Capitalising off Antibiotics:
The Case of Poultry Factories in the NCR

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DECLARATION

I declare that the thesis entitled "**Capitalising off Antibiotics: The case of Poultry Factories in the NCR**" submitted by me for the award of the degree **Doctor of Philosophy** of Jawaharlal Nehru University is my own work. The thesis has not been submitted for any other degree of this University or any other university and is my original work.

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CERTIFICATE

We recommend that this thesis be placed before the examiners for evaluation

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PREFACE

The writing of this thesis began with a vivid concept in mind about medicine (particularly antibiotics), and how our over-dependence on ‘magic bullets’ led to an unsustainable model of healthcare. A model that skipped over to agriculture and environment which has resulted in indirect impact our health landscape. It was to be about the retardation of healthcare in the present times, in India and elsewhere, and a need to revisit the concepts of health as envisaged during the hygienic revolution. Furthermore, I chose to study antibiotics from a poultry perspective because I wanted to study the indirect effects of rash medicinal use in an otherwise unrelated area, in so doing explore the broad definitions of ‘health’. Over time I saw the work as being more anthropological in nature and a study of food chains and the relations between health and the modern food industry. Food - its acquisition, preparation, and consumption which are part of the mundane, but the behemoth supply chains that bring them to the convenience of our doorsteps are another matter. And the role of antibiotics in this complex machinery was a fascinating topic, it touched all the bases and aligned with my interest – history, economics, and healthcare. However, considering the expanse and novelty of social science research on antibiotic use, the research changed to match the ever-evolving complexity that the subject encompassed.

The research in many ways is a commentary on the industrialised societies we live in today, and the industrial systems that have been created to sustain shifting populations, leading to the alienation of us from the very essence of our sustenance, a perspective that has been referred to as 'biospheric disorder.' This disequilibrium between humans and their environment is at once the result of human activity and detrimental to our collective wellbeing. However, the current economic paradigm rationalises to exploit these conditions and promote the view that they are actually desirable and even necessary conditions in order for society to progress. Meanwhile, little attention is paid to the social and environmental consequences of this neoliberal model of the market. An 'ism' which views all activity within the biosphere as an economic good, and so human-mediated disruption of natural systems is not considered problematic because it ultimately produces quantifiable economic activity.

Furthermore, the depopulation of the rural spaces and the ever-increasing urban sprawl has also led to increased stresses between the periphery and the centre, in terms of resource dependence. Our food has become a product of a complex economic machinery disengaging us from the source through multiple levels of buyers, and a system that is increasingly reliant on the pollution and poisoning of the rural landscapes. This economic engine of food production and distribution is today a multi-billion-dollar industry which is increasingly concerned with produce yield, size, and resilience through science and technology. In just the last century through scientific leaps, we gained mastery of a process that took eons of selective breeding and propagation of desired natural traits of animals and plants, and scaled it up through genetic technologies. Many argue that such interventions were necessitated due the increasing population and climate uncertainty, while others contest those shortages in food is a matter of improper distribution. Contemporarily, arguments have been made that the demand for food is sparked by an increased demand for meat-based protein, rather than increasing populations (T. Robinson, 2011). That is to say, that the increasing demand for animal protein has led to an increasing demand in grains and water to feed and grow livestock animals. Whatever the argument, the fact is that agriculture is a relatively new activity considering human history, and technological advancements in agriculture, while inevitable, comes with inevitable unpredictable repercussions. Of which antibiotic resistance stands out as another inevitability of uncontrolled technological use.

Indeed, there has been great benefits accrued to the application of technology to agriculture. Consider the humble plough, the invention of which harnessed the fertility of clay soils along river basins and created the abundance for economic growth and concentrated human settlements. Or the canals that continue to flood ancient terraced fields that launched great Asian civilisations, they were in tandem with nature. However, as technologies became more invasive and the effects more pronounced there has been increased dissention to the modern industrialised agricultural practices. Rachel Carson and her *magnum opus* Silent Spring provided the foremost example in this dissention, which lead to the development of the modern environmental movement. Her ideas were seeded in the idea that life is more interconnected than we assumed it to be, and in many ways this thesis proposes the same while trying to navigate the increasing complexity of the modern food chains.

Feeding a planet’s worth of humans is no small task, many of the products of agricultural technologies today are capital and energy intensive and have large carbon footprints. Moreover, rearing animals for an ever-increasing demand for meat is an even greater strain on the ecosystem as a whole. Hence, there have been numerous attempts and counter-culture movements to improve the sustainability of food systems, and to shift away from the current food paradigm.

The post-Woodstock era in which Rachel Carson wrote her book was also dominated with concepts of commune living of the Hippie persuasion in the United States. It was a shift away from materialist culture and was a call to return to the land. In contemporary times increasing climate change/environmental consciousness has pushed through a resurgence of this concept. The revival of the 'homestead movement', mainly in the West, has been one such attempt to regain control and move away from the fast-paced impersonal modern lives. Increasing popularity of farmer's markets, organic food, and veganism has also been a conscious choice to regain this control. Furthermore, more people have been returning to farming and/or kitchen gardening.

