. Firstly, the regulatory environment does not provide farmers with incentives to reduce AMR and/or improve poultry health. Secondly, the lack of strict implementation, enforcement and control of rules, regulations and policies hampers the sector's progress towards antimicrobial reduction and health improvement. This is partly caused by the lack of knowledge sharing between public-private stakeholders and reliable farm level antimicrobial usage and poultry health data. Additionally, there is no mandatory requirement for poultry farms in India to be registered under a government agency enhancing the difficulties in formulating and implementing targeted measures. While AMR reduction and poultry health are key items marked on the Indian government agenda, unclarity on roles, responsibilities and control create an unstructured, ineffective regulatory environment.

Other factors hampering AMR reduction and poultry health improvement are:

- Lack of antimicrobial and poultry health data (limiting the formulation of proper policies and interventions);
- Inadequate disease surveillance systems;
- Unregulated imports of antimicrobials and feed with antimicrobials;
- The inclusion of antimicrobials in feed as a growth promoter;
- Improper logistics degrading the quality of poultry inputs (e.g. feed, vaccines) and negatively impacting poultry health (e.g. stress during live transport);
- Low technology and biosecurity solution adoption as farmers do not have the financial management skills to calculate the business case for these investments.

AMR reduction opportunities

On the other hand, the high frequency of AMR and poultry health-related events (e.g. seminars, webinars and roundtables) implies the willingness of stakeholders to work towards a sector with improved animal health levels, increased application of antimicrobial alternatives, investments in biosecurity and lower AMR levels.

The Netherlands is internationally renowned for its responsible and sustainable poultry sector and innovative products, technologies, solutions and knowledge. Policies and practices applied in the Netherlands regarding product safety, food quality, hygiene, efficiency and animal health and welfare are considered as the highest international standards. The Dutch poultry sector (knowledge institutes, government agencies and private sector) could therefore add significant value in supporting sustainable poultry sector development in India by focusing on AMR reduction and animal health improvement.

To achieve AMR reduction and poultry health improvement in this study's focus states, Andhra Pradesh, Telangana and Haryana, Larive-SS4 recommends the implementation of interventions by different poultry sector stakeholders, being: private sector, public sector, a combination of public-private sector and knowledge institutes. These interventions are derived from the opportunities identified in this study. The opportunities for the different stakeholder groups overlap, as they all

tackle the same bottlenecks. However, the concrete activities and parties involved to seize opportunities and implement interventions differ. The impact of activities will increase when bottlenecks will be addressed by all stakeholder groups, as this will stimulate the creation of a sustainable enabling environment

On the public-private level, Larive-SS4 recommends establishing Dutch-Indian broiler and layer Model Farms (demonstration and training locations), creating a *'seeing is believing'* approach by showcasing the business case of AMR reduction and poultry health-enhancing investments and practices. All challenges and opportunities addressed in this study can be tackled and demonstrated in these model farms. A visualisation of this recommendation is provided in an infographic on page 57.

On a private sector level the following business opportunities have been identified:

- Genetic programs to create breeds less vulnerable to diseases;
- Offering antibiotic alternatives, vaccines and animal health solutions and services;
- Improvement of feed quality to reduce the need for antimicrobial feeds;
- Facilitating broiler and layer farm upgrades through technology introduction;
- Improving slaughtering and processing segment to increase health and AMR standards;
- Digitalization of farm management;
- Building laboratory capacity for efficient disease diagnosis, quality testing and analysis.

On a governmental level, the identified opportunities relate to sharing knowledge between India and the Netherlands about the practices and measures already taken, joint procedure and protocol establishment, increasing monitoring capacity, facilitating laboratory and disease surveillance infrastructure development, support with the formulation, implementation and control (e.g. enforcement strategies) of policies and regulations, increasing the availability of reliable data, facilitating value-chain wide knowledge sharing and education of government stakeholders and veterinarians.

On a knowledge level, there are opportunities to develop cross-country curricula, selective training programs and collaborations in joint R&D programs.

Foreword by Embassy of the Kingdom of the Netherlands in India

The Food and Agriculture Organization of the UN, FAO, is clear in their message about Antimicrobial resistance (AMR): it is a major global threat of increasing concern to human and animal health. The global annual rise of people dying because of antimicrobial-resistant bacterial infections is of great concern. AMR in food systems has negative implications for food safety, food security and the economic wellbeing of millions of farming households. Resistant bacteria don't care about international borders. This is why it is important to cooperate with other countries in fighting antimicrobial resistance. If we can reduce the number of resistant bacteria, the entire world will benefit.

The risk of AMR in animal husbandry has been recognized in the Netherlands at an early stage. The Dutch policy and initiatives of and innovative approaches by Dutch companies and knowledge institutes have resulted in low antibiotic prescriptions and AMR rates. Worldwide, the number of bacteria resistant to antibiotics is increasing. In the Netherlands, this number generally remains stable and is less high than in many other countries. Compared to 2009, the reference year, sales decreased by almost 70 per cent in 2019. For livestock, almost no antibiotics that are important to treat infections in humans have been used in recent years. The most significant decrease over the past five years in ESBL-producing intestinal bacteria is seen in broilers and on chicken meat. ESBL are enzymes that can break down commonly used antibiotics such as penicillins. The Dutch poultry sector (with an annual turnover of about 5.4 billion euros) has demonstrated the potential of alternative approaches to antibiotics. Whilst the increase in productivity has been an important factor in the Dutch livestock industry, sustainably increasing production is of even greater importance.

Findings of the Indian Council of Medical Research's 2020 report on *'antimicrobial resistance research and surveillance'* underlines the growing antimicrobial resistance across India. The Indian population is known to be the highest consumer of antibiotics in the world. The Government of India and different States and (research) institutions have taken steps in fighting AMR. As India is the world's third-largest poultry producer after China with a fast-growing domestic market, intervention in the use of antibiotics in this sector seems a logical approach. Thus providing a pool of opportunities for Dutch companies, knowledge institutions to collectively work on poultry and create sustainable farming practices.

Next to many multilateral initiatives undertaken by the EU, the FAO and the WHO (to name a few) to cooperate with the Indian Government to fight AMR, the Netherlands government wishes to initiate possible opportunities to reduce AMR and improve animal health by offering Dutch knowledge, technical assistance and technology. This contributes to achieving sustainable development goals (SDG's, SDG3 - Good Health), target 3d (Improve early warning systems through global health risks), indicator 3d2 (Percentage of bloodstream infections due to selected antimicrobial-resistant organisms).

This study is a joint effort of the Agriculture Department of the Embassy of the Kingdom of the Netherlands in New Delhi, the Netherlands Business Support Office in Hyderabad and supported by the Netherlands Enterprise Agency. The study, for which Larive International was commissioned, aims to start a long-term and multidimensional approach for the sustainable and responsible growth of the poultry sector in India. Ultimately this approach should lead to the responsible use of antibiotics, improved animal health levels and reduced risks of disease outbreaks in the Indian poultry sector.

I congratulate Larive International and its partner, SannamS4, for their dedicated efforts. We have no doubt it will be useful to policy analysts, policymakers, the research and development community at large. This study will also help to achieve commercial success by collaborating on mutually identified development projects and will contribute to respective bilateral goals for both India and Netherlands.

Michiel van Erkel,

Agricultural counsellor, the Embassy of the Kingdom of the Netherlands in India

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List of Acronyms

AGP	Antibiotic growth promoters
AMR	Anti-Microbial Resistance
B-2-B	Business-to-Business
BIS	Bureau of Indian Standards
BN	Billion
CCS NIAH	Chaudhary Charan Singh National Institute of Animal Health
CDSCO	Central Drugs Standard and Control Organisation
CSE	Centre for Science and Environment
CTC	Chlortetracycline
DAHDF	Department of Fisheries, Animal Husbandry & Dairying
DBT	Department of Biotechnology
DCGI	Drug Controller General of India
DOC	Day Old Chicken
DPR	Directorate of Poultry Research
EKN	Embassy of the Kingdom of the Netherlands
FAO	Food and Agriculture Organization
FCR	Feed Conversion Ratio
FSSAI	Food Safety and Standards Authority of India
G-2-G	Government-to-Government
GoI	Government of India
HHEP	Hen Housed Egg production
HPAI	High pathogenic avian influenza
ICAR	Indian Council of Agricultural Research
ICMR	Indian Council of Medical Research
INFAAR	Indian Network for Fishery and Animal Antimicrobial Resistance
INFAH	Indian Federation of Animal Health
INR	Indian rupee
IVRI	Indian Veterinary Research Institute
K-2-K	Knowledge-to-Knowledge
kg	Kilogram
LPAI	Low pathogenic avian influenza
MN	Million
MoHFW	Ministry of Health and Family Welfare
MT	Metric Ton
NAP	National Action Plan
NCDC	National Centre for Disease Control
NIVEDI	National Institute of Veterinary Epidemiology and Disease Informatics
NVWA	Dutch Food Safety Authority
OECD	Organisation for Economic Cooperation and Development
OTC	Oxytetracycline
PDP	Project Directorate on Poultry
PPP	Public-Private Partnership
ROI	Return on investment
Rs	Rupee
USA	United States of America
USAID	United States Agency for International Development
UT	Union Territories
VCI	Veterinary Council of India
WHO	World Health Organisation

1. Introduction

1.1 Study background

This study derives from the strategy of the agricultural department of the Netherlands Embassy of the Kingdom of the Netherlands (hereinafter referred to as the "EKN" or "Embassy") in New Delhi. The department strongly focuses on working along the lines of safe, healthy and valued food. To that end, the sustainable development of agro-value chains in India is one of their main priorities. In addition, the Embassy in New Delhi aims to work on "*nexus*" projects, in which topics on the intersection of the sectors agriculture, water and health are addressed. As such, the Embassy assigned the topic of *OneHealth*, including reduction of Anti-Microbial Resistance (AMR) and animal health as one of the priorities within this nexus.

According to a recent forecast released by the OECD and the FAO, poultry is projected to represent the clear choice of consumers over the next 10 years. Global meat production is projected to continue to grow over the coming decade, but at a slightly slower rate than over the past 10 years. Compared to the 2018-2020 average, meat production is set to increase by 13% by 2030.[1]

Poultry is one of the most important and advanced segments of the livestock sector in India, making it interesting for both domestic players and foreign investors. Over 5 MN people are directly engaged in the sector. Currently, India is the third-largest egg producer in the world (after China and the USA) and ranks fourth in terms of chicken meat production volumes, after China, Brazil and the USA. In the last six years, the per capita consumption of eggs in India has gone up from 30 to 70 eggs per year, and the consumption of meat went up from 400 grams to 3.4 kg per year. As the consumption volumes are below the global rates, the consumption of eggs and poultry meat is expected to increase in the near future.[2]

The poultry sector in India offers promising potential, offering more opportunities than threats in the next five years.[3] One key threat however is challenging sustainable sector development: antibiotic (over)usage and health issues. As the poultry sector has been growing, so has the use of antimicrobials in the sector. While good animal health practices, a pre-requisite for a sustainable growing sector, are not applied to their full potential causing high mortality rates and disease risks.

The Netherlands is internationally renowned for responsible and sustainable production of poultry products, innovation, productivity and creation of added value. Policies and practices applied in the Netherlands regarding product safety, food quality, hygiene, efficiency and animal health and welfare are considered as the highest international standards. The Dutch poultry sector (knowledge institutes, government, agencies and the private sector) could therefore add significant value in supporting sustainable poultry sector development in India by focusing on AMR reduction and animal health improvement.

There are currently no Dutch governmental-funded activities with respect to the poultry value chain being implemented in India. The agricultural department of the EKN in New Delhi commenced this study with the ambition to kick start a long-term and multidimensional approach of the Dutch government to support the sustainable and responsible growth of the Indian poultry sector. This study

[1] OECD-FAO Agricultural Outlook 2021-2030, PoultryMed, 22 July 2021.
[2] National Annual Poultry Development Day'2021 Webinar on "Building Disease Free Indian Poultry Sector", All India Poultry Breeders Association, 2 July 2021.
[3] Rabobank (2021). Shiva Mudgil, Building a Future-Fit, Sustainable Indian Poultry Business, RaboResearch Food & Agribusiness.

aims to develop an overview of promising Dutch-Indian interventions to implement animal health improvement and AMR reduction initiatives by:

- Providing insight into the poultry value chain characteristics, main trends, issues and challenges, key stakeholders and the profitability of the Indian poultry sector (broiler and layer) concerning AMR reduction and animal health;
- Identifying opportunities for trade, investment, innovation, capacity building and knowledge transfer between India and the Netherlands to reduce AMR and improve animal welfare in the Indian poultry sector;
- Increase awareness amongst Dutch stakeholders about the animal health and AMR reduction opportunities and developments in the poultry sector in India;
- Increase awareness amongst Indian stakeholders about the value proposition in terms of animal health and AMR reduction of Dutch companies and knowledge institutes.

For this study, the EKN identified three key focus States being: Andhra Pradesh, Telangana and Haryana.

This study has been performed on behalf of the Netherlands Enterprise Agency (hereinafter referred to as the "NEA") by Larive International B.V. (hereinafter referred to as "Larive"), a Netherlands-headquartered business development advisory firm specialized in assisting companies in developing and implementing their market entry or expansion strategies in(to) high-growth emerging markets. Larive is the parent of the Larive Group, a license based network with exclusive members in 25 countries throughout Asia, Central & Eastern Europe, Turkey and Sub-Saharan Africa. In India, the Larive Group is formally represented by Sannam S4 Ltd. (the combination is hereinafter referred to as "Larive-SS4").

1.2 Animal health and AMR reduction poultry sector in India

In India, the use of antimicrobials in the livestock sector is expected to double between 2010 and 2030, which is significantly higher than the global trend.[4] The use of antimicrobials in animal feed in India is currently an abundant and common practice. Antimicrobials are preventively applied to reduce disease risks, as growth promoters added in feed or as sub-therapeutic treatment added in drinking water. Antibiotic growth promoters (AGP's) are used to improve the growth of animals by positive interactions with the intestinal microbial population, with antimicrobials controlling pathogen growth. The use of antimicrobials is effective and cheap, however, over-application of antimicrobials poses a lot of risks. AMR among animals, caused by over-application, increase the antimicrobial doses required by animals to achieve the desired effect. Secondly, antimicrobial resistance amongst humans, caused by the consumption of products with antibiotic residues, pose serious health hazards for humans as antimicrobials to treat a disease become ineffective.

Reducing antibiotic usage and improving animal health will enable the Indian poultry sector to more sustainably develop and utilize the sectors' potential, increase food safety levels, improve farming practices and performance, positively contribute to human health and strengthen its export position.

1.2.1 Importance

Antibiotic usage in the Indian livestock sector is significantly rising. Globally, the annual utilization of antimicrobials in livestock is expected to grow by 53% between 2013-2030. An increase in the human population, strengthened by increased animal-based protein consumption, is the main contributing factor in this projected augmentation of antimicrobial use in livestock. In 2010, the largest amount of

[4] Global trends in antimicrobial use in food animals, National Academy of Sciences of the USA, May 2015.

antimicrobials was applied by the Chinese livestock segment, followed by the USA, Brazil, Germany and India. In 2013, China (23%) and the USA (13%) held the highest shares in the application of antimicrobials, with India (4%) at the fourth position. The current trends predict India to become the second-largest gross antimicrobial user in the livestock segment by 2030.[5]

Antibiotic usage reduction and animal health improvement are important factors determining the health of the Indian consumer and the success of the Indian poultry sector as:

- India faces a lot of infectious diseases threatening human health
  AMR is of particular concern in developing nations, including India, where the burden of infectious disease is high and healthcare spending is low. According to the World Health Organization (WHO), India has among the highest bacterial disease burden in the world. Antimicrobials, therefore, have a critical role in limiting death and disease in the country.[6] With the rising utilization of antimicrobials in the Indian livestock sector, AMR is a major concern. If not addressed and tackled, the antimicrobials which we use in human healthcare would no longer be effective.
- Indian poultry sector experiences (economic) losses due to poultry diseases
  At the end of 2019, the Indian poultry industry was valued at approximately EUR 19.8 BN. In 2020, the poultry sector lost around EUR 2.29 BN (11.5%) of its value due to higher mortalities caused by poultry diseases and reduced consumer demands.[7] Amongst the several bacterial species causing poultry diseases, Staphylococcus, Pasteurella, Multocida and other bacteria have shown 100% resistance to antimicrobials.[8] With the utilization of antimicrobials rising, resistance will increase which will negatively impact the economic results of the poultry sector.

The reputation of the Indian poultry sector collapsed in the last 1-2 years due to the arrival of the COVID-19 pandemic in March 2020 and the bird flu in December 2020. These outbreaks, combined with misinformation about the causes of the outbreaks, resulted in consumers losing confidence in the market and farmers losing income. A strengthened image will make the sector more resilient against misinformation. AMR reduction and improved animal health practices could contribute to reputation improvement.

1.2.2 Challenges

There are several bottlenecks hampering animal health improvement and AMR reduction in India. Bottlenecks primarily consist of:

- Lack of rules and regulations and ineffective implementation, enforcement and control;
- Lack of coordination and collaboration amongst stakeholders;
- Lack of data on antibiotic usage;
- Standard addition of chemicals and drugs in feed;
- Inadequate logistics, processing facilities and technology;
- Poor farmer knowledge and awareness;
- Low technology adoption;
- Higher costs of antibiotic alternatives;

[5] Understanding policy dilemmas around antibiotic use in food animals & offering potential solutions, Indian Journal of Medical Research, February 2019.
[6] Antimicrobial resistance in Indian poultry: cause, concern and measure, One Health Poultry Hub, 14 November 2019.
[7] All India Poultry Breeders Association (AIPBA) Webinar on "Building A Disease-Free Indian Poultry Industry", 22 June 2021.
[8] Understanding policy dilemmas around antibiotic use in food animals & offering potential solutions, Indian Journal of Medical Research, February 2019.

- Inadequate disease surveillance systems.

1.2.3 Legal and regulatory environment

Antimicrobials are under the purview of the Central Drugs Standard and Control Organization (CDSCO) which falls under the Ministry of Health and Family Welfare (MoHFW). In the Drugs and Cosmetics Act (1940) antimicrobials are typically placed under Schedule H which makes it mandatory that they are sold only under prescription by registered medical practitioners, including veterinarians.

When antimicrobials are added to feed, the product is no longer under the purview of CDSCO.[9] The department of Fisheries, Animal Husbandry & Dairying (DAHDF) is the supervising authority that outlines the standards and guidelines of feed additives.

The Food Safety and Standards Authority of India (FSSAI) is also in the process of framing out policies and guidelines for the regulation of animal feed and feed additives. The Indian Federation of Animal Health Companies (INFAH) is closely working with the FSSAI to formulate new regulations. The Animal Health industry is currently focusing on biosecurity solutions, vaccinations, and the use of suitable alternatives such as probiotics and organic acid, to reduce the use of antimicrobials in animals to the extent possible.[10]

In the absence of any uniform policy about antimicrobial usage in animals in India, preventive use of antimicrobials in poultry production is common. Despite the availability of advice and guidelines of different stakeholders on antimicrobials use in animals including poultry, antimicrobial use remains high and unregulated.[11] Currently, there is no uniform policy about antimicrobial usage in the livestock segment.

To address the implementation gap, the Indian National Action Plan (NAP) for AMR has been established by the MoHFW in 2017. It addresses the policy and regulatory issues concerning antibiotic usage. The Government of India (GoI) has implemented a few stringent regulations to minimise the use of antimicrobials including enforcement of Schedule H1 categorisation for all-important antimicrobials, restriction on animal use of critically important antimicrobial Colistin. The individual states are responsible for the implementation of the NAP.

Additionally, there have been ongoing efforts from organisations such as the Indian Council of Medical Research (ICMR) and the Indian Council of Agricultural Research (ICAR) on disease surveillance systems and the creation of a comprehensive database on the prevalence of AMR infections. Thus far, no national surveillance system is in place yet.[12]

Figure 1 provides an overview of past recommendations, including the time-indication, of Indian organisations to address the use of antimicrobials and AMR in livestock including poultry. Descriptions of and linkages between all governmental stakeholders are elaborated upon in chapter 4.1, and Annex 3 zooms in on the AMR reduction and poultry health improvement activities of the different stakeholders.

[9] Perpetually on antibiotics, DownToEarth, 10 April 2020.
[10] Expert views on Antimicrobial Resistance (AMR), Benison Media, 27 January 2021.
[11] Understanding policy dilemmas around antibiotic use in food animals & offering potential solutions, Indian Journal of Medical Research, February 2019.
[12] Expert views on Antimicrobial Resistance (AMR), Benison Media, 27 January 2021.

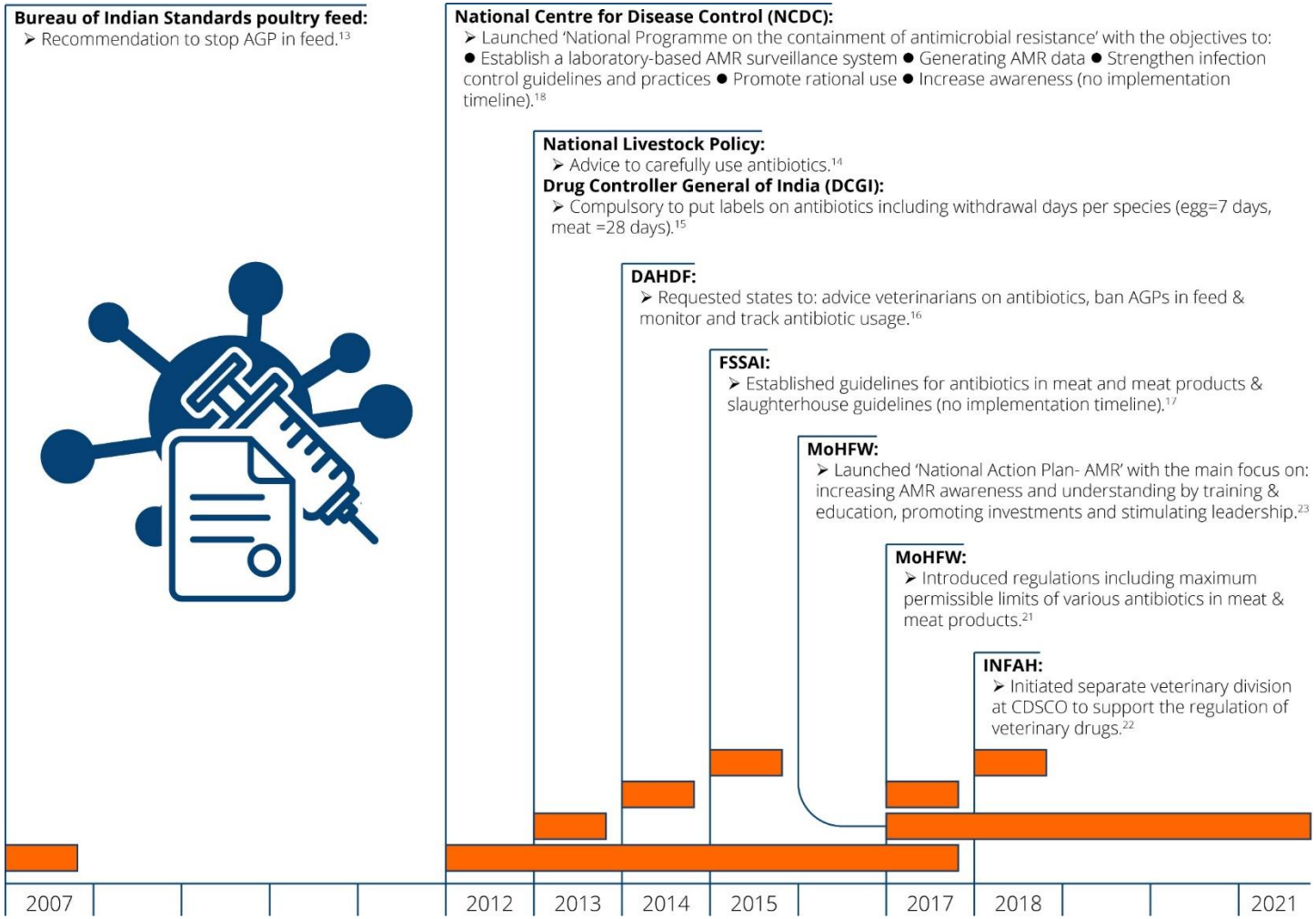

Figure 1:Recommendations Indian key stakeholders to address antimicrobial usage and resistance in livestock

[13] Understanding policy dilemmas around antibiotic use in food animals & offering potential solutions, Indian Journal of Medical Research, February 2019.
[14] Understanding policy dilemmas around antibiotic use in food animals & offering potential solutions, Indian Journal of Medical Research, February 2019.
[15] Understanding policy dilemmas around antibiotic use in food animals & offering potential solutions, Indian Journal of Medical Research, February 2019.
[16] Perpetually on antibiotics, DownToEarth, 10 April 2020.
[17] Understanding policy dilemmas around antibiotic use in food animals & offering potential solutions, Indian Journal of Medical Research, February 2019.
[18] Antimicrobial resistance in Indian poultry: cause, concern and measure, One Health Poultry Hub, 14 November 2019.
[19] Understanding policy dilemmas around antibiotic use in food animals & offering potential solutions, Indian Journal of Medical Research, February 2019.
[20] Antimicrobial resistance in Indian poultry: cause, concern and measure, One Health Poultry Hub, 14 November 2019.
[21] India to reduce use of antibiotics in poultry, Poultry World, 22 November 2017.
[22] Expert views on Antimicrobial Resistance (AMR), Benison Media, 27 January 2021.
[23] Understanding policy dilemmas around antibiotic use in food animals & offering potential solutions, Indian Journal of Medical Research, February 2019.

2. Methodology

The study has been completed on a '*best effort*' basis through desk research and qualitative research, including a vast number of in-depth interviews and field visits with private sector players (independent and integrated companies active in breeding, feed manufacturing, farming, and processing) active in the focus states, National and State government bodies and public stakeholders (policymakers, regulatory departments, associations, universities/educational institutes and NGO's). Annex 1 provides an overview of all interviewed stakeholders for this study. In total, N=44 interviews have been conducted, of which N=23 with local farmers. The local farmer interviews have been combined with field visits. In addition to the expert interviews in India, several Dutch poultry stakeholders have been contacted to get a better understanding of their views on the business opportunities in India, how Dutch actors could add value to AMR reduction and animal health improvement in the Indian poultry sector and how knowledge transfer between India and the Netherlands can be stimulated. These Dutch stakeholders have been linked to the opportunities as identified in chapter 6 and Annex 4-6.

3. Characteristics poultry sector India

The poultry sector in India has an important position in the global poultry industry. The sector primarily consists of broilers and layers, although a few other species such as ducks, turkeys, quail and pigeons are reared as well.[24]

3.1 Historical development poultry sector India

The Indian poultry sector was worth EUR 19.8 BN (INR 1,750 BN) in 2018 and is projected to reach EUR 49 BN (INR 4,340 BN) by 2024, growing at a CAGR of 16.2% between 2019 and 2024.[25] Annex 2 provides an overview of the global egg and meat production shares per country, indicating that India was the world's third-largest egg producer and the fifth-largest poultry meat producer in 2019. [25, 26, 27] Meat and eggs are mainly produced for domestic use and the export volumes are limited.

The poultry sector in India has undergone a shift in structure and operation over the years. Poultry, which was considered a backyard venture in the early 1960s, has today turned into a strong commercial farming activity, from a backyard activity to an organised, scientific, and vibrant industry. While historically, broiler farms produced about a few hundred (200-500) birds per cycle, the average amount of birds per cycle currently ranges between 5,000 to 50,000. For layer farms, flock sizes range from 10,000 to 50,000 birds.

Commercial farming

Commercial farms are organized and located mostly in urban and peri-urban areas where a market for poultry products is assured. Commercial farmers usually rear hybrid birds specifically bred either for meat or egg production. Lower production and marketing costs (due to volume advantages) enable commercial farmers to reduce consumer prices.[28] The advent of organised players in retail sectors, combined with the consumer focus on the quality and safety of meat and eggs has triggered the need for commercial integrated farmers.

The commercialization of the Indian poultry sector is enabled by the adoption of technology, increased production scales and the arrival of contract and integrated farms. Currently, around 70% of all poultry farming in India is executed by contract and integrated farms. Under the contract farming model, large integrators provide, amongst others, Day Old Chickens (DOCs), feed, vaccination, veterinary services (including advice on how to reduce antimicrobial usage) to contracted farmers with a buy-back arrangement. The integrator buys the end product of the contract farms and the farmers bear the costs of housing, labour, electricity, water and maintenance. Integrators include large national and regional farms integrating all aspects of the poultry value chain, from raising grandparent stock to feed production to wholesaling. In some cases integrators own all farming facilities, in other cases, they contract surrounding farmers (contract farming model). Integration reduces price fluctuation, as the farmers are present in the entire value chain. Integrators play an important role in reducing the use of antimicrobials as they are responsible for a large part of the national production.

Backyard farming

Backyard farming is typically unorganized and commonly practised in rural areas to supplement household income and nutrition requirements. High feed and transportation costs, expensive

[24] FAO. Microsoft Word - Duck book Edited SL-new.doc (fao.org).
[25] Indian Poultry Industry at a Glance in 2018-19, Indian Mirror.
[26] Poultry Sector: Count your chicken before they hatch!, Trade Promotion Council of India, 7 October 2020.
[27] http://www.fao.org/faostat/en/#data/QL.
[28] National Action Plan for Egg & Poultry-2022 For Doubling Farmers' Income by 2022, Department of Animal Husbandry, Dairying & Fisheries, Ministry of Agriculture & Farmers Welfare, Government of India.

vaccines and a lack of veterinary services are common issues for backyard farmers. Due to their low production volumes and lacking ability to purchase bulk, they are unable to pay their inputs on credit.

Backyard farmers often use dual-purpose indigenous breeds, being Vanaraja and Kadaknat, for their production. The GoI has recognized the inefficiency of these breeds for both eggs and meat production, and instead promote the development of improved, low technology input breeds (e.g. Chabro, Kuroiler, Rainbow Rooster and Kalinga Brown). Low technology birds grow faster, reaching a weight of 1.5 kg in 45 days and can withstand variable feed qualities and supplement themselves by scavenging. Female low technology birds lay 160 eggs versus a maximum of 60 eggs per year produced by indigenous birds.[29]

Production & consumption growth

While the number of backyard farms grows at a faster pace compared to commercial farms, the high level of productivity for commercial farms causes the majority of poultry products to be produced by commercial farms.[30] Table 1 provides an overview of the Indian poultry population between 2003 and 2019. In 2019, around 37% of the entire bird population was reared by backyard farmers, gross of the birds (63%) was reared by commercial farms. For layer, around 68% of the birds are kept at commercial farms, accounting for over 80% of the national egg production.[31] The commercialization of the sector is also feasible in the year-on-year poultry meat and egg production and consumption estimates for the coming years (2016-2027). Figure 2 and Figure 3 display the year-on-year increase in production and consumption figures.[32]

Poultry population in India (in MN)		% change in poultry population in India	
2003	489.01	1997-2003	40.68
2007	648.83	2003-2007	32.68
2012	729.21	2007-2012	12.39
2019	851.81	2012-2019	16.81

Table 1: Overview of the number of poultry birds in India, over 2003 - 2019

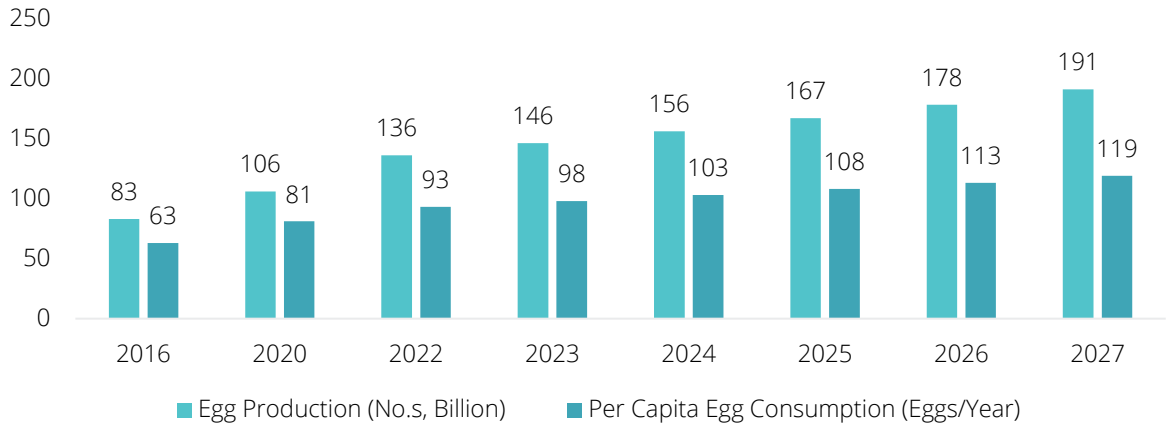

Figure 2: Egg production and consumption India 2016-2027

[29] All India Poultry Breeders Association (AIPBA) Webinar on "Building A Disease-Free Indian Poultry Industry", 22 June 2021.
[30] Primary Larive-SS4 research, 2021
[31] Government of India, Basic Animal Husbandry Statistics-2019.
[32] Amarthi Consulting, Department of Animal Husbandry and Dairying projections 2022-23, Conference on Poultry Technologies, Confederation of Indian Industry (CII), 23 April 2021.

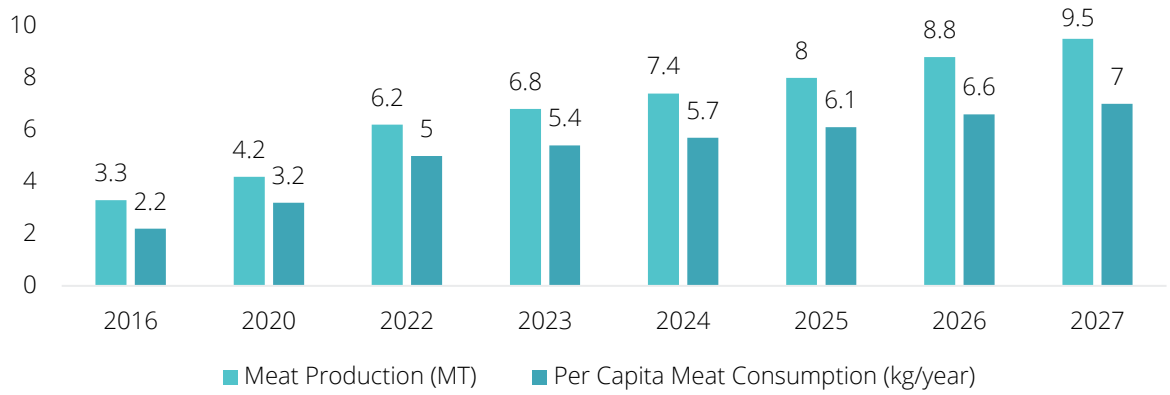

Figure 3: Poultry meat production and consumption India 2016-2027

Growth drivers

Growth drivers can be divided into production and consumption-driven factors. On the production side, the implementation of efficient breeding, hatching, rearing and processing technologies resulted in the availability and implementation of better-performing breeds. Desk research reveals that increased export rates driven by competitive production costs, the proximity to international markets and successfully losing the highly pathogenic avian influenza (HPAI) have been the primary causes for growing poultry production and processing rates.

On the consumption side, growth drivers include the rising disposable income, growing middle class, and increasing demand for processed, ready-to-eat products. The consumption growth driver all relates to national demand growth. The overall export of poultry products is limited due to a lack of processing infrastructure and food safety regulations and control.

3.2 Geographical characteristics poultry sector India

The majority of the poultry industry is located in the southern states of India. Andhra Pradesh and Tamil Nadu dominate the countries egg production, producing approximately 37% of the total Indian eggs. Other key egg production states are Telangana, West Bengal and Haryana. Jointly, the key states produce about 65% of all Indian eggs.

Haryana, Maharashtra, Uttar Pradesh, Tamil Nadu and Andhra Pradesh are the leading states in terms of poultry meat production, constituting approximately 58% of the total production. Figure 4 provides an overview of the production shares of the top five egg producing and poultry meat producing states in 2018 – 2019.[33]

[33] Government of India, Basic Animal Husbandry Statistics-2019.

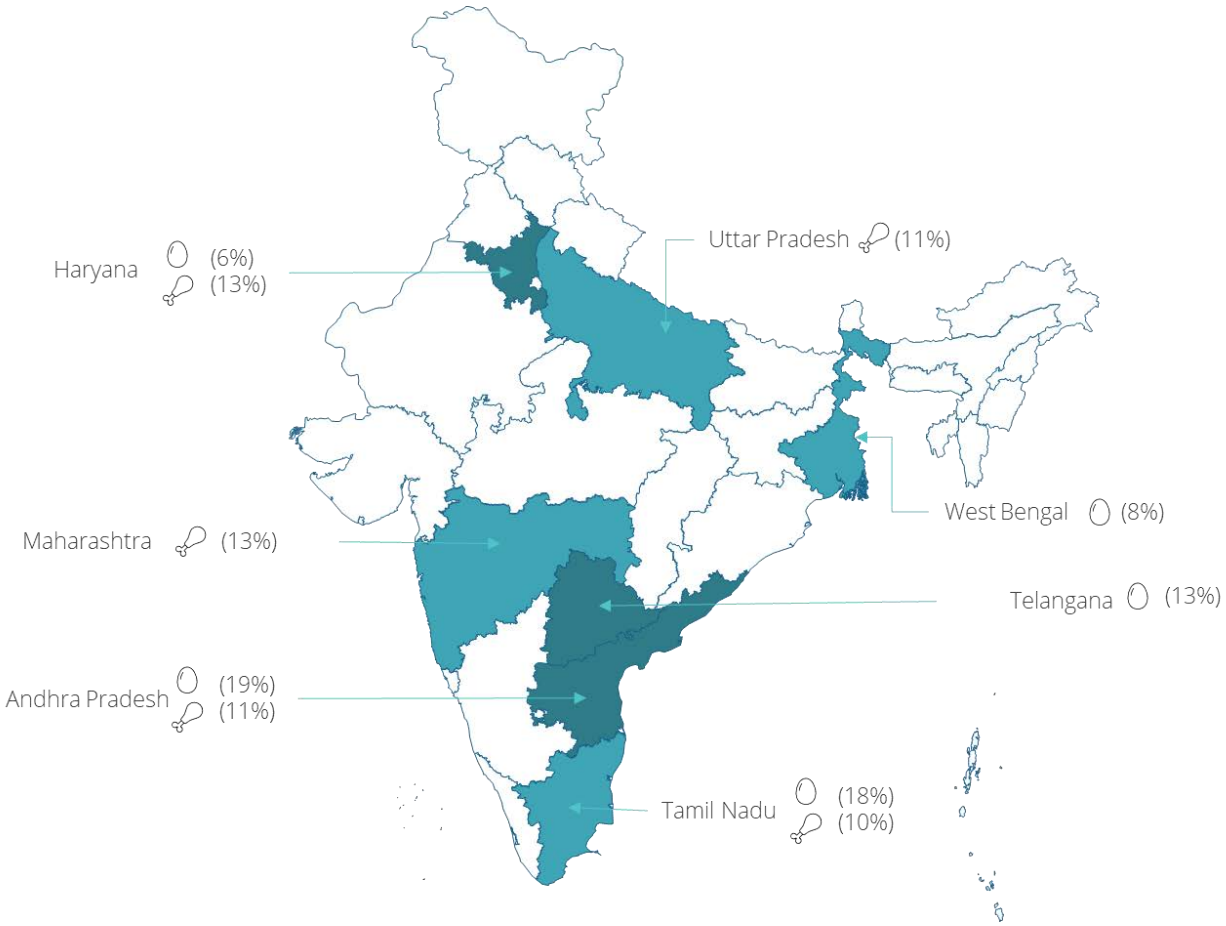

Figure 4: Production share of the top egg and meat producing states 2018 – 2019 (%)

The structure of the poultry industry, type of farming as well as antibiotic usage and animal health, differs considerably per state. Yet, increased production and consumption rates patterns are similar across the states.

This study focuses on the states Andhra Pradesh, Telangana and Haryana in which, the majority of poultry farms operate under a contract farming model. In Andhra Pradesh and Telangana, Srinivasa, Suguna, Sneha Foods, Sakku Group and Sreekanth are the leading players. In Haryana, Skylark and IB Group are the leading players. Table 2 displays the percentage and average size (in birds) of the broiler and layer contract farms in the focus states.[34]

Category	Particular	Andhra Pradesh	Telangana	Haryana
Broiler	Contract farms	75-80%	75-80%	60-65%
	Average farm size	5,000-6,000	5,000-6,000	4,000-5,000
Layer	Contract farms	60-70%	60%-70%	70%-75%
	Average farm size	28,000-30,000	28,000-30,000	25,000-30,000

Table 2: Percentage and size of contract farms in focus states

[34] Analysis primary interviews.

3.2.1 Andhra Pradesh

With 8 hatcheries, 96 registered slaughterhouses and 29 layer and broiler farms, Andhra Pradesh ranks first on egg production and is the fifth-largest state regarding Indian poultry meat production.[35] Figure 5 presents the different key poultry districts in Andhra Pradesh. East and West Godavari, Krishna and Guntur districts have the highest layer bird population. Chittoor, Nellore, Vizianagaram, Srikakulam and Visakhapatnam districts are also prominent districts with a medium number of layer farms. Prakasam and Kurnool have a small broiler population.[36] Around 84 % of Andhra Pradeshs' layer bird population is reared at commercial farms, accounting for 95% of the States' total egg production.[37]

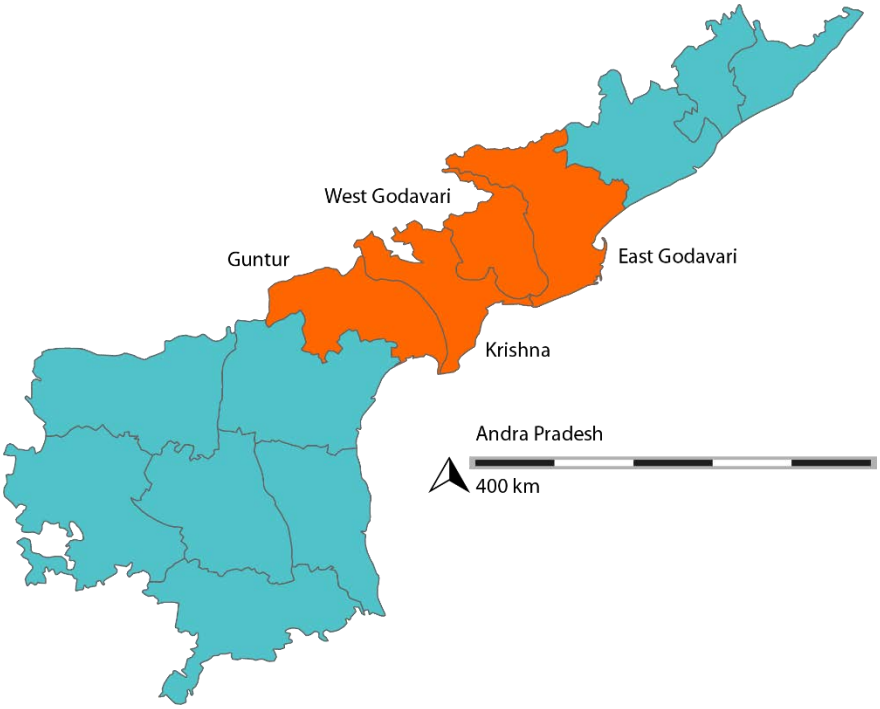

Figure 5: Map of Andhra Pradesh highlighting key layer population districts

The government of Andhra Pradesh has implemented the Poultry Development Policy aimed at enhancing the production level of commercial broilers and layers, encouraging value-added processing of eggs and promoting partnerships with private players through capital and interest subsidies.[38] Figure 6 provides an overview of the egg and poultry meat production growth and the states' contribution to national production.[39]

[35] Basic Animal Husbandry Statistics 2019.
[36] In 2916
[37] Basic Animal Husbandry Statistics 2019, Farming in Andhra Pradesh, Government of Andhra Pradesh.
[38] Government of Andhra Pradesh, https://www.ap.gov.in/wp-content/uploads/2016/11/2016AHF_MS27.pdf.
[39] Basic Animal Husbandry Statistics 2019.

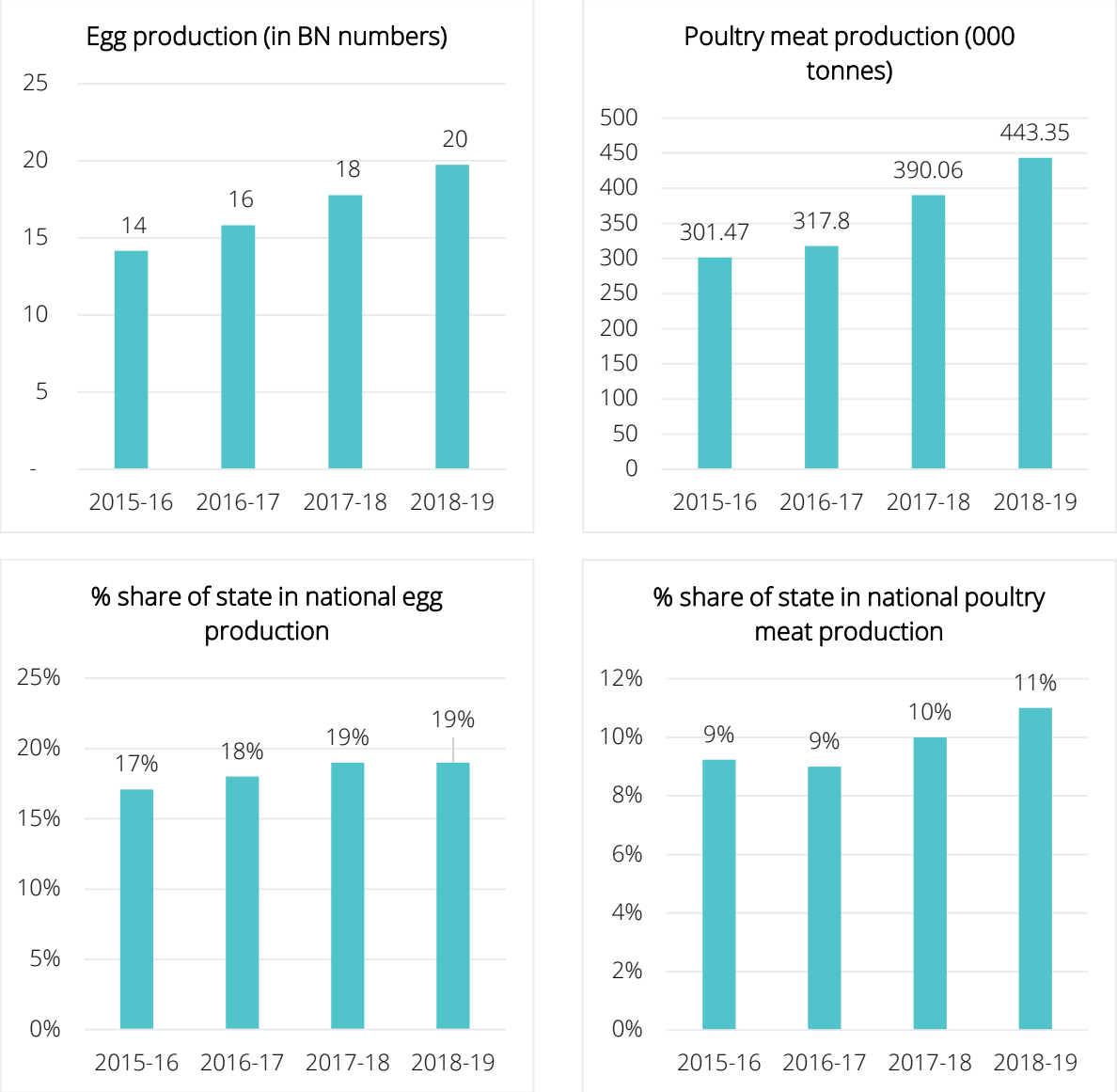

Figure 6: Egg and poultry meat production Andhra Pradesh 2015-2019

Poultry farming in Andhra Pradesh is the most dynamic and fastest-growing segment of the agriculture sector. Andhra Pradesh has reached a stage of self-sufficiency and sophistication in the production of breeding stock, feed, pharmaceuticals, vaccines and equipment to meet the current and future needs. Figure 7 shows a typical setup of a semi-intensive layer farm in Andhra Pradesh.

Figure 7: Semi-intensive layer farmhouse in Andhra Pradesh

3.2.2 Telangana

Having 37 hatcheries, 53 registered slaughterhouses, Telangana has the third-largest poultry population, ranks third for egg production and is among the top ten states contributing to poultry production.[40] The state contains around 10,000 broiler farms and 2,000 layer farms (these figures are not officially confirmed statistics).[41] Adilabad, Medak, Ranga Reddy and Mahbubnagar districts have the highest bird populations in the state. Figure 8 presents a map of Telangana, highlighting the key poultry districts. While both broiler and layer farms are present in the highlighted districts, they are mostly dominated by broiler farms.

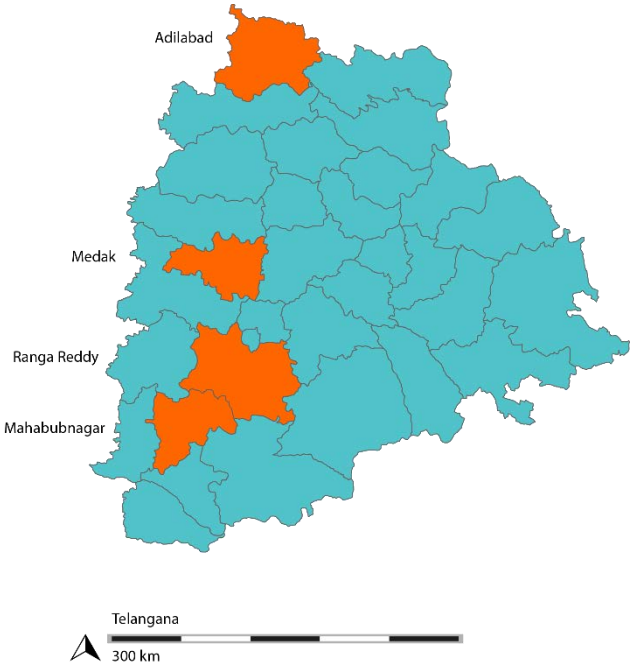

Figure 8: Map of Telangana highlighting key poultry population districts

[40] Basic Animal Husbandry Statistics 2019.
[41] The Siasat Daily, Telangana's poultry industry is now coming back to life, 25 September 2020, available through: https://www.siasat.com/telanganas-poultry-industry-is-now-coming-back-to-life-1982955/.

As Telangana is a relatively new state, the development of the poultry sector requires certain planned initiatives and policies to further develop the sector. The central government initiated the distribution of DOC's of native breeds to the local community, to reduce protein deficiency among rural communities. Additionally, the government provides DOCs and farmhouses at subsidized rates to independent small and medium-scale farmers. Governmental support does not include the provision of feed, as backyard farming relies on scavenging. Backyard farming is promoted as it provides households with the possibility to be self-sufficient in terms of poultry production.[42]

Figure 9 provides an overview of the egg and poultry meat production growth and the states' contribution to the total national production.

Figure 9: Egg and poultry meat production Telangana 2015-2019

[42] Telangana govt's chicken push to revive poultry business in villages, The Times of India, 09 February 2017.

Smaller farmers (<500 birds) use antimicrobials as prescribed by veterinarians and veterinary consultants for preventive care and yield enhancement. However, under contract farming, companies do not recommend the use of antimicrobials. Instead, they promote the use of vaccines and antibiotic alternatives due to rising consumer awareness and social responsibility for enhancing food safety. The majority of antibiotic-free farming is practised at large farms, as farmers are guided by companies employing in-house veterinarians/technicians. Figure 10 shows a typical setup of a semi-intensive broiler farm in Telangana.

Figure 10: Semi-intensive broiler farmhouse in Telangana

3.2.3 Haryana

The poultry sector in Haryana has been on the rise for the past few years. With one government hatchery, three registered slaughterhouses, 250 commercial layer and 2,000 broiler farms, it is one of the top five states contributing to egg production, the second-largest producer of poultry meat and it contains the highest number of birds slaughtered for meat production. The broiler production hubs include Jind, Panipat, Hisar, Sirsa, Karnal, Kaithal and Yamuna Nagar districts. There are four government-owned poultry farms in Ambala, Rohtak, Bhiwani and Hisar.[43] Figure 11 presents a map of Haryana, highlighting the key poultry districts and government-owned farms (stars).

[43] Poultry hubs in Haryana are in tatters, broilers and layer farms are closing by the dozens, Rural Connection, 2 April 2020.

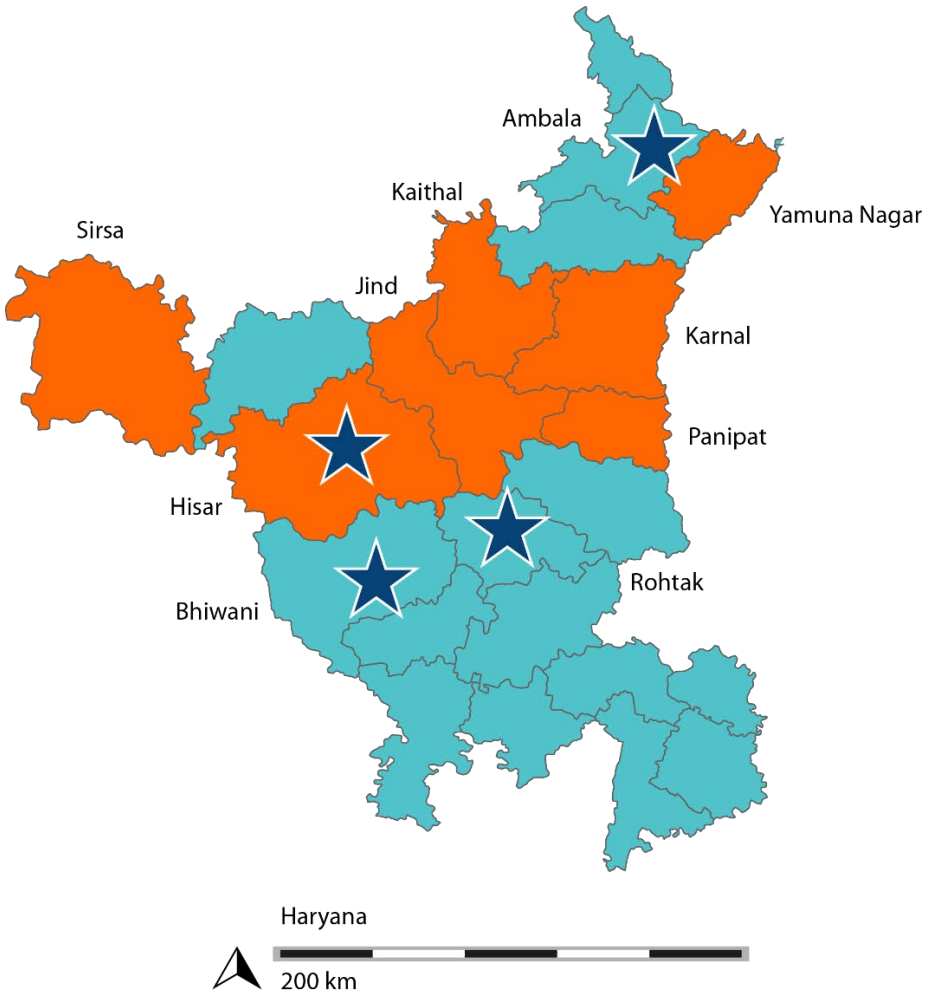

Figure 11: Map of Haryana highlighting key poultry population districts and location of government-owned farms

Figure 12 provides an overview of the egg and poultry meat production in Haryana between 2015 and 2019. While egg production is stable, poultry meat production shows a decreasing trend between 2015 and 2019.

State-specific factors hampering sector development include:

- No concessions subsidies/support schemes offered by the government;
- High electricity prices and property tax;
- Low-efficiency rates of chicken and eggs.

Figure 12: Egg and poultry meat production Haryana 2015-2019

A survey of the Centre for Science and Environment (CSE) in 2019 reported that antibiotic usage in commercial farming is rampant in Haryana. Preventive doses are given to DOC's at the farm, and parent stocks are consistently exposed to antimicrobials at breeder farms. Moreover, the use of AGPs is an integral part of broiler farming. Commonly used AGPs include oxytetracycline, chlortetracycline, bacitracin and furazolidone. Broilers are fed with antibiotic laden feed to reduce the Feed Conversion Ratio (FCR) and promote growth.[44] Feed with AGPs is available at feed mills, and millers often offer customization options. There are over 27,000 veterinary institutions in Haryana, which have a limited role in the provision of antimicrobials used without any medical ground. Figure 13 shows a typical setup of a semi-intensive broiler farm in Haryana.

[44] In animal husbandry, feed conversion ratio (FCR) or feed conversion rate is a ratio or rate measuring of the efficiency with which the bodies of livestock convert animal feed into the desired output.

Figure 13: Semi-intensive broiler farmhouse in Palwal, Haryana

Larger commercial farmers are aware of the importance of biosecurity measures such as those linked to the prevention of infection (e.g. hygiene protocols and closed water systems) and reduced stress (e.g. climate control). These farmers are mostly capable of integrating the infrastructure and resources required to allow for computerized ventilation systems, closed sheds for better temperature and humidity control, improved waste and dead bird disposal systems, testing toxins in feed and restricting access to broilers. Farmers try to control the quality of parents and chicks by limiting vertical transmission of diseases. Yet, there is no proof of farmers in Haryana investing in or adopting practices to substitute antimicrobials, this is mainly due to the lack of incentives for producing antibiotic-free chickens.[45]

3.3 Practices and systems influencing AMR and animal health

The current poultry sector characteristics, including practices and farming systems applied, determine the level of animal health and antimicrobials used in the sector. The following sections will elaborate upon frequent poultry diseases, antimicrobial usage, vaccination practices, different housing systems, drinking water systems, farmhouse climate, feed and additives and antimicrobial alternatives, and their impact on AMR and poultry health.

Diseases in the poultry sector

Numerous diseases are impacting antimicrobial usage and animal health in the Indian poultry sector. The most common diseases being reported include Marek's, Ranikhet, Gumboro and Infectious Bronchitis. These diseases are mostly spread by either direct contact amongst birds, contact with infected manure or through indirect contact with contaminated equipment, human interference and other animals (e.g. rats, insects). Table 3 provides an overview of commonly detected diseases in the focus states.[46]

In the last few years, there has been a rapid spread of viral diseases, low pathogenic avian influenza (LPAI) is one of these diseases. Due to this one disease, thousands of farmers have lost money and it affected all types of poultry species (broiler, layer, breeder). Massive mortalities appeared due to the non-availability of an effective vaccine against this disease.

[45] Poultry Industry and Practice in Haryana, HisarMetro, March 2020.
[46] National Annual Poultry Development Day'2021 Webinar on "Building Disease Free Indian Poultry Sector", All India Poultry Breeders Association, 2 July 2021.

State	Breeding	Broiler	Layer
Andhra Pradesh	• Mycoplasma, • E. Coli	• E. Coli • Kidney swelling • Ranikhet diseases	• Ranikhet diseases • Big liver and spleen • Infectious Bronchitis
Haryana	• Coryza, • Bumble foot • Clostridium perfringens	• Marek's disease • Gumboro disease • Ranikhet disease	• Avian Influenza • Marek's disease • Egg Drop Syndrome
Telangana	• Mycoplasma • E. Coli	• E. Coli • Ranikhet diseases	• Ranikhet diseases • Big liver and spleen • Infectious Bronchitis

Table 3: Common poultry diseases focus states

India:
Culling of infected birds is a common practice adopted across farms in the focus states, wherein the infected animals are separated from the farms and culled to prevent spread of diseases. After culling, the bird carcasses are either burnt or buried in deep pits. The culling in India is done in a radius up to one km from the contamination site. This implies that all domestic birds present in commercial farms, backyard farms or live bird markets in the infected zone are culled.

The Netherlands:
In case of suspicion of, or the outbreak of a disease, Dutch poultry farmers are obliged to report this to the Dutch Food Safety Authority (NVWA) and their veterinarian. The NVWA (under the supervision of Ministry of Agriculture, Nature and Food Quality) will immediately block all supply to and transport from the farm (e.g. birds, manure) to prevent further spread and start a research. The research team consists of a NVWA-veterinarian, a poultry specialist, the GD Animal Health (objective private party) and the farms' veterinarian. Samples are taken and analysed within 24-hours after the notification. The research is financed by the GD Animal Health. After the analysis, the outcomes is shared with the farmer. In case of a positive outcome (no disease), the farm is declared disease free and can continue its operations. In case of a negative outcome, the farm will be labelled as infected and further measures will be taken. These measure include, culling of all birds on the farm. The farmer is financially compensated for the loss of the animals (amount is determined by a sworn expert) by the Ministry of Agriculture, Nature and Food Quality. Other measures include disinfection of the farm (e.g. products, buildings, manure silos). Additionally, the NVWA will start a research to determine the origin of the virus and assess the neighbouring farmers. In case diseases are detected in the neighbouring area, region-wide measures will be implemented.

Antibimicrobial usage

The current vaccination schemes, practices and implementation are not sufficient to ban out all poultry diseases. Antimicrobials are a type of medication known to kill or slow down bacterial growth and have been used for the prevention or treatment of infectious diseases, growth promotion and to improve the performance of farm animals. With the increase in demand for poultry products, the usage of antimicrobials has increased over the years. Antimicrobials are not banned in India, and they are applied throughout the poultry value chain. The shift towards more intensive farming systems, due to the rising consumer demand increased the sectors' reliance on antimicrobials to achieve reduced FCR's (ratio indicating the amount of feed needed to increase the animal's body weight by 1 kg), increase growth rates, reduce cycle times, and substitute for on-farm hygiene and sanitation measures at poultry farms.

Especially small and medium-sized commercial farms use antimicrobials in their everyday farming practices as the chances of disease outbreaks are higher due to flock size and contamination risks through waste and litter as compared to the outbreak chances for backyard farming. The level of

awareness amongst the farmers about the harmful effects of antimicrobials is increasing. Most of the large farms which are operating the business for 10-12 years are more aware of the discriminatory use of antimicrobials than the new entrants (less than 5 years). In the states of Andhra Pradesh and Telangana, farmers working under contract are also aware of the harmful effects of antimicrobials and AMR issues due to the efforts of integrators in educating the farmers. While in contract, farmers follow the antibiotic practices and policies defined by the integrators (e. g. Suguna, Srinivasa Farms, Sneha Poultry). In Haryana, the level of awareness amongst farmers about the harmful impacts of antimicrobials is lower. One of the key reasons for this is the transmission of knowledge from private and government sector stakeholders about antimicrobials usage has percolated more in Southern states than in the North Indian States.

According to an interviewed leading global biopharmaceutical company, in absolute terms, the broiler industry uses more antimicrobials as compared to the layer industry. However, the per bird usage is higher in the layer industry. The use of antimicrobials in broilers has declined due to increasing residue issues in meat causing rejection of products and due to increased awareness levels. Within the domestic market, there is no formal mechanism in place for rejection. Private players/retailers/farm owners follow their own protocols. The Indian poultry sector mainly produces for national consumptions, in the case of export, the Export Inspection Agencies (EIAs) have been designated as Competent Authority to ensure compliance by the poultry processing plants with requirements. In layers, the use of antimicrobials has increased due to an increase in avian influenza and other viral diseases. This statement is unfortunately not validated through the desk research, webinars and seminars attended and the other interviews. Nevertheless, this might be a trend coming forward in the near future. [47]

In broiler farms, gentamicin and levofloxacin/ enrofloxacin are the most common antimicrobials used. Gentamicin is administered through injection while levofloxacin/ enrofloxacin is given through drinking water. In the layer farms, tiamulin, chlortetracycline (CTC) and oxytetracycline (OTC) are the antimicrobials used to treat Mycoplasma, E. Coli and Coryza respectively. OTC is administered through injection while Tiamulin and CTC are given through feed and drinking water.[48]

Irrespective of any signs of diseases, antimicrobials are administrated to DOC's to combat transportation stress or prevent gut infections, possibly caused by the hatchery's incubator. In broiler farms, antimicrobials are administered at different stages of the cycle wherein mainly DOCs are given preventive doses. Broilers are raised to attain the average slaughter size weight of 2 kg in 35-42 days and AGP's are used to reduce the number of days to reach slaughter weight.[49]

Various studies have been conducted to research the AMR rate among poultry birds in India, and resistance profiles amongst broiler and layer farms have been identified. As per a study conducted in the states of Northern India (2017), high levels of resistance to many life-saving (in case of severe diseases) antimicrobials occur across the layers and broilers, ranging from 39% for ciprofloxacin, which is used to treat respiratory infections, to 86% for nalidixic acid, which is used to treat urinary tract infections.[50] Broiler farms were 2.2 times more likely to house resistant strains than layer farms. This high rate in broilers indicates increased extensive use of antimicrobials, either to promote growth or to prevent infection.[51] A study of CSE found antimicrobials in 40% of the meat samples taken in Delhi. Broilers are fed with antimicrobials, as feed including AGPs is easily available and feed mills prefer to make feed with AGPs. This preference is driven by the demand from framers and integrated players

[47] Primary Larive-SS4 research, 2021
[48] Primary Larive-SS4 research, 2021
[49] Primary Larive-SS4 research, 2021
[50] High levels of resistant E coli found in Indian poultry, Center for Infectious Disease Research and Policy, 21 July 2017
[51] Scoping Report on Antimicrobial Resistance in India, Research Councils UK, November 2017

for AGPs. [52] Since poultry feed ingredients, such as cereals, maize and edible oil seeds, are competing with human consumption needs directly, feed prices for poultry feed are increasing. The use of antimicrobials is effective and cheap and therefore often used as a mechanism to reduce high conversion ratios in poultry feed.[53] The use of premixed feed and the lack of documentation causes farmers to lose control over the amount of antimicrobials provided to birds. Smaller farmers, using home-mixed feed, do not add antimicrobials to their feed. In addition, antimicrobials are added to layer feeds to boost yields and obtain better-looking eggs. Antimicrobials are administered to water as a preventive measure or for the treatment of waterborne bacterial infection.

Vaccination

Every poultry farm faces infection risks. Infection risks are related to poultry density, often expressed by the number of birds present per km^2 in a certain region and biosecurity levels. Having a strict biosecurity plan, with strict biosecurity measures in place, can be effective to reduce the risk of contact infections. However, there are always certain risks that cannot be kept away from the farm and poultry flocks. An example of these risks are airborne and contact pathogens. Fortunately, vaccines have been developed that protect against airborne pathogens and against contact pathogens that have passed the biosecurity barriers. Vaccination could be used to prevent diseases and thus lower the need for antimicrobials to treat diseases. Before 2000, diseases (both viral and bacterial) were rampant in broiler farming due to cyclical farming i.e., multiple age groups at a single farm. With the arrival of integrated and contract farming, which lead to non-cyclical farming (i. e. single age group at one farm), 80% of diseases vanished.

Across the focus states, broiler DOC's are vaccinated thrice (5^{th} day, 11^{th} day and 20^{th} day) within the production cycle. Vaccination costs are between Rs 3-4 (EUR 0.035- 0.046) per bird per cycle of 35-40 days. Table 4 provides an overview of the broiler vaccination schedule in the focus states.[54]

Disease	Type of Vaccine	Age	Route Of Vaccine
Marek's disease	Marek's Disease Vaccine	1 day	Subcutaneous (given by hatchery)
Ranikhet disease	F1 OR Lasota (booster)	2-6 days	Intranasal/ intraocular/ drinking water
Gumboro disease	Live attenuated vaccine Booster	7-9 days	Intraocular
Infectious Bronchitis	LA Massachusetts strain	20 days	Intraocular

Table 4: Broiler vaccination schedule focus states

For layers, 15 vaccines are given between day 1 and 18 weeks. Vaccination and medicine costs are around Rs 27 (EUR 0.31) per bird per cycle. The practice is followed uniformly in Andhra Pradesh, Telangana, and Haryana and the vaccination schedule is provided in Table 5.[55] Overall, amongst the layer farms, 90% are cyclical farms (multiple age groups at one farm).

[52] Centre for Science and Environment
[53] Poultry Sector: Count your chicken before they hatch!, Trade Promotion Council of India, 7 October 2020.
[54] Primary farm visits Andhra Pradesh, Telangana and Haryana SS4, 2021
[55] Primary Larive-SS4 research, 2021

Disease	Type of Vaccine	Age	Route of Vaccine	Dose
Ranikhet disease	F1 OR Lasota (Booster) R2B strain booster	2-6 days 6-8 days 16+ weeks	Intranasal/ intraocular/ drinking water/ subcutaneous	0.5 ml
I.B.D	Live attenuated (L.A) booster	18-21 days 25-28 days	Intraocular/drinking water	
Marek's disease	HVT ORIVBP	1-3 days	Subcutaneous	0.2 ml
I.B.V.	LA Massachusetts strain booster	3 weeks 14-16 weeks	Intraocular	
Fowl Pox	Live vaccine deworming	6 and 9 weeks	Intramuscular/wing web	0.2 ml
Fowl cholera	Killed vaccine IVRI	Above 6 weeks	Subcutaneous	1.0 ml
Infectious coryza	Inactivated srini vaccine	15-18 weeks	Intramuscular	0.5 ml
Egg drop syndrome	Killed vaccine	15-18 weeks	Intramuscular	0.5 ml

Table 5: Layer vaccination schedule focus states

Housing systems

Poultry housing systems in India are classified into four systems, being 1) extensive free-range systems, 2) semi-intensive systems and 3) intensive systems with low biosecurity, and 4) intensive systems with high biosecurity. The type of system used influences the size and productivity of the farm. Additionally, the housing system applied also influences the level of biosecurity, the risks of disease, animal health levels and the need for antimicrobials. The characteristics and positive (+) and negative (-) implications on antimicrobials and animal health for each housing system are summarized in Table 6.

System	Description	Stocking density	Antimicrobial usage	Animal health
Extensive free-range	Applied when adequate land is available. Birds are scavenging, with low production costs. Often for own consumption. Reared for meat and eggs.	250 birds/ha	+ Low usage - No alternatives used	+ Low contamination risks due to low birds volumes - Low animal health interference - No climate control - No health checks - No disease registration - No vaccination
Semi-intensive	Performed in (semi-) open houses. Reared for meat and eggs.	750 birds/ house	- High usage to boost immunity for heat and cold diseases - High need due to poor biosecurity - High usage to promote growth - No alternatives used	+ Protection against extreme weather + Regular cleaning and litter removal - No climate control leading to sub-optimal productivity and heat and cold diseased. - No health checks - No disease registration and control policies - No vaccination - Live bird sales

System	Description	Stocking density	Antimicrobial usage	Animal health
Intensive with low biosecurity	Performed in (semi-) closed houses preventing birds from predators and diseases. Levels of technology are low and maintenance is poor. Applied by small/medium independent commercial producers. Reared for meat or eggs.	10,000-50,000 birds/ farm	- High usage and need due to poor biosecurity - No alternatives used	+ Climate control + Predator protection + Automated drinking water and feed systems - Live bird sales
Intensive with high biosecurity	Performed in closed houses preventing birds from predators, diseases and contamination. Applied by large integrators their contract farmers, and large independent farms. Requires high investments. Reared for meat or eggs.	50,000-100,000 birds/ farm	+ Awareness about AMR reduction + Usage of alternatives + Monitoring and registration + High biosecurity reducing the need for antimicrobials	+ Climate control + Predator protection + High biosecurity + Use of high-quality inputs + Vaccination + Health policies, control and data registration + Automated drinking water and feed systems - High contamination risks (quick disease spreading)

Table 6: Overview housing systems in India

Drinking water systems

Water is a critical and often overlooked, nutrient. Water is involved in every aspect of a birds metabolism. It plays an important role in regulating body temperature and digesting food. At normal temperatures, chickens typically consume twice as much water as feed. During periods of high temperature, water consumption can double or quadruple. To remain healthy, poultry flocks require water of adequate quality and quantity. Factors influencing water quality include colour, taste, water odour, the presence of bacteria and other microbes, the levels of minerals and other chemical and physical factors. Water quality, and thus animal health, can be guaranteed by investments in closed drinking water and wastewater treatment systems. Open water sources allow bacteria to enter the birds' system posing serious animal health threats. Figure 14 shows semi-closed drinking water systems (with pipes) in Telangana and open drinking water systems (without any pipes transporting water to the drinking bowl) in Haryana respectively.

Figure 14: Common drinking water systems in poultry farms in Telangana and Haryana

Farmhouse climate

Climate control in farmhouses is important to guarantee animal health, achieve optimal performance and prevent diseases. The lack of climate control systems exposes the birds to (heat and cold) diseases such as Newcastle Disease, E. coli infection, Klebsiella spp infection, Salmonellosis, Fowl Cholera, Clostridia infection and Candida infection. Besides, it can cause bird stress, such as oxidative stress, acid-base imbalance and suppressed immunocompetence, eliciting physiological, behavioural and production changes in birds and performance decline. This stimulates farmers to use antimicrobials to reduce disease risks.[56] Table 7 provides an overview of the different technological solutions for climate control.

System	Functionality
Ventilation	Ensures adequate supply of oxygen while removing CO2, waste gasses and dust.
Fans	Mechanical ventilation systems supplying the energy required to exchange the desired amount of air in a farmhouse.
Heaters	Required in naturally ventilated (by wind) farmhouses to maintain the desired indoor temperatures during cold weather.
Climate controls	Adjust ventilating rates (fan controls), supplemental heating rates, air velocity rates (fan controls) based on weather, bird age and size.
Cooling systems	Cool farmhouses when the temperature is above 30 degrees Celsius.

Table 7: Overview technological climate control solutions

Feed and additives

Poultry feed is an important aspect of poultry farming as it determines health and performance. Feed contributes up to 80% of the total costs of egg and broiler meat production. Typically, feed mixtures include various grains, de-oiled extractions of the groundnut, soybean, rapeseed, sunflower and calcium carbonates. Table 8 provides an overview of the available poultry bird feed ingredient categories and their raw ingredients. The quality of the feed applied and its ingredients significantly influence animal health. Additionally, the formulation used influences the level of antimicrobials in the feed. High-quality feed, including animal health-enhancing minerals, vitamins and additives will positively impact animal health and reduce the need for antimicrobials.

[56] A study performed by the Veterinary University Disease Diagnostic Laboratory (VUDDL) in Tamil Nadu between 2014 and 2016 investigated 160 samples of chickens and indicated the rapid prevalence of infectious diseases mentioned in the text.

Feed categorization	Raw materials included
Cereal and grains	Maize, rice, wheat, sorghum, bajra, ragi and other millets, broken rice, germs, middling and damaged wheat.
Cakes or oil meal	Groundnut cake, soybean meal, rapeseed meal, sesame meal, sunflower meal, coconut meal, palm meal.
Feed of animal origin	Meat meal, fish meal, squilla meal, hatchery waste and bone meal.
By-products	Rice bran, rice polish, solvent extracted rice, wheat bran, molasses and sal seed meal.
Minerals and vitamins	Calcium, phosphorus, trace minerals such as Fe, Zn, Mn, Cu, Co and I and vitamins A, D3, E, K and B Complex.
Feed additives	Antimicrobials, prebiotics, probiotics, enzymes, mould inhibitors, toxin binders, anti-coccidial supplements, acidifiers, amino acids, antioxidants, feed flavours, pigments and herbal extract of Indian origin.

Table 8: Categorization of poultry feed mixtures

Antimicrobial alternatives

Vaccination, high-quality inputs and improved biosecurity, housing systems and climate control will reduce the need for antimicrobials. Besides, there are also alternative products in the market which function as antibiotic substitutes. Alternative products can reduce the need for antimicrobials while positively impacting animal health.

A variety of alternatives (i.a. prebiotics, probiotics, organic acids) have emerged in India, and across the focus states, the application of alternatives is predominantly limited to large farms or big players such as Skylark Group in Haryana and Srinivasa, Sneha Foods, Suguna Poultry in Andhra Pradesh and Telangana. However, these alternatives are not considered affordable for small farms. Small and medium-scale independent farms try to reduce the cost of production and minimize the expenses on feed, medicine, and vaccines, and antimicrobials are often still the cheapest solution. Most alternatives are imported into India, and there is a lack of local infrastructure for the production of alternatives. This negatively influences the affordability and availability of antimicrobial alternatives. Table 9 provides an overview of alternatives for antimicrobials.[57]

Alternative	Function	Advantages	Application in India
Probiotics	Improve intestinal microbial balance.	Improve poultry health and increase production.	Mostly applied by larger farmers and contract farms as the probiotics are too costly for independent medium and small-scale farmers. In Andhra Pradesh and Telangana farmers apply Rossysil for gut health. In Haryana, farmers apply probiotics such as Multipro.
Prebiotics	Selective stimulation of growth and/or metabolic action of useful bacteria already present in the intestine and suppressing pathogenic bacteria.	Can be used in combination with probiotics to get the maximum advantage.	Mostly applied by larger farmers and contract farmers and are often combined with the use of probiotics.

[57] Primary Larive-SS4 research, 2021

Alternative	Function	Advantages	Application in India
Bacteriophages	Infect harmful bacteria.	Cannot infect animals.	Indian poultry farmers do not apply Bacteriophages yet at they are considered too costly (Rs 2/bird).
Organic acids	Improve intestinal health and performance of birds.	Improve body weight gain and FCR.	Largely available in India for application in water and feed.
Enzymes	Reduced the pollutant potential of excreta and modulate intestinal microbiota.		Not generally used. Only applied by a few players and feed mills. Kenzyme is a popular brand in India of which 50-100 grams are applied per 1,000 kg of feed.
Essential oils	Improve intestinal integrity, gut environment and microflora.	Stimulate feed intake and digestive secretions.	Not generally used.
Biosurfactant	Improve absorption of nutrients from feed.	Can be used in combination with probiotics to improve performance, carcass yield and litter quality.	Not generally used.
Mycotoxin binders	Prevent the toxic effects of Mycotoxins present in feed.		Not generally used.

Table 9: Overview antimicrobial alternatives in the broiler and layer segments

The use of antibiotic alternatives gains attention as stakeholders believe they will have no choice but to use them in the coming future. In order to maintain a strong (international) poultry sector, India will have to follow other countries concerning food safety and animal health. Moreover, with the COVID-19 pandemic, people have become more aware of the importance of vaccination. Antimicrobial alternatives, based on research, will have an important role in reducing dependence on antimicrobials. However, key to their widespread usage will be the affordability and accessibility for independent farmers.

4. Stakeholders in the Indian poultry sector

The poultry value chain involves all stakeholders required to bring poultry meat and eggs to final consumers. Stakeholders included in the poultry value chain are National and State level public stakeholders (governments, veterinary institutes, knowledge and research institutes), private sector players, global organisations, retailers and consumers. Each stakeholder has particular roles, responsibilities and connections. Additionally, stakeholders have different linkages and responsibilities regarding AMR reduction and poultry health improvement.

The poultry value chain, including key stakeholders per segment, is summarized in Figure 15.[58] The key stakeholders will be further elaborated upon in this chapter and Annex 3.

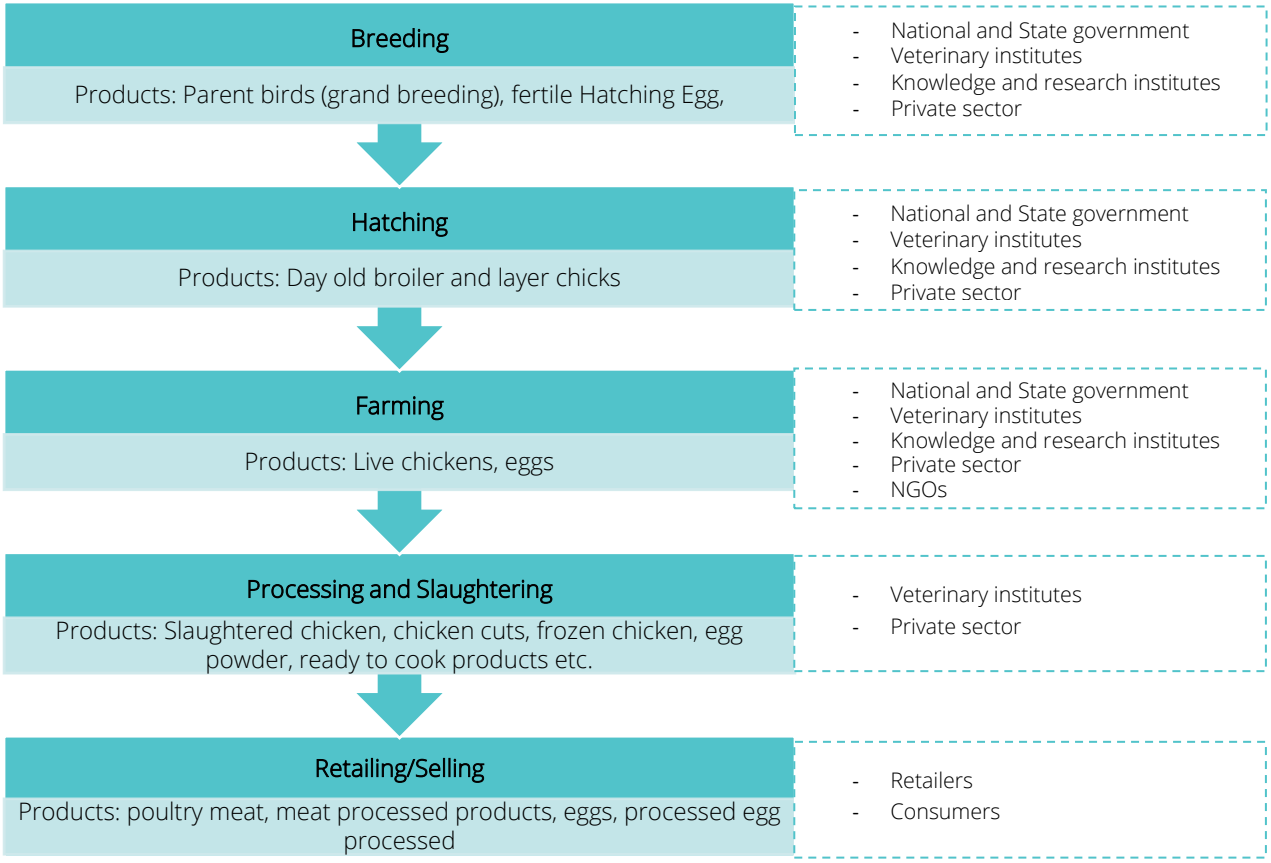

Figure 15: Overview Indian poultry sector value chain and involved stakeholders

4.1 Public stakeholders

The national and state government bodies are essential to creating a favourable policy environment for poultry sector development while ensuring animal health and food safety. Figure 16 provides an overview of the governmental stakeholders related to the Indian poultry sector and the linkages between them. Key national and state-level stakeholders are further elaborated upon below Figure 16. Additionally, Annex 3 further elaborates upon their specific poultry health and AMR reduction activities.

[58] Poultry Value Chain Analysis for risk based and people centered control of HPAI in two recent HPAI affected district viz. Jalpai-guri (West Bengal) and Dhubri (Assam) of Eastern India, (Fellowship for Agri-Resource Management and Entrepreneurship Re-search, 30 September 2012.

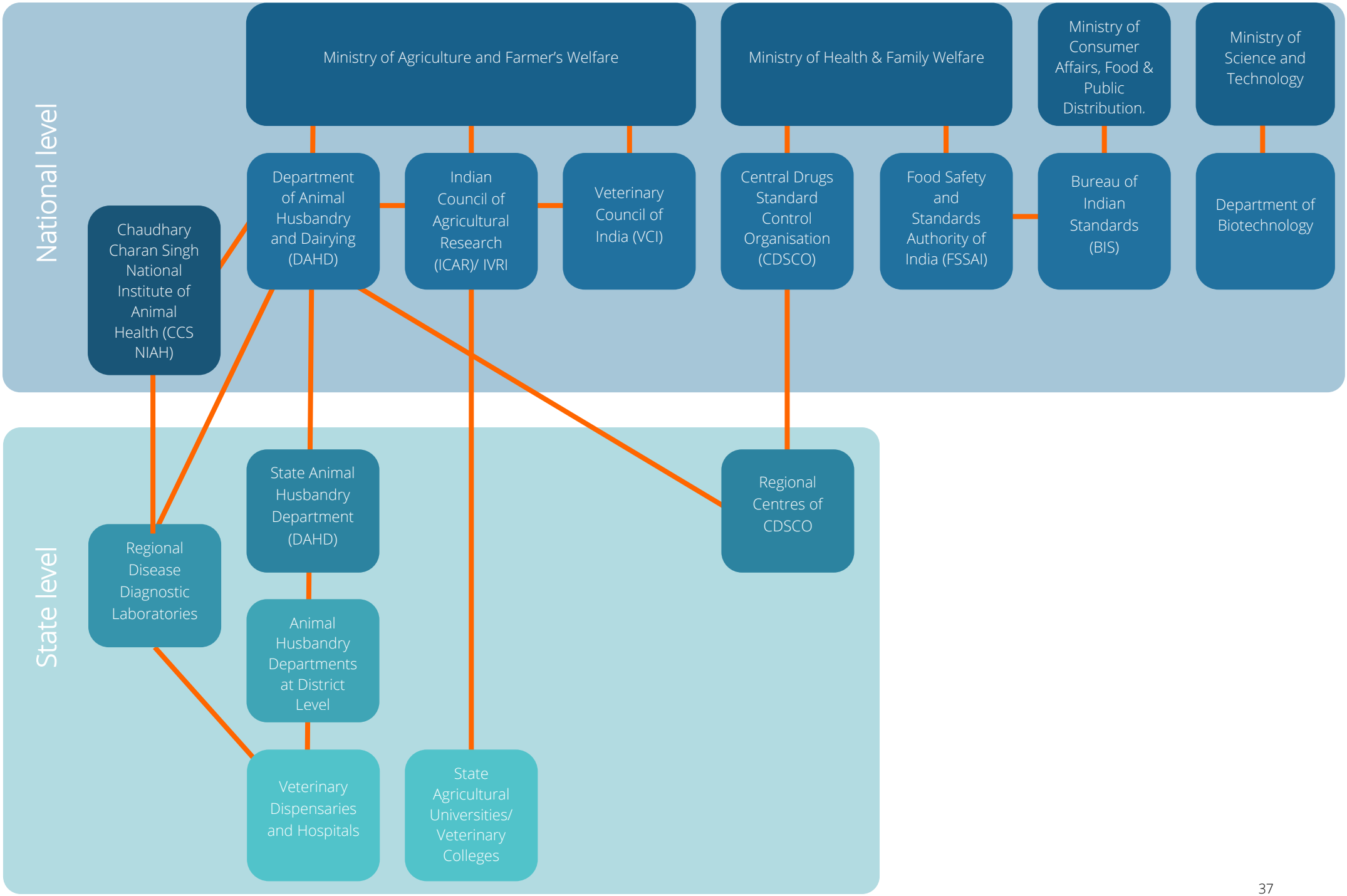

Figure 16: Overview government organizations involved in the Indian poultry sector

National government

The following key stakeholders fall under the national government:

- DAHD: is the department providing advice and policies to state governments and Union Territories on livestock-related matters. Key focus topics related to AMR and poultry health: infrastructure for disease diagnostics, veterinary network creation, vaccine quality supervision, training and skills development.
    - CCS NIAH: is the facility for the quality assessment of veterinary biologicals (e.g. vaccines) to be used in India. CCS NIAH facilitates the harmonisation of standards of veterinary biologicals in India including poultry.
- ICAR: is the autonomous organization responsible for the coordination of research across India.
    - ICAR directorate of Poultry Research: is the poultry research institute focusing on improved poultry breeds for backyard and commercial farming. Key research topics related to AMR and poultry health: breeding and genetics, improved breeds for backyard and commercial farming, poultry nutrition, disease control and disease management.
    - ICAR Institute of Veterinary Epidemiology and Disease Informatics: is the only national institute focused on surveillance and monitoring of livestock diseases. The institute gathers and stores livestock population and disease profile data in a database. Their focus is on disease forecasting, outbreak prediction and disease control strategies.
- Indian Veterinary Research Institute (IVRI): is the institute with the mandate of research, teaching, consultancy and technology transfer activities in the discipline of veterinary services. They offer programs and courses in veterinary preventive medicine, animal husbandry, veterinary biological products, animal reproduction, poultry husbandry, medicine and surgery, zoo and wild animal health care and management and meat and meat products technology.
- VCI: is the stator body responsible for veterinary practices applied in India. Key focus topics related to AMR and poultry health: supervision of veterinary practices, infrastructure for veterinary services, provisions for regulation, standards for veterinary education and registering of veterinary practitioners.
- CDSCO: is the National regulation authority responsible for veterinary and human health drugs & cosmetics regulations.
- FSSAI: is the Statutory body for food safety standards providing scientific advice and technical support to the Central Government. Key focus topics related to AMR and poultry health: setting antibiotic intake and residue limits, antibiotic usage policies, animal health administration, laboratory guidelines for food testing and compliance to international safety standards.
- BIS: is the National standard body responsible for quality and food safety standards in close collaboration with the FFSAI. Key focus topic related to AMR and poultry health: safety and quality standards for feed and poultry products.
- DBT: is the department responsible for R&D on agriculture and animals with the aim to enhance the production and productivity of livestock. R&D focus topics related to AMR and poultry health: genetic improvement, vaccinations and disease detection systems.

State government

The following key stakeholders fall under the state government of Andhra Pradesh, Telangana and Haryana:

- Veterinary and Animal Husbandry Department Telangana: is the department responsible for food security for animal-based products and the implementation of the NAP and a healthy

State population. Key focus topics related to AMR and poultry health: strengthening the veterinary infrastructure, disease outbreak prevention and vaccination.

- Animal Husbandry Department Andhra Pradesh: is the department responsible for enhancing the productivity of livestock, food security, implementation of the NAP, and a healthy state population. Key focus topics related to AMR and poultry health: strengthening the veterinary infrastructure, disease outbreak prevention, vaccination, breeding and feed quality.
- Animal Husbandry & Dairying Department Haryana: is the department responsible to support livestock sector growth and the implementation of the NAP. The department provides health care and breeding facilities. Key focus topics related to AMR and poultry health: strengthening the veterinary infrastructure, genetic improvement, animal health services, disease diagnostics, and feed quality.
- NTR College of Veterinary Science of Sri Venkateswara Veterinary University, Andhra Pradesh: is a State college and university that provides training for field veterinarians and students and interacts with farmers to identify knowledge gaps. They supply (under mandate) improved breeding stock to farmers in Andhra Pradesh. Additionally, they operate a Clinical Complex for animal treatment in Andhra Pradesh where farmers can bring their animals after referral of a field veterinarian. The college has a department of Poultry Science, which mainly conducts research concerning the promotion and impact of backyard poultry farming among the rural population.
- PVNR Telangana Veterinary University: is a State University that provides animals science and veterinary programs and courses related to livestock. The university has a Poultry department, which mainly focuses on backyard poultry breeds, nutrition, health, management, economics and marketing.
- Colleges of Veterinary Science: there are state colleges in Tirupati and Proddatur (Andhra Pradesh, Hisar (Haryana), Korutla and Hyderabad (Telangana). These colleges offer undergraduate, graduate and doctoral level veterinary programs and courses. The curricula of these colleges are in line with the standards set by the VCI.

Key takeaways

The following key takeaways, derived from the desk research, interviews and field visits with public stakeholders, have been taken into account during the bottleneck and opportunity identification and formulation (Chapter 5 and 6) of this study:

1. AMR reduction and poultry health improvement are not specifically mentioned as focus areas by the stakeholders (although some focus topics relate to them). There are no separate budgets allocated for AMR reduction and/or health improvement.
2. Although state governments are responsible for the implementation of the NAP, only Kerala, Madhya Pradesh and Delhi developed their State Action Plans and implemented a surveillance network (with software developed by the WHO). The three focus states are yet to design their Action Plans.
3. Gross of the stakeholders solely formulates advice (no regulations) regarding antimicrobial usage and poultry health, which does not directly lead to implementation.
4. There is a lack of knowledge sharing between public and private sector players, making it hard for the government to cater for the needs of the private sector and tailor actions and regulations accordingly.
5. AMR reduction is not a core focus of veterinary institutes.
6. Public stakeholders experience difficulties with the introduction of improved poultry breeds to farmers, causing low adoption rates.

7. Stakeholders working on improved breeds indicate that given the variety of climates in India, they cannot establish a one-size-fits-all breed. Each region has its particular environment, demanding region-specific breeds.
8. In general, laboratories are solely available to veterinary institutes. While resources are available to veterinary services, facility maintenance is not always up to date and old equipment is replaced inconsistently.
9. A gap has been observed concerning the adequate number of veterinarians and veterinary paraprofessionals across various states. Table 10 provides an overview of the number of veterinary institutes in India and the focus states.[59] Although these numbers seem impressive, the number of veterinary institutes is not sufficient to adequately fulfil the veterinary service need in India.[60]
10. Besides the veterinary institutes, there are 27 veterinary biological units producing vaccines, of which 20 are public and seven are private facilities.[61] The public veterinary biological units are under the control of respective State Animal Husbandry Departments. The units produce vaccines such as HS, bluetongue, CSF, anthrax, BQ, ND, IBD, rabies, sheep and goat pox, fowl cholera, FMD, PPR, fowl and pigeon pox, enterotoxaemia, duck cholera, duck virus hepatitis.

	Polyclinics	Veterinary Dispensaries	Veterinary aid Centers	Total
Andhra Pradesh	337	1,576	1,275	3,188
Haryana	1,029	1,817	22	2,868
Telangana	108	909	1,201	2,218
India	12,076	25,571	28,168	65,815

Table 10: Number of veterinary institutes as of March 2019

4.2 Private sector

Private sector players are present in all parts of the poultry value chain. Therefore, they are important stakeholders in terms of animal health improvement and AMR reduction. Besides growth in feed and farm production, the Indian animal healthcare industry is expected to be a flourishing segment. The poultry vaccination market is worth between EUR 40- 50 MN and is expected to grow by 10% in the coming years.[62] The projected growth in the animal healthcare industry put the private poultry healthcare players in an important place to introduce innovative vaccines to curb the excess use of antimicrobials among poultry birds. These companies need to collaborate with the government for approval to market new products and vaccines. Some of the key private sector stakeholders operating in the focus states are:

- The Indian Federation of Animal Health Companies (INFAH): is an association representing 52 private animal health industry companies (e.g. producers of animal therapeutics, biologicals and nutritional products). Its members represent over 85% of the Indian animal healthcare and nutrition business. The vision of INFAH is to create trust among the veterinary professionals and livestock, poultry, aqua and companion animal stakeholders to enhance the animal health industry's value and contribution to society, by setting high standards of competitiveness, ethical business practices, innovation, and leadership among its members for a sustainable animal health industry in India and ensuring significant presence across the

[59] Animal and Livestock Biotechnology, Department of Biotechnology website.
[60] Primary Larive-SS4 research, 2021
[61] National Action Plan for Egg & Poultry-2022 For Doubling Farmers' Income by 2022, Department of Animal Husbandry, Dairying & Fisheries, Ministry of Agriculture & Farmers Welfare, Government of India.
[62] Inside India's animal healthcare: The vaccine makers eyeing Rs 13,343 crore programme, Business Today, 21 May 2020

globe. INFAH's mission statement is: '*Healthy Animals, Healthier India*'. INFAH is affiliated with Health for Animals, a global Animal Medicine Association. Jointly, the INFAH members promote the judicious and responsible use of antimicrobials by communicating that antimicrobials should be used according to global guidelines and withdrawal periods.

- Venkateshwara Hatcheries Private Ltd. (Venky's): is the largest poultry integrator, established in 1971, operating nationwide. They are active in: genetic development, feed production, equipment manufacturing, broiler and layer breeding, meat and egg processing, poultry disease diagnostics, vaccine production (largest poultry vaccine producer in India), production of biosecurity solutions, nutritional health products and supplements. They focus on the production and usage of high-quality feed and health solutions, health and vaccine R&D and breed improvement to lower the need for antimicrobials and improve health.
- Skylar Hatcheries: is a large poultry integrator, established in 1985 operation nation-wide. They are active in: grandparent breeding, parent breeding, hatching, broiler contract farming, feed production, meat processing and equipment manufacturing. They focus on the production and usage of quality feed and breed improvements to lower the need for antimicrobials and improve health and they introduced policies and standards for all contract farmers.
- Srinivasa farms Pvt. Ltd.: is a poultry integrator, established in 1965, operating in Telangana, Andhra Pradesh, Tamil Nadu, Karnataka and are looking to expand into Maharashtra, Haryana and Punjab. They are active in: breeding, commercial farming, feed production and retail. It is estimated that one in five eggs consumed in India originates from Srinivasa's breeding activities. They focus on the production and usage of high-quality feed, integrated policies, health and vaccine R&D and breed improvement to lower the need for antimicrobials and improve health.
- IB Group: is a large protein-centric conglomerate, established in 1985, operating in central India. In poultry, they are active in: breeding, hatching, farming and processing and retailing.
- Surgana Foods Private Ltd.: is a large poultry integrator, established in 1994, operating in the Southern region of India with plans to expand to North India. They are active in: broiler and layer farming, hatching, feed production, meat processing, vaccine production and export. They focus on the production and usage of high-quality feed and vaccines to lower the need for antimicrobials and improve health and they implemented disease detection and vaccination administration systems at their own farms.
- Bharat Hatcheries: is a poultry integrator, established in 2004, operating in Haryana. They are active in broiler breeding and hatching and feed production. They focus on the production and usage of high-quality feed and breed improvement to lower the need for antimicrobials and improve health.
- Sneha farms private Ltd.: is a broiler integrator, established in 1982, operating in Telangana. They are active in broiler breeding, hatching, farming, meat processing, retailing, poultry feed production and feed supplements. They focus on the production and usage of high-quality feed, breed improvement and integrated standards to lower the need for antimicrobials and improve health.
- Hestor Biosciences: is a leading animal healthcare company and 2nd largest vaccine producer (after Venky's), established in 1987, operating across India (and international). They are active in: poultry vaccines (45 types of vaccines), poultry health products and R&D.
- MSD Animal Health: is a global animal health company focusing on vaccine research and production. In India, they have an operating facility in Pune.

- Keggfarms Pvt. Ltd.: is the oldest poultry breeding organization of India established in 1967. And is also recognized by the Department of Science and Technology as a Research and Development centre for Poultry Breeding.

Key takeaways

The following key takeaways, derived from the desk research, interviews and field visits with private sector stakeholders, have been taken into account during the bottleneck and opportunity identification and formulation (Chapter 5 and 6) of this study:

1. Private sector players experience problems due to high feed ingredient prices (resulting in high cost prices of feed, broilers and layers). Players seek government support to reduce ingredient prices (e.g. favourable import policies). These high prices might negatively influence the quality of the feed produced and/or the usage of quality feed (switching to cheaper low-quality feed).
2. Disease outbreaks jeopardize the sector's reputation, resulting in consumers reducing meat and egg consumption.
3. Over the past 2 years, the private sector experienced losses which, according to them, were caused by a poor sector reputation (fuelled by misinformation regarding birds transferring COVID-19) and reduced demand due to the COVID-19 pandemic.
4. The interviewed private sector players are highly interested in technologies that support the adoption of more sustainable farming practices.
5. Lack of national AMR and health monitoring and diagnostic mechanisms triggers private sector players to implement their own systems. This reduces the need and incentives for knowledge sharing (with other stakeholders). As the players already have systems in place, they will be less willing to adopt nationwide systems (when they arrive).

4.3 NGO's and global organizations

NGO's, global organization and their current initiatives especially focus on practices at farm level, by promoting the implementation of good poultry farming practices and increasing awareness amongst value chain stakeholders. Key stakeholders and initiatives are elaborated upon below.

- Centre of Science and Environment (CSE): is a not-for-profit public interest research and advocacy organisation based in New Delhi, India. Established in 1980, CSE works as a think tank on environment-development issues in India, poor planning, climate shifts devastating India's Sundarbans and advocates for policy changes and better implementation of the already existing policies. Raising AMR awareness at both government as well as consumer-level is one of their spearheads. They interact with FSSAI, CDSCO, BIS and ICAR to advocate for necessary policy changes to guarantee the stimulation of AMR reduction. The CSE is advocating for policies incorporating WHO, FAO, UN and other international platform standards.
- Food and Agriculture Organisation (FAO): is a specialized agency of the United Nations that leads international efforts to defeat hunger and improve nutrition and food security. It strives to assist member countries to take advantage of growing and changing livestock sectors. The FAO seeks collaboration with governmental stakeholders by providing insights and advice on global AMR reduction and health improvement standards and practices.
- Indian Network for Fishery and Animal Antimicrobial Resistance (INFAAR Network): is a network of laboratories for the fishery and livestock sector established by the FAO, ICAR and the United States Agency for International Development (USAID). The aim of the network is to undertake laboratory-based surveillance of Antimicrobial Resistance in the livestock and

fishery sector. This network facilitates standard protocols, data management systems and knowledge sharing systems for AMR. Currently, INFAAR focuses its operations at locations where local institutions are willing to collaborate and have the required expertise to operate the systems as INFAAR does not aim to invest in laboratory infrastructure development. Based on the data collected from the field i.e. poultry farms, INFAAR executes awareness campaigns and communicates the problem concerning antibiotic AMR to local farms. ICAR plans to expand and sustain the network for the next five years and has submitted the proposal for the same to the Ministry of Finance.

- One Health Poultry Hub India: is an impact-driven development research programme working in Bangladesh, India, Sri Lanka and Vietnam. Taking an interdisciplinary and intersectoral 'One Health' approach, they are exploring how rapid expansion of poultry production increases the risk of infectious disease and why certain processes and behaviours are risky. The Hub is working in Gujarat and Tamil Nadu states. The hub participants in numerous collaborations focused on AMR reduction and awareness.

Research CSE (2018) resulting in a Colistin ban

In 2018, a study of CSE (2018) exposed the intensive use of colistin by private sector players supplying leading foodservice chains (KFC, Pizza hut etc.) Resistance to Colistin is a problem, as it is the last-resort antimicrobial used in human healthcare. Following this study, the GoI banned the manufacturing, sales and distribution of Colistin.

Research CSE (2019)

In 2019, the CSE published a report on the existence of AMR in the Indian poultry sector. The report highlighted the over-usage of antimicrobials for growth promotion purposes and disease prevention over the last decade. Based on the results, CSE advocated the need to urgently restrict and reduce the use of antimicrobials as growth promoters in livestock and aquaculture.

Key takeaways

The following key takeaways, derived from the desk research, interviews and field visits focused on NGOs and global organisations, have been taken into account during the bottleneck and opportunity identification and formulation (Chapter 5 and 6) of this study:

1. The lack of a nationwide mechanism to estimate poultry health and the quantities of antimicrobials being produced, imported, sold and used hinders the FAO in the development of a uniform mechanism to assess usage and formulate measures.
2. This lack causes the CSE to be unable to support and verify their findings.

4.4 Retailers & consumers

The Indian poultry retail sector consists of traditional wet markets (unorganized retail) and modern retail stores (organized retail). As consumers in India presume wet markets offer fresher, higher-quality meat, the unorganized sector constitutes more than 90% of the poultry retailing business in India. Consumers are the last link in the poultry value chain. However, they are an important stakeholder driving the growth and development of the poultry sector in the country. Food safety awareness and a growing urban middle class cause the demand for chilled, slaughtered and safe meat being sold at organized retail to increase. A description of wet markets, modern retail and Indian consumers are provided below.

- Wet markets: are markets with open-air stalls, spread over a large area, where vegetables, fruits, meat and fish is sold. Most birds are sold alive and slaughtered at the wet markets after-

sales. There are food safety concerns related to wet markets: quality and health of the animals are not checked, safety of meat products (residue levels) is not checked, unhygienic practices applied, no proper storage and cooling facilities in place, high contamination risk, poor animal welfare conditions.

- Modern retail: are outlets that sell cooled/frozen and further processed poultry products and have proper storage and cooling facilities. As consumers perceive on-spot prepared products as being fresh, a lot of outlets have in-store butchers who hygienically prepare (e.g. cut) meat in the store. Modern retail outlets have poultry health and antimicrobial-level policies for poultry-product suppliers. They also work with product certification (HACCP, FSSAI, ISO, HALAL) and demand free-range or biological products. Some of the larger outlets have in-house laboratories for quality and safety checks.
- Consumers: have a strong preference for fresh meat and perceive wet market products as the freshest option. Consumers buy >90% of poultry meat products at wet markets, eggs are usually bought at traditional local grocery stores. The COVID-19 pandemic caused an increase in food safety awareness, consumers are more aware of the AMR challenge, switch towards modern retail.

Key takeaways

The following key takeaways, derived from the retail and consumer-oriented desk research, interviews and field visits, have been taken into account during the bottleneck and opportunity identification and formulation (Chapter 5 and 6) of this study:

1. 76% of consumers surveyed by World Animal Protection in 2020, mentioned the quick service restaurants to be responsible for animal welfare and health of the poultry products they source.
2. Wet markets are not contributing to AMR reduction and animal health improvement, aside from Licensing and Registration of Food Business Regulations (2011) which requires the registrations and licensing of any food business including the wet market and Cruelty to Animals (Slaughter House) Regulations (2001) which requires that animals must be certified by a veterinarian as healthy and disease-free before slaughtering, no other regulations apply to wet markets. And the current legislation is not being enforced properly.
3. Modern retail outlets implement voluntary ARM reduction and health improvement measures, however, no legislation requests this.

5. Bottlenecks hampering animal health improvement and AMR reduction

There are several bottlenecks hampering animal health improvement and AMR reduction in India: ineffective regulation and enforcement measures, lack of coordination amongst stakeholders, the standard use of chemicals and antimicrobials in animal feed and water, lack of AMR and animal health data, inadequate logistics, the lack of knowledge and awareness on the importance of animal health and vaccination opportunities, low technology adoption, high costs of antimicrobial alternatives and the lack of surveillance and monitoring systems all hamper animal health improvement and AMR reduction in India.

The lack of regulations, law enforcement and control by public stakeholders

There is a lack of policies restricting antibiotic usage in animal feed and drinking water. In addition, existing regulations lack proper enforcement, control and monitoring, leading to both antibiotic suppliers and consumers ignoring implemented measures.

For example, following Indian regulations, antimicrobials can solely be sold to farmers by veterinarians and local veterinarian shops if prescribed by registered veterinarians. However, due to the lack of enforcement of regulations for pharmacies, antimicrobials are freely sold to farmers and recklessly used as AGPs at farms.[63] Similarly, in 2015, the FSSAI outlined principles limiting antibiotic usage for livestock rearing. Yet, without an implementation roadmap or plan and monitoring the current situation remains unaffected, hampering animal health improvement and AMR reduction developments.[64]

Additionally, there is a lack of quality control on imported feed at the Indian borders. China is the main supplier of imported animal feed in India. With China ranking first globally on antimicrobials usage in animal feed, the lack of proper import quality controls results in animal feed containing high percentages of antimicrobials easily entering India.[65]

One reason for the lack of regulations, control and monitoring is the lack of knowledge, awareness and resources at the national government side, making it hard for state-level governments to implement and control initiatives and policies. Farmers can for example receive licences from municipal officials if they adhere to quality standards regarding poultry housing and sanitation. However, the officers providing these licences lack knowledge, awareness and resources to adequately perform controls, leading to poultry farms with poor housing (rearing) and sanitation conditions and high usage of antimicrobials to compensate, being licensed as well.

Furthermore, the lack of control allows antibiotic manufacturers to discharge wastewater containing high percentages of antibiotic residues. Even though the government included developing standards for antibiotic residue in industrial effluents as part of the Indian National Action Plan on AMR in 2017, a report published by the Nordea and the Changing Markets Foundation (2018) showed that pharmaceutical companies in Telangana continuously discharge untreated or inappropriately treated

[63] DCGI moves to curb sales of antibiotics without prescriptions, Livemint, 26 December 2019.

[64] In 2019, The Drug Controller General of India (DCGI) has asked authorities of all states and Union territories (UTs) to stop pharmacies from selling antibiotic drugs without a doctor's prescription in a step aimed at tackling drug resistant bacteria. The regulator also asked All India Organization of Chemists & Druggists (AIOCD) to "educate their members" on licencing conditions regarding antibiotic sales, and told drug makers to discourage pharmacists from selling drugs without prescriptions.DCGI moves to curb sales of antibiotics without prescriptions, Livemint, 26 December 2019.

[65] Veterinary antibiotics in animal manure and manure laden soil: Scenario and challenges in Asian countries, ScienceDirect, March 2020.

wastewater into the environment. As a result, India is on its way to becoming a hotbed for AMR among both animals and humans.[66]

Lack of coordination and collaboration amongst value chain stakeholders

Although the *One Health* approach is a key agenda item of multiple governmental stakeholders, there is a lack of coordination amongst various ministries and departments such as FSSAI and CDSCO. For example, CDSCO has no testing facility nor authority to test animal feed, while it is the National regulation authority for drugs & cosmetics responsible for veterinary drugs regulations. The efforts to work on *One Health* occurs in silos, and there is no specific budget allotted for AMR reduction by the various stakeholders. As a result, there are gap areas in terms of poultry animal health, food safety and AMR reduction. Furthermore, knowledge sharing between the different departments and ministries is not stimulated. This might be caused by the lack of a federal authority to lead and implement the *One Health* approach in the Poultry sector. The same accounts for knowledge sharing and collaboration between the government and the private sector players, as there are no incentives to collaborate.

Srinivasa farms monitoring the activities in the poultry value chain in Andhra Pradesh and Telangana

This case study highlights the lack of incentives for value chain-wide knowledge sharing as the private player has implemented its own systems in a reaction to the non-existence of monitoring and protocols dedicated by public stakeholders. Srinivasa farms is one of the leading players in poultry in India and follows biosecurity protocols to prevent spread of infectious diseases and maintain animal health. The company operates under a contract farming model. The contract farmers are required to follow strict protocols and monitoring practices. Farmers can only use the feed supplied by Srinivasa. The feed being used is properly monitored and recorded. Infected birds are separated from the healthy birds and culled to prevent the spread of disease. The disposal of dead animals underground is strictly followed. The field representatives of company regularly train farmers and advise them about vaccination, medicine and overall animal health related issues.

Lack of antimicrobial usage data

There is no reliable data available about the antimicrobial volumes applied at farm level. The lack of data causes rules, regulations and initiatives to be less impactful as compared to when sufficient data would be available. As there is no incentive for knowledge sharing amongst value chain stakeholders, this bottleneck poses a serious limitation for AMR reduction.

Chemicals and drugs in animal feed

Another cause of AMR is the large amounts of chemicals and medicines added to animal feed to boost yields and obtain better-looking eggs. Examples include Ammonium Chloride, Potassium Chloride and Baking Soda. This negatively influences animal health, farmer productivity and can seriously repercuss human health.[67]

Improper logistics

After the rearing stage, birds are often subjected to unhygienic and harsh conditions, degrading the quality of poultry products and leading to mortalities. The lack of cold chain logistics and facilities cause challenges to transport high-quality poultry products in India. Similarly, the lack of proper logistics hampers the supply of vaccinations and health care services. As farmers often live in remote areas with improper electricity connections and refrigerators, cold chain facilities are inadequate. This combined

[66] Animal Disease Surveillance and Control: The Indian Perspective, Acta Scientific Veterinary Sciences, February 2020. Check effluents for antibiotic residue: Government to pharma firms, Livemint, 5 November 2019.
[67] Poultry Sector: Count your chicken before they hatch!, Trade Promotion Council of India, 7 October 2020.

with high transport costs due to the large travel distances, cause these areas to be unfavourable distribution environments, leading to an extremely low supply of vaccines and animal healthcare services for farmers.[68]

Insufficient knowledge and awareness

Larger private sector players are aware of AMR and animal health and their implications and requirements. Smaller-scale farmers, especially in Haryana, lack awareness regarding the importance of vaccinations, the impact of antimicrobial usage and the availability of feed alternatives without antimicrobials. Farmers are unaware that vaccines can prevent infections and diseases among their birds and of alternatives for antimicrobials. Therefore, farmers are reluctant to shift towards innovative solutions and stay dependent on antimicrobials for AGPs and disease prevention and control.[69] Besides, farmers are often unaware of the products, technologies solutions available to reduce disease risks (e.g. biosecurity improvement solutions) at farms, and thus lowering the need for antimicrobials.

Succes story: Newcastle Disease (ND) transforming lives in the Mayurbhanj district of Odisha

Local Indian farmers often experience mortalities due to ND disease outbreaks. Bhodal Milk Producers Cooperative Society, an Odisha based NGO, together with Hester Biosciences Limited and GALVmed, introduced the vaccine NobvivacTM for Canine Rabies. When a local poultry farmer used the vaccine, the number of birds available for consumption, breeding and sales increased considerably, allowing him to cover the cost of the vaccinations. This success motivated other farmers in the area to invest in vaccinations, leading to improved poultry health, increased farmer profits, and increased protein intake among residents living in Odisha.

The lack of understanding of the antimicrobial and animal health practices being applied among public stakeholders is another bottleneck. The interviewees highlighted that impactful AMR reduction and animal health improvement changes can only be achieved by private as well as public sector efforts. As long as insights, understanding and awareness at the public (especially governmental) level lacks, changes will not be achieved.

Low technology and biosecurity solution adoption

The expansion of the poultry sector is linked with technological change and increasing scale of production. Automation is important at farm level to improve production efficiency, disease control and traceability and product quality. The use of technology and sensors for disease diagnosis and farm management would significantly improve the sector's efficiency.[70] However, the adoption of technology and automation is low. Feed and water intake monitoring systems, biosecurity solutions, climate control systems, disease prediction and detection systems, traceability and medicine recording solutions are key technologies that need to be adopted for tackling the AMR challenge. However, as farmers are not aware of the options and/or are not convinced about the benefits and business case, the adoption rate will remain low.

Biosecurity for improved animal health and immunity in broiler farm, Haryana

Venky's is an example of a private player who implemented biosecurity solutions within their everyday farm practices. They maintain proper biosecurity to address animal health and address the AMR challenges. In the broiler farm at Panipat, Haryana, visitors have to maintain proper signage at the entry gates and access points and no unauthorized entry is allowed to the farm. For visitors, there are mandatory entry requirements such as mandatory washing of external vehicles or equipment, usage of proper disinfectants for footwear in foot washing baths at the entrance of each shed, wearing of hygienic and clean overalls and boots.

Higher costs of antimicrobial alternatives

Adoption of antibiotic alternatives such as prebiotics and probiotics currently entail higher costs for farmers as compared to using antimicrobials. Also, there is no proven reputation of the positive effects of the alternatives yet. As farmers regard alternatives as costly, and rules and regulations are not properly in place, there is no incentive for farmers to switch to the alternatives. Most of the alternatives are imported and there is no infrastructure for local production yet, this negatively impacts the affordability and availability of the alternatives.

Inadequate disease surveillance systems

While India has been marked as a 'hotspot' for emerging infectious diseases, animal disease surveillance and monitoring programs are inadequate.[71] India performs surveillances through the reporting system: National Animal Disease Reporting System (NADRS) and the livestock disease database: National Animal Disease Referral Expert System.[72] NADRS is a centrally sponsored scheme under the DAHD, involving a computerized network integrating management Information and geographic information systems to link different blocks, districts, UT headquarters to the Central Disease Reporting and Monitoring in New Dehli. In principle, the Central and State Animal Health Department, ICAR and NIVEDI are responsible for monitoring 143 animal diseases through 7,000 locations at the sub-district level. Data is collected using event data from 31 centres monthly entered in the database. However, the actual number of diseases monitored appeared to be very low, as a result of poor monitoring capacities.[73]

[71] Animal Disease Surveillance and Control: The Indian Perspective, Acta Scientific Veterinary Sciences, February 2020.
[72] Integrated Disease Surveillance Programme, MoH&FW, Government of India, 26 November 2015.
[73] Animal disease surveillance: Its importance & present status in India, Indian Journal of Medical Research, April 2021.

6. Dutch-Indian opportunity analysis

The bottlenecks mentioned in chapter 5 combined with the positive outlook for the Indian poultry sector (in terms of demand) offer various opportunities for Dutch-Indian collaborations. These opportunities can, upon capitalization, be beneficial both for the sector as a whole as for public and private Indian and Dutch stakeholders.

As the Indian poultry sector is a challenging and complex market, a multifaced approach will be required to capitalize on the identified opportunities. Implementing only a single intervention on a single stakeholder level might, although providing a desirable outcome, not yield the potential outcomes if not accompanied with other changes necessary for the intervention to succeed. This multifaced approach is grouped into the following opportunity clusters: Public-Private-Partnership (PPP), Business-to-Business (B-2-B), Government-to-Government (G-2-G) and Knowledge-to-Knowledge (K-2-K). The opportunities for the different clusters overlap, as they all tackle the same bottlenecks. However, the concrete activities and parties involved to seize the opportunities differ.

The impact of activities to seize the opportunities will increase when bottlenecks will be addressed by all four clusters as this will stimulate the creation of a sustainable enabling environment. A combination of private sector, knowledge institutes and public (governmental) sector activities towards a bottleneck is known as the *Golden Triangle*. Chapter 7 visualized how Larive-SS4 envisions establishing the golden triangle to reduce AMR and improve poultry health in India.

Table 11 provides an overview of the potential PPP, B-2-B, G-2-G and K-2-K opportunities focused on poultry sector development by improving animal health and reducing AMR. The opportunities are elaborated upon below the table.

	PPP: Training, demonstrations & model farms	B2B: Investments, development programs, localized solutions, upgrades	G2G: Documentation, databases, monitoring, control and policy knowledge sharing,	K2K: Collaborative research, networks & knowledge sharing
Animal health	➢ Improving the availability and affordability of vaccines.		➢ Adopting farm hygiene codes applied in the Netherlands. ➢ Establishing procedures for animal disease prevention and outbreak control.	
AMR reduction	➢ Increasing the availability of antibiotic alternatives.		➢ Building monitoring capacity and set limits for antibiotic usage. ➢ Establishing enforcement strategies for AMR reduction. ➢ Establishing procedures on tracking and controlling the use of antimicrobials in animal feed.	
Animal health & antibiotic reduction	➢ Improving biosecurity (including drinking water facilities) and management at hatcheries and farms. ➢ Improving poultry feed quality and reduce antimicrobials in feed. ➢ Implementation of digitalization solutions to improve animal health and reduce AMR. ➢ Increase (practical) knowledge, skills and awareness of farmers (especially in Haryana). ➢ Facilitation of value chain-wide knowledge sharing.	➢ Genetic programs to create breeds less vulnerable to diseases. ➢ Offering antibiotic alternatives, vaccines and animal health solutions and services. ➢ Improvement of feed quality to reduce the need for antimicrobial feeds. ➢ Facilitating broiler and layer farm upgrades through technology introduction. ➢ Improving slaughtering and processing segment (including cold chain) to increase health and AMR standards. ➢ Digitalization of farm management. ➢ Building laboratory capacity for efficient disease diagnosis, quality testing and analysis.	➢ Building laboratory capacity for efficient disease diagnosis and analysis. ➢ Educating veterinarians and extension workers in focus states to assure monitoring and control of antibiotic sales and usage and diseases. ➢ Rules and regulations regarding food safety. ➢ Facilitation of value chain-wide knowledge sharing.	➢ Cross-country curriculum development. ➢ Development of selective training programs. ➢ Joint R&D programs.

Table 11: Overview of the opportunities in the Indian poultry sector

6.1 Public-Private Partnership opportunities

Given the current level of development of the Indian poultry sector, its large geographical size and the level of complexity of doing business in India, entering the market as a consortium could offer advantages. Consortia offer the possibility to enter and develop the sector with integrated solutions covering the entire poultry value chain while mitigating risks by leveraging the experiences and relations of the parties involved. Public-Private Partnerships (PPPs) in the poultry sectors have proven to be successful in other Asian countries. The goal of a PPP would be to develop and strengthen the poultry sector in India by focusing on AMR reduction and animal health improvement. This can be established by providing training, demonstrating best practices and offering affordable localized solutions. Based on the desk research and interviews, several fields within the Indian poultry sector could be addressed by PPPs, including:

- Improving poultry feed quality and reduce antimicrobials in feed;
- Increasing the availability of antibiotic alternatives;
- Improving the availability and affordability of vaccines;
- Improving biosecurity (including drinking water facilities and housing systems) and management at hatcheries and farms;
- Implementation of digitalization solutions to improve animal health and reduce AMR;
- Increasing (practical) knowledge and skills;
- Facilitation of value chain-wide knowledge sharing.

These PPP opportunities, including the identification of potential Dutch- Indian project partners, are further elaborated upon, in Annex 4. PPPs could focus on one or multiple of the above-mentioned topics. As there are many interlinkages, Larive-SS4 recommends addressing multiple topics with a variety of activities within one PPP.

Local PPP success story: A tribal start-up provides improved access to health care services in Andhra Pradesh

In 2016, the DAH and Tribal Welfare Department of the government of Andhra Pradesh designed the Rural Deshi Backyard Poultry program. The objective of this program is to improve the income and nutrition provision of 13,000 tribal households. The interventions include improvement of production systems, vaccination and healthcare service, the establishment of a breeding farm enterprise and the Common Interest Group. With WASSAN as the Lead Technical Agency, this program has been initiated in 129 clusters spread over five districts in AP: Srikakulam, Vizianagaram, Visakhapatnam, East and West Godavari. To improve access to health services in Visakhapatnam, local para-veterinarians were trained in the village to perform health care practices relating to chickens and other livestock. The trainers constituted in veterinary doctors of the local veterinary clinic, facilitating staff from LAYA (a local NGO), while WASSAN provided the required resources. As a result, two para-veterinarians per 100 households provided livestock health services to the community.

Asian PPP success story: FoodTechIndonesia (https://www.larive.com/ppp/foodtechindonesia/).

FoodTechIndonesia (FTI) is a PPP initiative combining the strengths of Dutch companies (mainly SMEs) active in the poultry value chain to improve and strengthen the poultry sector in Indonesia, in close cooperation with their Indonesian counterparts. Jointly, they analysed the Indonesian poultry sector, identify interventions to sustainable develop the sector, established broiler and layer demonstration farms including Dutch-Indonesian products and (biosecurity) solutions feasible within the Indonesian environment, executed training programs for local broiler and layer farmers and hatchery operators and organized sessions to facilitate value chain-wide knowledge sharing.

6.2 Business-to-Business opportunities

The Netherlands is internationally renowned for its sustainable and well-developed poultry sector. The Dutch poultry sector employs over 22,000 people in the entire poultry value chain. In 2019, the Netherlands counted 875 broiler farms housing 380 MN broilers. Local production in 2019 was 1.1 MN tons of broiler meat, coming from 760,000 MT in the year 2000. The Dutch layer sector counted 867 farms housing 33.4 MN layers in 2019. In 2019, 10.5 BN eggs have been produced in the Netherlands. The yearly per capita consumption of eggs in the Netherlands is over 200 pieces. Besides the impressive production and consumption figures, the Netherlands is considered a world-leading country in terms of feed, poultry health, antibiotic reduction, food safety, biosecurity and environmentally friendly solutions. The Netherlands hosts numerous large, international operating, companies covering various parts of the poultry value chain. Some of these companies are even internationally active for over 100 years, making them experts in offering products and solutions especially adjusted to local circumstances. As such, Dutch companies could play a role in improving animal health and reducing AMR in the Indian poultry sector. Besides the opportunities for businesses to collaborate in PPP activities, several fields have been identified that could be addressed by private sector collaborations, including:

- Genetic programs to create breeds less vulnerable for diseases;
- Offering antibiotic alternatives, vaccines and animal health solutions and services;
- Feed quality;
- Facilitating broiler and layer farm upgrades (model farms);
- Improving slaughtering and processing segment;
- Digitalization of farm management;
- Building laboratory capacity.

These fields overlap with the fields mentioned in 6.1 and 6.3, however in this case the activities are more focused on direct investments (product offerings and sales) and collaboration between two (or multiple private) parties. While the activities in 6.1 and 6.3 focus more on long term collaborations, the inclusion of all stakeholders and the creation of enabling environments. Detailed descriptions, including potential collaboration partners, are provided in Annex 5.

6.3 Government-to-Government opportunities

Given the rising poultry production in India, efforts must be taken to have a robust poultry infrastructure in place. Such an infrastructure is required to boost sustainable sector development, reduce AMR and improve animal health. There is a key role for Dutch-Indian governmental collaborations to facilitate the realization of an enabling poultry sector infrastructure. Dutch governmental organizations, such as the Dutch Food Safety Authority ('NVWA') and the Dutch Ministry of Agriculture, Nature and Food Quality, possess an abundance of knowledge on food and animal safety, biosecurity, veterinary practices, food circulation and how to limit the impact of poultry farming on the environment. At current, local governments in India do not fully implement proper guidelines as to what actions to take upon disease outbreaks, how to improve biosecurity, how to increase the vaccination rate of farms and how to reduce AMR. The Indian Government and public institutes could learn from Dutch experiences. This enriches regulatory bodies in India with effective regulations that control antibiotic usage and improve animal health. It furthermore offers handles to respond adequately in case of disease outbreaks. Therefore, it is recommended that workshops are organized where government delegates interact to share knowledge and execute reviews on Indian poultry regulations.

The Dutch government started monitoring and controlling antibiotic usage in livestock in 1999 by recording the total sales of veterinary antimicrobials. Combined with application regulations and quotes, this resulted in a reduction of veterinary antibiotic sales of 63% in the Netherlands between 2009 and 2017.[74] There is a lack of consolidated data on antimicrobials usage and the scale of the AMR challenges residing in the Indian poultry production and distribution segments. Systematic documentation on antimicrobials is hardly existent and if, small and localized.[75] Creating centralized State databases that use a systematic approach to document data on AMR in the poultry sector and its implications, will provide a consistent, reliable source of knowledge for research and education. For example, this data can provide information on potential guidelines and training programs across the industry to improve poultry farming practices, and to communicate best practices for AMR reduction.[76] Similar to the Netherlands, India could implement national targets to reduce antimicrobials usage and to ban antimicrobials usage for livestock feed, benchmark antimicrobials usage on farms and stewardship, based on the systematically gathered data synthesized in the centralized system.[77] For this, value chain-wide knowledge sharing by all stakeholders in India is key. Therefore, there is an opportunity for interventions that facilitate knowledge sharing.

In terms of disease outbreaks and prevention, the Dutch government has implemented a detailed protocol for the identification of animal diseases, including proper disease and autopsy analyses. If a disease is detected inside a farmhouse, other houses and neighbouring farms are identified and put under lockdown, after which they are linked to relevant Ministries and food security departments. Based on on-farm assessment corrective measures are being implemented to prevent a disease outbreak in the region. In the worst-case scenario, all birds in a specific range from the infected farm are culled. Indian poultry farmers are often unaware of possible treatments available for bird diseases. This results in farmers witnessing their birds dying without knowing what caused the mortality and what to do. The government could change this pattern by developing disease diagnostic facilities accessible to farmers at nominal costs, providing information and recommendations on diverse drug opportunities favourable to the bird's disease. In addition, there could be continuous monitoring of resistance against any bacterial pathogens such as E-coli, Staphylococcus spp, Pseudomonas spp and Klebsiella spp. This plan requires a nationally organized antimicrobial monitoring plan in collaboration with all associated agencies such as the FSSAI, DBT, DAHD and DCGI.

In India, there is a need for monitoring and control of antibiotic usage and efficient disease diagnosis and management to be in place. Knowledge sharing and collaborations between the Dutch and Indian governments could support the Indian poultry sector on the following topics:

- Building monitoring capacity and set limits for antibiotic usage;
- Establishing enforcement strategies for AMR reduction;
- Building laboratory capacity for efficient disease diagnosis and analysis;
- Establishing procedures on tracking and controlling the use of antimicrobials in animal feed;
- Establishing procedures for animal disease prevention and outbreak control;
- Strengthening food safety focus and control;
- Educating veterinarians and extension workers in focus states to assure monitoring and control of antibiotic sales and usage and diseases;
- Facilitating value chain-wide knowledge sharing;

[74] Dutch poultry industry not affected by antibiotic reduction, Poultry World, 28 June 2019
[75] Antimicrobial resistance in Indian poultry: cause, concern and measure, One Health Poultry Hub, 14 November 2019.
[76] Chicken or Egg: Drivers for Antimicrobial Resistance in Poultry in India (DARPI), UK Research and Innovation
[77] Understanding policy dilemmas around antibiotic use in food animals & offering potential solutions, Indian Journal of Medical Research, February 2019.

- Adopting farm hygiene codes applied in the Netherlands.

6.4. Knowledge-to-Knowledge opportunities

The Dutch poultry industry has shown major developments due to investments in scientific research, information and education by the Dutch Government and knowledge institutes. This has resulted in the development of a strong knowledge base and increased awareness regarding antibiotic usage and its negative impacts on animal health and AMR. India has recognized the need for increased research to reduce AMR and improve animal health in the poultry sector. Collaboration between research institutes of both countries could provide an infrastructural base for knowledge sharing between the Netherlands and India. Fruitful opportunities for knowledge sharing are:

- Cross-country curriculum development;
- Development of selective training programs;
- Joint R&D programs.

Detailed descriptions of these opportunities, including joint R&D program topics are provided in Annex 6.

7. Opportunity roadmap

Due to its large size, population, state differences and legal systems, India is known for having a complicated doing business environment. The large, semi-structured, price-sensitive poultry sector, involving lots of stakeholders and experiencing fluctuating prices and reputations, increases the complexity of collaborations, investments and improvements in the sector. Therefore, AMR reduction and animal health improvement in the Indian poultry sector requires a holistic approach. Figure 17 displays the recommended roadmap for the implementation of the opportunities identified in Chapter 6. These recommendations follow from the field visits, interviews and desk research. Larive-SS4 recommends the application of a 'seeing is believing' intervention method. Until it is demonstrated how animal health improvement and AMR reduction can be achieved while operating a successful poultry business, large scale implementation of poultry health and AMR reduction interventions remain omitted.

Therefore, The roadmap starts with the establishment of Dutch-Indian demonstration model farms/ Centres of Excellence to increase awareness, showcase localised best practices, prove the business case and support stakeholders with the implementation of AMR reduction and animal health improvement practices and solutions. All other interventions are (in)directly linked to the demonstration farms with a specific focus on biosecurity solutions, vaccinations, and the use of suitable alternatives like probiotics, organic acid to reduce the use of antimicrobials in animals. The initial model farm activities will be targeted towards commercial farmers (independent and under contract of integrators) and larger integrators (e.g. Srinivasa Farms, Suguna, Venky's etc.) as they are often regarded as first movers. After this target group has shifted towards more AMR reduction and health improvement-enhancing practices and solutions, the smaller-scale independent farmers are expected to follow the example. In terms of public stakeholders, the focus will be on extension workers, veterinary experts and professors and those people interacting with and advising farmers. Increasing their knowledge and skills will positively contribute to the knowledge and skill levels of farmers. While at the same time, these public stakeholders have a better position to advise policy and decision-makers regarding AMR reduction and animal health initiatives, rules and regulations. To increase awareness and impact, the business cases of the model farms should be incorporated in marketing and AMR and health awareness campaigns. This allows all stakeholders to use the model farms as a case study, sharing the information with a broader public.

This PPP-type activity will stimulate the initiation and boost the progress of the more complex opportunities that require more time to be implemented and/or completed (e.g. g-2-g interventions tend to have a multi-annual timeline). Additionally, the establishment of model farms will open up business opportunities as the demand for training, technology and solutions will increase.

As global attention towards food safety is rising, AMR problems are regarded as a global key concern and solutions are available, Larive-SS4 highly recommend starting the roadmap implementation on short notice (1-2 years). Besides, the rising number of Indian events, webinars, seminars and initiatives indicate that the Indian poultry sector is ready for AMR reduction and animal health action and interventions. Examples of webinars and events include:

- All India Poultry Breeders Association (AIPBA) webinar on "BUILDING A DISEASE-FREE INDIAN POULTRY INDUSTRY" held on 22 June 2021;
- IEC Technical Seminar: India – Profitable Egg Consumption held on 21 July 2021;
- INFAH Webinar on 'Zoonoses & Role Of Animal Health' held on 6 July 2021
- CII's conference on Poultry Technologies in April 2021;

- Poultry Feeding Trends in webinar India by Central Poultry Development Organisation and Training Institute held on 27 March 2021.

As India in terms of size and poultry stakeholders, it is highly recommended to establish demonstration farms and organize training programs in all top poultry farming states (chapter 3.2).

Risks of the recommended interventions and the business case for investments are key factors determining the success of AMR reduction and poultry health initiatives. Larive-SS4 identified external and internal risks that may influence the impact of interventions. These risks, their probability, impact and mitigation measures to reduce the risks as summarized in Annex 7. Furthermore, Annex 7 provides recommendations for intervention-related CSR policies to assure environmental and social responsible implementation. Additionally, Larive-SS4 outlined the contours and key parameters for profitability and business case analyses of the identified opportunities and roadmap.

In the end, implementation of the roadmap will result in better poultry farming sector performance, AMR reduction and animal health improvement. Which all will positively contribute to sustainable overall poultry sector development (e.g. hatcheries, slaughtering, marketing, etc.).

Local appetite for Dutch-Indian model farms:
"The concept of Model Farms for providing demonstrations and training can play a big role in addressing AMR, through creating awareness and increasing adoption of innovations and practices for reducing AMR at farm level. The best practices adopted in Dutch farms can be adopted in Indian context first in the states with similar climatic conditions to the Netherlands." Governmental official

Local appetite for Dutch-Indian collaborations:
"The Indian poultry sector has made great progress in achieving efficiencies, genetic improvement, nutrition programs, and managemental practices have resulted in reducing the use of antibiotics. A strong focus on prevention of diseases by virtue usage of vaccines, biosecurity products and adoption of diagnostic tools should be stimulated. INFAH members would like to explore export opportunities in Netherlands & looking forward to exchanging ideas and best practices." Dr Vijay Makhija, General Secretary, INFAH (Indian Federation of Animal Health Companies).

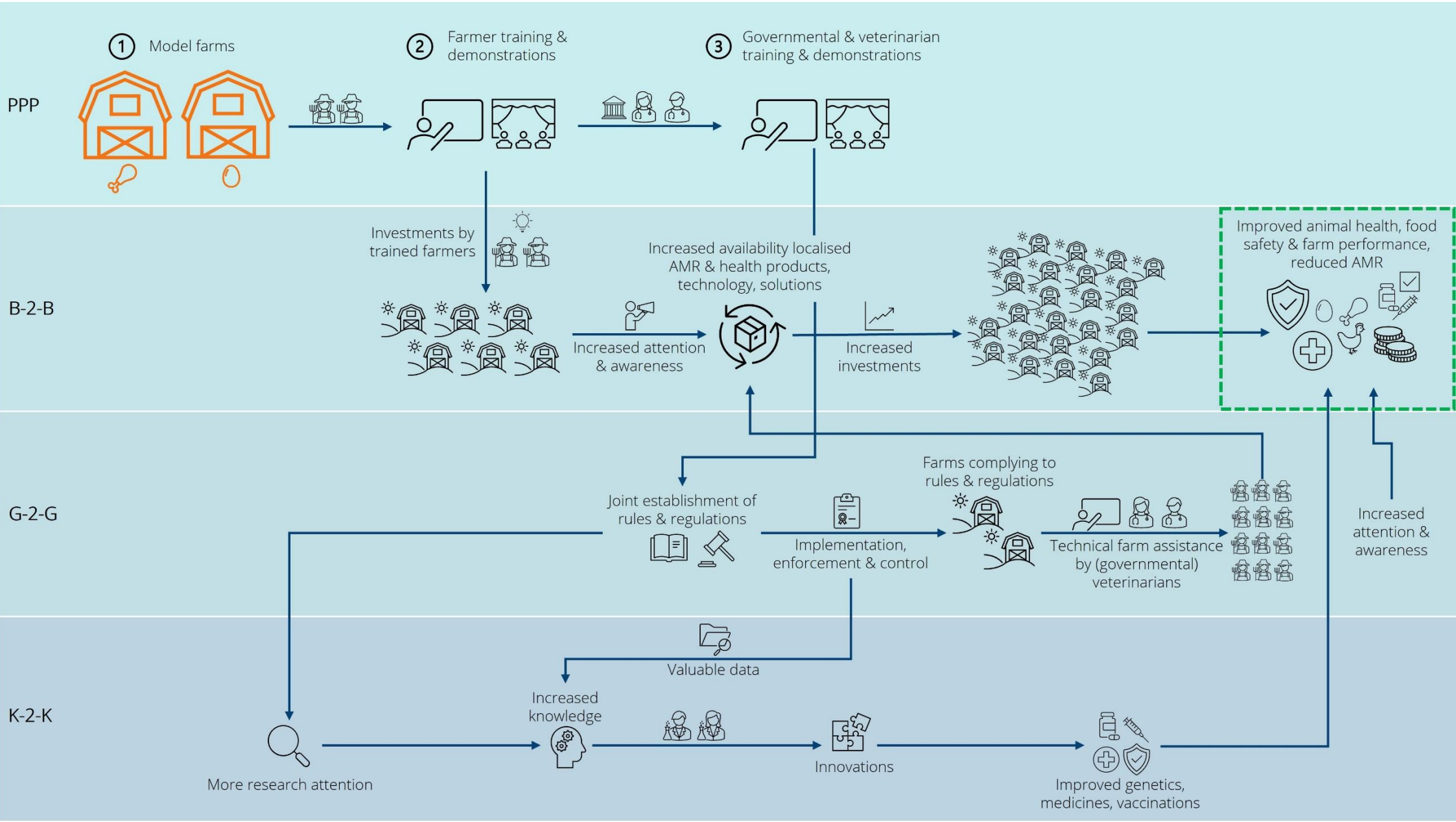

Figure 17: Roadmap Dutch-Indian AMR reduction & Animal health improvement opportunities poultry sector

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Annex

Annex 1: Overview interviewees

Organisation	Function interviewee	State
Private sector players		
Srinivasa Hatcheries	Head of Operations	Telangana
Sneha Foods	Marketing manager Live birds & Head of Production Department	Telangana
Walmart	Procurement Head-Meat section	National
Venkys	Deputy General Manager	National
IB Group	Business Manager	Southern states
MSD	Head Poultry Business Unit	National
Kegg Farms	General Manager	Haryana
Associations		
Poultry Federation of India	Vice President	National
National Egg Coordination Committee	Business Manager	National
Indian Federation of Animal Health Companies	General secretary	National
Andhra Pradesh Poultry Federation	Member of Federation	Andhra Pradesh
Telangana Poultry Federation	Member of Federation	Telangana
International Egg commission	Chairman	National
Governments		
Department of Animal Husbandry and Dairying, Government of India	Assistant Commissioner	National
Department of Animal Husbandry and Dairying, Haryana	Veterinary Surgeons Jind & Karnal districts	Haryana
Animal Husbandry Department Andhra Pradesh	Assistant Director department	Andhra Pradesh
Veterinary & Animal Husbandry Department Telangana	Assistant Director department	Telangana
Public Stakeholders		
FAO Indian Network for Fishery and Animal AMR	Consultant	National
Centre for Disease Dynamics, Economics & Policy	Head South Asia	National
Indian Council of Agricultural Research/Indian Veterinary Research Institute	Principal Scientist	National
Directorate of poultry research	Principal Scientist	National
Local farms		
Poultry farms Haryana	12 farms visited in Yamuna Nagar & Radaur	Haryana
Poultry farms in Andhra Pradesh	4 farms visited in Srikakulum, Prakasam & Vijaywada	Andhra Pradesh
Poultry Farms in Telangana	7 farms visited in Ibrahimpatnam, Hyderabad, Hyathnagar & Medchal	Telangana

Annex 2: Overview global egg and meat production shares per country

Global egg production share per country										
	Eggs, hen in shell (MN tonnes)					% Share global production				
	2009	*2012*	*2014*	*2016*	*2019*	*2009*	*2012*	*2014*	*2016*	*2019*
China	23.63	24.66	24.97	27.26	28.89	38%	37%	36%	37%	35%
USA	5.37	5.59	5.97	6.05	6.71	9%	8%	9%	8%	8%
India	3.23	3.66	4.11	4.56	5.78	5%	5%	6%	6%	7%
Mexico	2.36	2.32	2.57	2.72	2.95	4%	3%	4%	4%	4%
Japan	2.51	2.51	2.50	2.56	2.64	4%	4%	4%	3%	3%
World total	62.92	67.08	70.13	74.10	83.48	100%	100%	100%	100%	100%

Table 12: Overview of global egg production share per country (%) 2009 – 2019 (FAO, 2021)

Global meat production share per country										
	Chicken meat production (MN tonnes)					% Share global production				
	2009	*2012*	*2014*	*2016*	*2019*	*2009*	*2012*	*2014*	*2016*	*2019*
US	16.33	17.04	17.73	18.71	20.15	20%	18%	18%	18%	17%
Brazil	9.94	11.53	12.50	13.23	13.52	12%	12%	12%	12%	11%
EU	9.40	10.33	10.88	11.62	12.62	11%	11%	11%	11%	11%
China	11.75	13.20	12.83	13.42	15.15	14%	14%	13%	13%	13%
India	2.09	2.68	3.05	3.3	4.19	3%	3%	3%	3%	4%
Russia	2.31	3.30	3.77	4.23	4.61	3%	4%	4%	4%	4%
Mexico	2.64	2.79	2.88	3.08	3.48	3%	3%	3%	3%	3%
Argentina	1.50	1.90	1.93	2.06	2.20	2%	2%	2%	2%	2%
Turkey	1.29	1.72	1.89	1.88	2.14	2%	2%	2%	2%	2%
Thailand	1.15	1.54	1.76	1.60	1.72	1%	2%	2%	1%	1%
Others						0%	0%	31%	31%	32%
World	83.01	94.09	100.46	106.74	118.02	100%	100%	100%	100%	100%

Table 13: Overview of global meat production share per country (%) 2009 – 2019 (FAO, 2021)

Annex 3: Animal health and AMR reduction activities public stakeholders

Focus "Livestock Health & Disease Control" scheme of DAHD
Assistance to states for control of animal diseases: control economically important and zoonotic diseases of livestock and poultry by immunization, strengthening of the existing State Veterinary Biological Production Units and the existing Disease Diagnostic Laboratories as well as providing in-service training to veterinarians and para-veterinarians.
Establishment and strengthening of existing veterinary hospitals and dispensaries: financial support to help States establish new veterinary hospitals, dispensaries and mobile ambulances.
Professional efficiency development: assists the State Veterinary Council of India (VCI) to carry out their statutory functions and Continuous Veterinary Education (CVE) for in-service veterinarians.
Chaudhary Charan Singh National Institute of Animal Health: this institute has been established to undertake quality control and assurance of standard, efficient and safe veterinary biologicals and to act as a nodal institute to recommend licensing of veterinary vaccines in the country.
Central/Regional disease diagnostic laboratories: provide referral services in addition to the existing disease diagnostic laboratories in the States.
Advice judicious use of antimicrobials (2014): DAHD advised to use antimicrobials judiciously for treatment of all food-producing animals. And advised stopping the use of all antimicrobials and hormones in animal feed immediately.
Collaboration with Ministry of AYUSH: DAHD has signed an MoU with the Ministry of AYUSH to introduce the concept of Ayurveda and its allied disciplines into veterinary science by their promotion in research and development including research on new formulations in quality drugs for veterinary science through medicinal herbs. This cooperation is expected to assist in developing a regulatory mechanism for the use of Ayurveda in the veterinary sector for the benefit of animal health, livestock owners' community and the society at large. The cooperation is expected to develop herbal veterinary education programs and creating awareness among dairy farmers and agro-farmers about the utilization and importance of herbal veterinary medicine and cultivation of medicinal herbs.
Collaboration with Bill and Melinda Gates Foundation (BMGF) September 2021: DAHD and BMGF signed an MoU for sustainably improving India's livestock sector to support the food and nutritional security in India. The MoU aims to protect the economic well-being of small-scale livestock producers. Developing the livestock sector envisages strengthening animal husbandry infrastructure, entrepreneurship development and implementing the *'One Health'* framework. Through this collaboration, BMGF will provide technical assistance for the design and delivery of new technologies and the implementation of best practices that are relevant in the local context.
FSSAI
Food Safety and Standards Rules 2011 & Food Safety Regulations 2018: prohibited the use of 19 antimicrobials at any stage of production of meat and meat products, poultry and eggs.
Issued tolerance order (March 2019): tolerance limits of 43 antimicrobials and veterinary drugs for the food have been specified.
Filled direction (August 2019) prohibiting the use of Colistin (an antibacterial used as a growth promoter in the poultry sector) **in the food sector.**
Directive (January 2015) principles to limit the use of antimicrobials in livestock rearing
CDSCO
Withdrawal period norms (January 2012): norm that specifies the withdrawal period for poultry, livestock and marine products to be kept off antimicrobials before they enter the food chain. According to the new insertion, eggs and milk products will have to be off antimicrobials for seven days before they enter the food chain. The corresponding figure for poultry and livestock items will be 28 days.
BIS
Poultry feed specifications (IS 1374) (2007): recommendation not to use antimicrobials as systematic growth promotion action.
GoI
Colistin (antimicrobial) ban: A study of CSE (2018) exposed the intensive use of colistin by private sector players supplying leading foodservice chains (KFC, Pizza hut etc.) Resistance to Colistin is a problem, as it is the last-resort antimicrobial used in human healthcare. Following this study, the GoI banned the manufacturing, sales and distribution of Colistin.

Veterinary departments and institutes in India are working to improve poultry health with the implementation of NAP interventions. They have been collaborating on the following themes:
Epidemiology, economics and impact assessment: evolution of pathogenic infectious agents with varying infectivity, virulence, transmissibility and adaptations over time to re-emerge; analysis of social factors responsible for the transmission of pathogens and studying genetic resistance factors.
Technology development and improvisation: development of tools for diagnosis, management, control and prophylaxis of diseases; training, infrastructure and information sharing for responding to emerging diseases; combating outbreaks of avian influenza and strengthening Sanitary & Phytosanitary measures to deal with exotic agents; development of effective and convenient biosecurity; establishment of Compartments / Disease Free Zones.
Professional efficiency development: assists the State Veterinary Council of India (VCI) to carry out their statutory functions and Continuous Veterinary Education (CVE) for in-service veterinarians.
Innovation tools to support the application of technologies: participatory epidemiological tools and GIS techniques to help effective need-based input and service delivery.
ICAR directorate of Poultry Research
Research (2015-2020): Exploring medicinal plants as an alternative to AGPs in broiler production.
Research (2017-2020): Development of a composite feed additive using promising organic acids and plant bioactive compounds for improving gut health and productivity in chicken.
Research (2017-2020): Disease diagnosis, vaccination and monitoring in pure-line chickens.
Research (2018-2021): Chicken or egg: Drivers of antimicrobial resistance in poultry in India. The project aims at the identification of probable routes in the poultry production chain which contribute to AMR in different poultry pathogens and to find out potential alternatives for AGPs in the chicken diet.
Seminar Antimicrobial resistance and its implications in poultry (July 2019): 98 participants attended the event, which included scientific and technical staff of DPR, students at Telangana Veterinary University, senior poultry professionals, representatives and field veterinarians.
ICAR Directorate of Veterinary Epidemiology and Disease Informatics
Research projects: to fulfil its aim of early detection of diseases in livestock.
AMR study 2018-2021: an interdisciplinary study investigating antibiotic use, drivers of AMR, and transmission dynamics under the project "Does antimicrobial resistance (AMR) in livestock contribute to AMR in people in Northeast India?"
NTR college
Department of Poultry Science: researches promotion and impact of backyard poultry among the rural population.

Annex 4: Public-Private Partnership collaboration opportunities

Feed quality

Feed quality is an important determinant influencing animal performance and health. There is an opportunity for setting up PPPs to focus on increasing the availability and usage of high-quality feed while assuring availability for local farmers. Investments in (alternative) quality raw materials, mixing formulations, quality feed mill equipment, quality testing, feed storage solutions, knowledge and skills could significantly increase the production and usage of quality of feed, positively influencing animal performance and health.

Additionally, public and private sector players could combine their strengths to increase the availability and affordability of alternative growth promotors added to feed. In the Netherlands, alternatives such as Phytogenic feed additives are used as growth promotors. Adding this additive does require other additives such as organic acids to be added as well. The shift towards usages of alternative growth promotors could be achieved by offering alternatives, training programs to increase knowledge and skills and demonstrations to prove the performance of the alternatives.

Antibiotic alternatives

Although antimicrobials are often applied as growth promoters in feed, they are also added to water and feed to prevent diseases. There is an opportunity for PPPs to increase the availability of antibiotic alternatives (e.g. probiotics), by offering products, providing training and demonstrating the performance of the alternatives.

Vaccines

Increasing the application of vaccinations at hatchery, breeder and farm level significantly reduces the need for antimicrobials as disease prevention. There is an opportunity for public and private sector players to increase the availability of vaccines and implement vaccination programs by offering effective, suitable vaccines (also for backyard farmers), investments in transportation and storage solutions for vaccines, training programs and demonstrations to prove the effects of the vaccines. Small-dose vaccinations which are easy to transport and can be stored at room temperature have a high potential in India. Involving NGOs, public stakeholders and drug manufacturers could support the facilitation of educating both veterinarians, farmers, and distributors of vaccines on the availability, effectiveness and benefits of vaccines for poultry. Supporting such provision by implementing local government vaccination programs could foster this process and enable the cost-effective production of affordable and suitable vaccinations for poultry farmers.

Biosecurity

Higher levels of biosecurity reduce the need for antimicrobials as it lowers the disease risk. Biosecurity protects birds from diseases, predators, and other potential (climatic) hazards. A lack of biosecurity, or ineffective implementation results in poor hygiene and sanitation, sub-optimal nutrition, disease transmission by other animals (e.g. rats, insects), infected water sources and overcrowding at poultry farms. Causing huge losses in terms of animal health and reduced farmer profit. There lies an opportunity to increase the level of biosecurity at breeders, hatcheries, and farms to improve animal health and reduce the need for antimicrobials. Improved biosecurity levels can be achieved by offering equipment solutions such as ventilation, climate control, heating, closed water systems, investments in hygiene such as gloves, closed shoes, aprons, proper sanitation, cleaning materials and sanitiser, investments in closed houses including doors and walls, training programs, and demonstrating best practices in model farms. While simple improvements include restricting entry to solely essential personnel, washing hands regularly and avoiding mixing different bird species, using Dutch solutions (e.g. climate control installation and cleaning protocols) can improve biosecurity practices at farms at

increased speed. Integration of a pest control program can prevent the entry and transmission of pathogens in farms, minimizing the negative impact pathogens have on poultry production and protects against perpetuation, penetration, and infection.[78]

Digitalization

Digitalization plays an important role in the reduction of AMR and the improvement of animal health. Recording, storing and analysis of data, such as disease outbreaks, vaccination schemes, and animal performance provides valuable information to prevent outbreaks, take disease outbreak measures, provide optimal veterinary health services, and diagnose diseases. Insights in these data can be used by different poultry sector stakeholders such as policymakers, veterinarians and farmers. There is an opportunity to increase the level of digitalization in the Indian poultry sector to increase the control of animal health and antibiotic usage. Digitalization can be achieved by the implementation of data recording systems and technology, the introduction of early disease warning systems, training programs on on-farm data collection and registration, showcasing how data could prevent/cure disease outbreaks.

Knowledge & skills

Higher knowledge levels and skills have the potential to reduce the need for antimicrobials and improved practices will significantly improve animal health in the Indian poultry sector. There is an opportunity to increase the (practical) knowledge and skills levels of Indian poultry sector stakeholders to improve practices applied at all stages of the supply chain. Improved practices result in higher biosecurity, increased knowledge on poultry health and diseases and increased awareness regarding the benefits of using high-quality inputs (e.g. feed, DOC). This can be achieved by practical training programs, demonstrations of best practices, and investment in services and solutions required to implement best practices (e.g. biosecurity equipment, quality feed, education books).

Dutch partners

Potential Dutch public and private players to support these initiatives are: DSM, GD Animal Health, Kepro, Kanters Specialty products, Impex, AviVet, MSD Animal Health, Hendrix Genetics, Intracare, FarmResult, Biocheck, Palital Feed Additives, Viscon, Vostermans Ventilation, VDL AgroTech, Vencomatic, Gasolec, Fancom, Hotraco, Sanovo, Jansen Poultry Equipment, Celtic cooling, Coolfinity, Agrifirm, ForFarmes, Trouw Nutrition, De Heus, Wageningen UR, HAS Den Bosch, Aeres, Van Aarsen, Feed Design Lab, Roodbont Publishers, Redoc Water Technology, Qwinsoft, Van Eck bedrijfshygiene, TS Group Holland, and Ottevanger.

Indian partners

Based on the desk research and interviews, the following Indian players are identified as potential collaboration partners for Dutch organisations in PPP initiatives: The Indian Veterinary Research Institute (VRI), National Institute of Veterinary Epidemiology and Disease Informatics (NIVEDI), Indian Federation of Animal Health Companies (INFAH) and Srinivasa.

[78] Biosecurity on Poultry Farm in India, Proteon Pharmaceuticals.

Annex 5: Business-to-Business collaboration opportunities

Genetic programs

Improved genetic breeds could make the birds less vulnerable to diseases while still fitting within the Indian market conditions and consumer preferences. Breeds with lower disease risks and/or stronger immune systems reduce the need for antimicrobials. Besides, localized breeds will perform better (also in terms of animal health) within the Indian poultry sector while catering to the demand of the local consumers. There is an opportunity for private sector Dutch-Indian collaborations to develop improved poultry genetics to improve animal health and reduce AMR.

Potential Dutch private players to collaborate on genetic programs: Hendrix Genetics, Innovatec Hatchery automation, Royal Pas Reform, Pluriton, HatchTech, Ter Heerdt Kuikens en Hennen and Viscon.

Antibiotic alternatives & animal health solutions

The Netherlands has a wide range of companies offering alternatives for antimicrobials. Additionally, Dutch companies are internationally renowned for their vaccination programs and products, and animal health products and services. Not all solutions, such as low-cost technologies for disease prediction, automatic feeders, probiotics, and prebiotics, are available in India yet. There is an opportunity for private sector Dutch-Indian collaborations to increase the availability and boost the applications of these solutions.

Potential Dutch private sector players to collaborate on alternatives, vaccinations and animal health solutions: Poultry Vets, AviVet, Globe Ingredients, MSD Animal Health, GD Animal Health, Kepro, Plantema Groep, Intracare, Kanters Special Products, Van Eck Bedrijfshygiene, FRAmelco.

Feed quality

As mentioned in the previous section, the application of quality feed is important to improve animal health and reduce AMR. Additionally, the growing sector combined with increased consumer demand increases the need for feed. Given the leading position of Dutch companies within the global poultry feed sector, there is an opportunity for private sector Dutch-Indian collaborations to boost the production and uptake of quality feed.

Potential Dutch private sector players to collaborate on feed quality: F2Care, Marvesa, V.A.V. Conveyor components and solutions, Palital Feed Additives, Cagemax, Globe Ingredients, Van Aarsen, GMP+ International, De Heus, Schothorst Feed Research, Darling Ingredients International, Kepro, Ottevanger Milling Engineers, Provimi, Jadis Additiva, ForFarmers, Orffa International, FRAmelco, Coppens Diervoeding, Agrifirm, Trouw Nutrition, E.F.S. Holland and DSM.

Farm upgrades & technology adaptation

Upgrades of current broiler and layer farms will significantly reduce the need for antimicrobials while improving animal health. Investments in localized Dutch farming solutions including closed drinking water systems, and climate control will increase biosecurity. This will positively impact the health of birds and reduce the risks of diseases. Dutch solutions are internationally renowned for their quality and attractive returns on investment. While the investments cost money, they offer serious costs reduction for farmers as risks (e.g. mortality, disease) are reduced and performance (e.g. weight, egg count) increase. Such upgrades boost efficiency while making animal health a priority. There is an opportunity for private sector Dutch-Indian collaborations to invest in farm upgrades. The establishment of model farms, within PPP projects, could showcase the positive effects and prove the business case. With model farms, the Dutch private sector could introduce best farming models, including technologies fitting to the local situation, to the Indian sector.

Potential Dutch private sector players to collaborate on farm upgrades: Chore-Time Europe, Peer System, Bincx, MJ-Tech, Scan-Air, Impex Barneveld, Vencomatic Group, VDL Agrotech, Gasolec, Hato, Fancom, Hotraco Agri, Jansen Poultry Equipment, TPI Polytechniek, Thermobile Industries, Stienen BE, Val-co, Nijhuis Industries, Microfan, Dorset Green Machines, Vostermans Ventilation, Ridder Drive Systems, TS Group Holland, Winterwarm.

Slaughtering and processing

While at current only 20% of the poultry meat and 6 % of the eggs are slaughtered and or further processed, there is an increasing trend of consumer acceptance regarding processed chicken, especially in urban markets.[79] This trend leads to an expected increase of value addition from processed poultry products. In combination with stricter regulations on hygiene and food safety, this trend will increase the demand for safe farming practices, thus fostering animal safety, and it will stimulate poultry processing. There is an opportunity for private sector Dutch-Indian collaborations in the Indian slaughtering and processing segment. Increased investments in this segment will drive up the demand for uniform produced, safe broilers. Modern slaughterhouses and processing plants apply quality standards for their products sourced, including restrictions for antibiotic residues in the birds (and in eggs).

Potential Dutch private sector players to collaborate on slaughtering and processing: Foodmate, Marel, Meyn Food Processing Technology, Moba, Poultry Machinery Joosten, Check-Points, Mavitec.

Digitalization of farm management

Digitalization could introduce standards to breeder, hatchery, farm, feed mill and slaughterhouse management, provide insights into performance and highlight points for improvement. Additionally, digital information could function as an early warning system for managers, indicating potential failures and issues. With the introduction of digitalized solutions (e.g. data management, climate control), effective measures can be taken when problems occur and/or remote management can be performed (e.g. remote adjustment of temperature). There is an opportunity for private sector Dutch-Indian collaboration to introduce digitalization solutions in the Indian poultry sector. Digitalization reduces risks, increases performance and is also beneficial for biosecurity (as facilities need fewer physical visits for control).

Potential Dutch private sector players to collaborate on digitalization: Ridder Drive Systems, HATO, TS Group Holland, Microfan, Hotraco Agri, Fancom, VDL Agrotech, Vencomatic Group, FarmResult, Qwinsoft.

Laboratory capacity

To assure proper disease diagnosis, (feed) quality testing and analysis, sufficient and up-to-date laboratory capacity is key. The better the laboratory capacity, the more targeted impact measures and (disease) interventions will have. Additionally, the ability to monitor and control the adaptation of rules, regulations and policies will increase with improved laboratory capacity. There is an opportunity for private sector Dutch-Indian collaboration to maintain and increase the laboratory capacity in the Indian poultry sector.

Potential Dutch private sector players to collaborate on laboratory capacity: Agraplan Farmaca, Plantema Group, AviVet, BioChek, GD Animal Health, MSD Animal Health and Poultry Vets.

[79] Poultry Processing and value addition, poultry Punch magazine (2020) https://thepoultrypunch.com/2020/09/poultry-processing-and-value-addition/

Annex 6: Knowledge-to-knowledge collaboration opportunities

Cross-country curriculum development

Employing well-trained human resources encourages the application of best animal health and antibiotic usage practices. This can be realized only if educational resources are accurately targeted at different groups active in the poultry value chain. Training should be practically oriented and tailormade as different actors have different levels and intensities of poultry farming. Currently, knowledge and training institutes in India inadequately respond to the growing industry and the situation smallholder poultry farmers are in. Academic curricula on agriculture exist in India, but particularly practical education targeted at farmers and veterinarians is lacking. To bridge the knowledge gaps of farmers and veterinarians, more resources should be allocated for improving and expanding practical oriented education. Extension agents in India play decisive roles herein. They are ought to possess essential know-how and should offer direction in prioritizing knowledge gaps. Extension agencies among others include intermediate private training institutes, but also public institutes, such as the Department of Animal Husbandry and Dairying (DAHD), can conduct training programs and raise awareness. The project team identified three possible ways through which practical training programs can be improved.

First, for Dutch knowledge on poultry farming to better reach local farmers, there are opportunities to establish a more closely-knit network between Dutch knowledge institutes and local extension agencies. To enable the formation of cross-country collaborations, local extension agencies should connect directly with Dutch education and training institutes. After establishing cooperation, through these extension agencies, teaching practices and curricula can be shared to better educate (smallholder) poultry farmers.

Secondly, there is a lack of veterinary surveillance on AMR and awareness among veterinary professionals regarding the AMR problem. They are unable to capture reliable data on the relationship between the unstable veterinary sector and the AMR problem. There have been various requests by different stakeholders to carefully use antimicrobials and to ban antimicrobials in feed mixtures. Similarly, antimicrobials should be supplied to registered users only. However, due to the lack of veterinarians' awareness on the issue of AMR and potential consequences for animal health, and the quality of poultry meat, and the lack of control on veterinarians compliance to these advises, veterinarians ineffectively guide farmers on the use of antimicrobials, and antimicrobials are still supplied to every type of user. By training veterinarians on the problems regarding AMR and animal health, veterinarians would be more inclined to adhere to the advice and reduce antimicrobials prescription, reducing antimicrobial usage in animal feed. In addition, veterinarians could map the specific AMR issues along the poultry supply chain, to understand the specific challenges and needs for education and training required to improve farmer awareness on the AMR issue.

Thirdly, local education institutes may employ more appropriate extension agents that link Dutch knowledge with local players. Knowledge conveyers ideally are graduates from agricultural schools with deep sector knowledge of the Indian poultry sector. A common finding is that agricultural students after graduation do not utilize their knowledge and share it with local farmers as they frequently end up in governmental organizations. There is a large unexploited opportunity to engage more agricultural graduates in training Indian farmers. Organizing exchange programs, allowing students enrolled in poultry education in India to visit Dutch universities can have the desired effect. Exchange programs can expand their horizon in terms of realizing the possible ways through which the remaining potential of the domestic poultry sector can be bridged. These programs may increase awareness among students for them to fulfil a more active role in the development of the domestic poultry sector. Conversely, through organizing student exchange programs, accompanied with the right incentives,

Dutch students enrolled in agricultural programs may fulfil the role of a local extension agent in India to improve and expand training. Support from (local) government and State bodies in both countries is required to launch these exchange programs.

Finally, both primary and secondary research results indicate a lack of awareness on the topics of animal health and AMR and their consequences, amongst farmers and consumers. Educating farmers on the effects of AMR on their birds could motivate them to adopt biosecurity measures. In turn, this could sincerely decrease the occurrence of diseases in animals, while simultaneously reduce the need for antibiotic usage to cure birds, and reducing AMR among the birds. Educating consumers on the issue of AMR, especially creating awareness about the potential consequences of high antibiotic residues in poultry meat on human health, could help out working out changes in the policy environment to control AMR in poultry.

Development of selective training programs

Dutch stakeholders, preferably a combination of education institutes, possessing didactic skills and poultry farmers, possessing practical knowledge, can fulfil an active role in forwarding existing and developing new cooperative programs if matched with local extension agencies. To benefit from the cooperative, from local farmers it is demanded that they measure their farm performance (with a focus on antibiotic usage and animal health) and actively participate in the cooperative's curriculum. Based on performance, the cooperation suggests alternative measures if needed. Joining forces facilitates knowledge sharing amongst various stakeholders. When locally active, Dutch stakeholders themselves gain from the development of cooperative programs as it results in more robust sales and procurement channels. Therefore, there is an opportunity for Dutch stakeholders to transfer knowledge by playing a more prominent role in developing cooperative programs.

Joint R&D programs

Research and development programs provide sector stakeholders with additional information which allows them to implement better-focused actions and interventions to develop the Indian poultry sector, reduce AMR and improve animal health. The table below provides an overview of future research and development opportunities in the Indian poultry sector is provided. This overview is based on the Vision 2050 of the Directorate of Poultry Research (ICAR). [80]

[80] Vision 2050, ICAR – Directorate of Poultry Research.

R&D opportunity	Focus topics
Genetic performance of poultry birds	➢ Best fitting genetic characteristic within the Indian market conditions; ➢ Trial with new breeds; ➢ Germplasm through phenomic, structural and functional genomic tools; ➢ Elite germplasm; ➢ Molecular growth markers; ➢ Disease resistance traits; ➢ Epigenetic and gene silencing technology.
Standards for pure line and commercial poultry production	➢ Management procedures for chicks, growers and adult birds in pure lines and commercial crosses; ➢ Housing and welfare practices with for intensive and semi-intensive farming; ➢ Gut microflora for better feed efficiency; ➢ Nutritional requirements; ➢ Novel and alternative feed ingredients; ➢ Efficient nutrition production and feed utilization; ➢ Immunity and gut health; ➢ Nutritional and management approaches to minimize residues of extraneous toxic or deleterious compounds in poultry products.
Germplasm for egg and meat production	➢ Nutritional qualities of different chicken breeds; ➢ Genetic engineering tools; ➢ Therapeutic protein production through transgenic technology; ➢ Nutrition characteristics to enhance egg and meat quality;
Nanotechnology applications in poultry production and health	➢ Nanoparticles for drugs and vaccines to improve utilization efficiency and activity against diseases; ➢ Nanoparticles for gene therapy and physiological mechanisms.
Health management practices for the production of hygienic poultry products	➢ Mortality patterns and causes; Disease mapping techniques; ➢ Vertically transmitting diseases; ➢ Disease resistant birds; ➢ Vaccines, peptides and novel drugs against emerging and re-emerging diseases; ➢ Disease prevention measures; ➢ Disease outbreak measures.
Modules to mitigate the impact of climate change and global warming	➢ Climate change impacts on poultry production and health; ➢ Adaptability character profiles in indigenous and commercial birds; ➢ Management strategies for heat and cold stress.
Modules for poultry litter and waste management to prevent environmental and human health hazards	➢ Chemical assessments of poultry litter and waste; ➢ Poultry litter as organic manure for crop production; ➢ Poultry litter as feed for fish; ➢ Poultry litter as bio-gas and for electricity production; ➢ Organic farming; ➢ Consumer preferences.

Annex 7: Risks analysis interventions & CSR policy

Risk	Probability	Potential impact	Mitigation
External risk factors (uncontrollable)			
Unpreventable disease outbreaks resulting in high mortalities and/or poor reputation and/or low investments in the sector	Medium	High	• Be watchful for misinformation in the sector and act accordingly. • Inform sector players and consumers correctly after unpreventable disease outbreak. • Support sector players with re-starting their business operations. • Support the development of a strong veterinary and laboratory infrastructure. • Support the development of monitoring and control systems. • International knowledge sharing regarding diseases.
Changes in state government policy limiting the poultry sector in its sustainable development	Low	High	• Singing of Action Plans and Memorandum of understanding. • Value chain-wide knowledge sharing to address the importance of sector development. • Close involvement and capacity development of relevant local government institutions and universities. • Pressure from international organisations to sustainably develop the sector. • Local lobby.
Change of political climate causing poultry sector initiatives to lose momentum	Low	High	• Closely align with the Indian Ministry of Agriculture & Farmer's welfare and contribute to their agenda. • Contribute to the improvement of the business environment with sector interventions.
Social and economic instability	Medium	High	• Monitor developments (such as elections and major events) and assess their impact on the poultry sector and the initiatives.
Negative environmental impact of intervention	Low	Medium	• Execution of environmental impact assessment. • Implementation of sustainable solutions and products.
Corruption by local players resulting in unforeseen/higher costs and lower intervention impact	Medium	Medium	• Thorough pre-investment research. • Partner with reliable and experienced companies.
No enabling environment for intervention implementation	Low	High	• The recommended interventions are derived from extensive desk and field research, which increases the probability of the interventions fitting within the Indian sector.
Internal risk factors			
Preventable disease outbreaks resulting in high mortalities and farmer losses, negatively impacting sector development and investments	High	High	• Implementation of interventions mentioned in this study. • Introduction of best practices. • Increasing awareness regarding the importance of biosecurity. • Increase the availability of affordable disease prevention products and solutions.
No access to farmers, causing the intervention impact and adoption rates to be low	Medium	High	• Involvement of local stakeholders (associations, private companies, clusters) within interventions. • Focus on affordability. • Utilize the 'seeing is believing' approach and convince farmers of practices and investments.

			• Include strong Indian staff members in the execution of interventions.
Inability to find collaboration partners causing interventions to fail	Low	High	• Strong local presence. • Strong poultry sector network. • Inclusion of different types of stakeholder groups (government, NGOs, private sector). • Use information from this study. • Dissemination of study results and call to action to jointly implement initiatives. • Conduct a partner search study.
Conflicts with collaboration partners (differences in views/ opinions/ ideas)	Low	High	• Specify collaboration details in an agreement. • Establishment of a detailed project plan that needs to be signed by all partners. • Frequent communications and updates. • Strong project manager.
Lack of incentives for poultry sector stakeholders to adopt and invest in AMR reduction and poultry health improvement practices and solutions	Medium	High	• Lobby for rules and regulations regarding AMR and health. • Showcase the business case for adoption and investment. • Increase awareness regarding the issue of AMR and poultry health. • Educate consumers about AMR and poultry health to increase the demand for safe poultry products. • Global pressure to reduce AMR and increase poultry health.
The lobby of stakeholders against the reduction of Antimicrobial usage, as lower usage lowers their sales volume	Low	Low	• International pressure. • Antimicrobial suppliers can focus on supplying alternatives (e.g. probiotics, prebiotics).
No business case for the interventions causing adoption rates and investments to be minimal	Low	High	• Business case and profitability analysis. • Trials at demonstration locations. • Utilize examples from other Asian countries. • Build on the success of other initiatives in Asia. • Focus on the localisation of products and solutions to assure fit.
Violation of key CSR guidelines, negatively impacting the local environment and society	Low	High	• Establishment of a CSR policy* that needs to be signed by all collaboration partners (in accordance with the OECD principles).

*Larive-SS4 recommends the following guidelines to be incorporated in the CSR policy:

Wages, Hours, Status and Benefits:

- Maintain a clear policy regarding employees' safety, compliance with wages, hours, benefits, age and status of employees and good employee relations and abide with the national labour laws for (overtime) payment and holiday compensation); and
- Employ only legally documented workers and do not engage in any form of forced or bonded labour. This includes human trafficking, the holding of original identity papers, prohibiting workers from leaving the premises after their shift, or other coercion intended to force anyone to work.

Child Labour and Young Workers:

- Do not engage in or support the use of child labour. Comply with national labour laws regarding minimum working age or ILO Minimum Age Convention 138 (which is set 15 years of age), whichever is higher.

Worker Health and Safety:

- Provide a safe and healthy work environment for all employees and management, proper measures for fire safety and prevention and identify and eliminate or minimize any workplace health and safety hazards.

Worker Rights and Employee Relations:

- Provide to all employees involved in the intervention written and understandable information regarding the terms of employment; and
- Provide equal opportunity with respect to recruitment, compensation, access to training, promotion, termination, or retirement, treat workers with respect and not engage in or permit physical, verbal or sexual abuse, bullying or (sexual) harassment regarding any Workers.

Gender:

- Do not discriminate in any selection of employees in terms of gender and pay female employees equally to male employees with the same function; and
- Ensure that working times, facilities and opportunities are appropriate and friendly to women's participation and minimize sexist practices and in particular those that objectify women.

Environment:

- Conserve water and land resources, species diversity, wild population and conserve natural habitats and local biodiversity; and
- Embed positive environmental contributions. During the intervention, efficient usage of raw materials and poultry feed ingredients, waste reduction practices, spill and pollution prevention methods and efficient feeding practices should be embedded as an integral part.

Animal Welfare:

- Improve animal welfare across the poultry value chain and promote farms where the animals are treated humanely, adhering to the Five freedoms set out by the World Organisation by Animal Health (OIE); in their Animal Health Codes and the Farm Animal Welfare Committee (FAWC), and do not use any banned antimicrobials or drugs and reduce the level of Antimicrobials used on the locations where the intervention is implemented.

Food & feed Safety:

- Promotion of product quality and safety practices, through the implementation and continuous improvement of effective quality and food and feed safety management systems; and
- Strengthen capabilities in the field of food and feed quality and safety (including antimicrobials usage and poultry health), mindset and culture through structured programmes that develop competencies and technical skills, increase awareness, manage risk and drive increasing levels of excellence across the livestock value chains; and
- Promote feed and food sustainability, quality and safety practices.

Legal compliance:

- Comply with local and national laws and environmental regulations with regards to environmental conservancy, the usage of antimicrobials, animal welfare, water and medication or any other drug supply, hygiene standards and feed mixture standards; and
- Provide proper documentation that demonstrates legal rights for land use, water use, operation and waste disposal; and
- Any fuel, lubricants and agricultural chemicals used shall be stored and disposed of in a safe and responsible manner. Paper and plastics shall be disposed of in a sanitary and responsible way; and
- Transport feed and animals in a manner that aims to maintain temperature control and minimization of spills and stress, physical damage and contamination.

Annex 8: Profitability analysis & business case

The animal health improvement and AMR reduction opportunities for the Indian poultry sector seem promising and beneficial for sector development. However, Indian poultry sector stakeholders need incentives to adopt and invest in more animal health-improving and AMR reduction practices. Especially for farmers, the investment incentives should be clear. On the one hand, the opportunities offer farm performance benefits, including for example shorter cycle times and lower mortality rates. On the other hand, financial benefits (profitability) would function as an additional incentive for farmers to implement and invest in the opportunities.

A business case for investments in health improvement and AMR reduction solutions and the implementation of best practices will function as a proof of concept for Indian farmers. A detailed business case analysis including the exact investment costs, return on investment (ROI) and profitability increase is farm, species, location and situation-specific. Nevertheless, the key parameters to include in the business case and profitability analysis are generic for broiler and layer.

The establishment of model farms or poultry centres of excellence will offer the opportunity to showcase the business case for investments to local farmers as it caters to the 'seeing in believing' approach. Seeing that a farmer who made the necessary investments operates successfully (in terms of production and finance), will stimulate investments of other farmers.

Key business case elements animal health improvement & AMR reduction

In general, poultry farms require lower investments as compared to other livestock animal farms. As the birds are small in size and thus require less space, birds require less labour and the cycle times are relatively short.

The key elements for broiler farm business case calculations are summarized in Table 14. These elements allow for the calculation of the (financial) performance metrics listed on the right. The elements and metrics for layer farms are displayed in Table 15.

Business case for opportunities

It is recommended to perform a profitability analysis for the animal health improvement and AMR reduction opportunities as identified in this report. To strengthen the analysis, (financial) performance data should be gathered before and after the implementation of animal health improvement and AMR reduction practices and solutions. Comparisons with these data will not only indicate the financial benefits of the investments and newly adopted practices but also provide an overview of the technical farm performance improvements.

It is expected for the given opportunities to improve farm performance which will result in a profitability increase. A decrease in mortality will result in increased production, which means increased income. Similarly, an increase in egg production per bird will result in increased income. Additionally, fewer sick animals reduce medicine costs and will thus increase income.

Business case elements broiler farm	Explanation
Mortality	Number of mortalities during the entire cycle
Feed consumption	Kg of feed fed per day, week and cycle
Average bird weight	In the beginning, after 7 weeks, at the end of the cycle
Feed Conversion Ratio	Total feed consumed to produce 1 kg live chicken
Productive efficiency index	PEI (%)= (Body weight (kg) x livability (%) x 100)/ (Age (days) x feed conversion ratio)
Water usage	Litres of water used during one cycle
Water intake	Litres of water consumed per bird
House temperature	Temperature in the farmhouse (°C)
Medicine use	Amount of medicines (e.g. probiotics and antimicrobials) used during one cycle
DOC price	Price of Day Old Chicken
Feed price	Per kg feed price/feed costs per cycle
Medicine price	Price per-pack
Water costs	Costs of water used during cycle
Energy costs	Costs of energy used during cycle
Labour costs	Amount of labour X wages
Animal health & AMR reduction investment costs	Total investment costs
Other costs	Litter etc. per cycle
Sales price	Per bird or kg

Financial performance metrics
Mortality (%)
Cycle time
Average bird weight (kg)
Total harvest weight (kg)
Feed Conversion Ratio
Productive efficiency index
Production costs
Profitability
Profit per cycle
Profit per year
ROI of animal health & AMR reduction investment costs, year

Table 14: Broiler farm business case elements and performance metrics

Business case elements layer farm	Explanation
Mortality	Number of mortalities during the entire cycle
Feed consumption	Kg of feed fed per day, week and cycle
Average bird weight	At the beginning of the cycle and after cycle
Feed efficiency per kg egg mass	Kg of feed consumed/Kg of egg produced
Hen-housed Egg Production (HHEP)	Total number of eggs laid during the period/Total number of hens housed at the beginning of laying period
Performance efficiency index	PEI= [K(EW)P]/ F K= 30EW/EW, BW= Average body weight, EW= Average egg weight, P= Percentage production, F=feed consumed/bird
Water usage	Liters of water used during cycle
Water intake	Liters of water consumed per bird
House temperature	Temperature in the farmhouse
Medicine use	Amount of medicines (e.g. antimicrobials) used during cycle
DOL price	Price of Day Old Layers
Feed price	Per kg feed price/ feed costs per cycle
Water costs	Costs of water used during cycle
Medicine costs	Price per pack
Energy costs	Costs of energy used during cycle
Labour costs	Amount of labour X wages
Animal health & AMR reduction investment costs	Total investment costs
Other costs	Litter etc. per cycle
Egg sales price	Per egg or kg

Performance metrics
Mortality (%)
Cycle time
Average bird weight (kg)
Total harvest weight (kg)
Total eggs produced
Feed Conversion Ratio
Performance efficiency index
Production costs
Profitability
Profit per cycle
Profit per year
ROI of animal health & AMR reduction investment costs, year

Table 15: Layer farm business case elements and performance metrics

Example

The tables below provide an example of the poultry farm economics of an Indian poultry integrator. The tables reveal that the current production costs for eggs, 3.80 Rs/egg (EUR 0.044), are slightly above the sales price in the domestic market with prices of 3.71 Rs/egg (EUR 0.043). Additionally, the prices for the main poultry feed ingredients, being maize and soybean, have increased by 90% and 88% respectively within the last 10 years. Resulting in increased feed costs and thus higher meat and egg production costs.[81]

	Rs/bird	EUR/bird	% of total
Feed (46.6 KG)	1,048	12.07	89.27
DOC	39	0.45	3.32
Medicine /Vaccine	27	0.31	2.30
Rent/Labour	60	0.69	5.11
Total	**1,174**	**13.52**	

Table 16: Cost price layer birds (0-72 weeks)

	Rs/bird	Eur/bird	% of total
Feed (3.5 kg*Rs. 30)	105	1.209	74.38
Day Old Chick	23.26	0.268	16.48
Medicine /Vaccine	4.0	0.046	2.83
Labour	3.5	0.040	2.48
Power	1.4	0.016	0.99
Other costs*	4.0	0.046	2.83
Total	**141.16**	**1.625**	

Table 17: Cost price broiler birds (0-40 days)

* Housing, repair and maintenance, consumables for hygiene i.e. sanitiser, gloves, mask, etc.

	RS/egg	EUR/egg[82]	% of total
Feed (41.5 KG)	3.10	0.04	81.48
Pullet Depreciation	0.55	0.01	14.45
Rent/Labour/Medicine	0.15	0.00	4.07
Total	**3.80**	**0.05**	

*Table 18: Cost price structure egg**

* A layer consumes 41.5 KG of feed during the egg-laying cycle which is priced Rs 22 (EUR 0.253) per kg. A layer lay eggs starting from week 18-19 till week 72-78. During this time, a layer can lay 250 – 300 eggs. For the calculation, it is assumed that a layer will lay 295 eggs during 19-72 weeks cycle.

[81] Primary Larive-SS4 research

[82] Converted @Rs 1 = EUR 0.011516478 accessed on XE currency converter on 03 September 2021, 6:00 PM IST

Year	Production cost (Rs)	Sales price /Egg (Rs)	Margin (Rs)
2011-12	2.20	2.45	+0.25
2012-13	2.81	2.95	+0.14
2013-14	2.80	3.25	+0.45
2014-15	2.78	3.14	+0.36
2015-16	3.00	3.28	+0.28
2016-17	2.89	3.58	+0.69
2017-18	2.66	3.63	+0.97
2018-19	3.12	3.79	+0.67
2019-20	3.80	3.71	-0.09

Table 19: Cost and sales price eggs 2011-2020

Year	Broiler DOC price (Rs)	Broiler DOC price (EUR)	Change (%)
2011-12	16.69	0.19	
2012-13	17.15	0.20	3 %
2013-14	23.05	0.27	34 %
2014-15	20.54	0.24	-11 %
2015-16	22.13	0.25	8 %
2016-17	32.20	0.37	46 %
2017-18	37.91	0.44	18 %
2018-19	32.15	0.37	-15 %
2019-20	23.26	0.27	-28 %

Table 20: Day old chick broiler prices 2011-2020

Year	Maize (Rs/kg)	Change (%)	Soybean (Rs/kg)	Change (%)
2011-12	12.22		18.98	
2012-13	14.03	15%	33.61	77%
2013-14	14.03	0%	35.89	7%
2014-15	13.30	-5%	35.82	0%
2015-16	15.23	15%	35.46	-1%
2016-17	15.39	1%	30.54	-14%
2017-18	14.23	-8%	27.85	-9%
2018-19	16.54	16%	32.89	18%
2019-20	23.28	41%	35.76	9%

Table 21: Maize & soybean ingredient prices 2011-2020

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