Conversely, agriculture in the countries of the global South is still considered an occupation of the rural poor and are usually made up of farmers with small land holdings based on human labour rather than machinery. But dependent on modern technologies like high-yielding seeds, hybrid animal lines, fertilisers, chemicals, medications, etc. As per the 78th round NSSO data - in India, farmers on average spend about 30% of revenues on inputs, mostly fertiliser and labour, additionally, most famers do not own the land they farm on and sharecropping is a common practise. Most small farmers try to supplement their income by rearing animals for sale in the market, or by labouring in the cities in the off seasons. Hence, India has an unregulated supplementary market of animal growers. And in an industry with marginal gains the only way to make profits would be to increase produce and decrease costs. The poultry industry is a typical representation of this model. The backyard chicken rearing, sustenance culture of animal husbandry has mutated into an intensive operation in order to meet the demands of modern life and the broiler chicken has become the poster-child for industrialised food production. It is the most successful commercial breed of poultry ever. The broiler has been sailed oceans and lands to now be bred across the entire world, along with the industrial chemicals and materials that is required for its propagation.

A chicken today is market ready in a month and a half, sold when the bird is not even an adolescent, making it a quicker source of food than most vegetables. This makes chicken farming an attractive business to invest in, considering at least eight cycles of production in a year. However, growing live animals are pocked with a multitude of issues that a farmer has to troubleshoot. Concentrated animal operations (CAFOs) are vulnerable to diseases, both to the animals as well as the growers. Hence, medicated feeds are fed to induce unnatural growth and antibiotics are used prophylactically to prevent disease.

In the recent years a revival of conscience healthy eating has resulted in the rising popularity of organic foods, the industry reacted by marketing such goods at a premium for those that can afford it. The animal produce industry has also reacted similarly; "antibiotic free eggs", "Hormone free milk", "grass fed beef", "ethically harvested mushrooms", "USDA organic". However, in this post structural world, the image of going back to nature is contrasted by genetically modified plants and animals, as well as an increasing interest in lab-grown meats. Furthermore, ethical considerations abound in the discussion of growing animals for food – for instance, in the West and among certain conscientious consumers and animal rights groups the evils of factory farming have been well documented. Therefore, this thesis adds to this body of knowledge by addressing the conditions that necessitates the use of antibiotics for rearing food animals. I proposed to do this by conducting an in-depth study of poultry farmers and corroborating my field studies with expert interviews.

However, during the course of my research the SARS-Cov2 pandemic struck which derailed the world, its markets, and my research as well. In India, poultry farmers were dealt a double blow as the pandemic market disruptions were followed by an Avian flu spike in 2021, causing the price of chicken in North India to rise then collapse steeply. The initial rise in prices were due to food chain disruptions and increasing grain prices during the pandemic which made poultry feed dearer, thereafter, the closure of the hospitality industry – catering, restaurants and hotel enterprises, which constitute the largest buyers of poultry products, impacted demand severely only to be done in by Avian flu finally. This led to the loss of livelihood for many farmers, who by then many of whom were already reeling under the loss of business due to the several lockdowns. Alternatively, antibiotic use among people drastically rose as increasing panic, unclear treatment protocols, and circulation of fake news upped the consumption of antibiotics.

The Indian Poultry production is one of the largest in the world (fourth after the US, China and Brazil). Within the country the southern States of India (Andra Pradesh, Tamil Nadu, Maharashtra) account for a majority of the chicken production, followed by the northern and eastern States (Haryana, West Bengal and Punjab). Paradoxically, as of 2018 India has also began importing frozen poultry from the US after losing its case for protectionism in the WTO. Threatened with trade sanctions India yielded, the oversupply of chicken in the Indian market pushed exports to other countries. This is a classic example of how 'poor countries aid rich countries' (Hickel, 2017). Those without the resources to compete with cheaper exports lose out, while the benefits and opportunities provided by international trade are accrued by the larger producers. Hence, presently only 30 percent of poultry farmers in India are still small-scale operations, this segment once upon a time compromised the majority. But in the last two decades increasing commercialisation have resulted in organised contract farming similar to the arrangements established in the United States of America. Nevertheless, the sale of poultry within the country remains largely unorganised. A lack of infrastructure like abattoirs and freezers and a preference for fresh culled meat have sustained the operation of wet-markets and live bird sale even in the larger cities of the country. This continues in spite the passing of many legislations that discourages such practices, this inconsistency of law to practice is characteristic of many Indian arrangements. The gap in implementation has been blamed on underfunding and training shortcomings, furthermore, a complex legal system complimented with the vastness of the subcontinent provides the country with unique systemic problems.

The food chains of any human settlement are made up of a composite web of growers, wholesalers, traders, export and importers. These chains form a web of infrastructure (formal or otherwise) that spans the country and across the globe, but most chains are based on the periphery-centre relationships. So it is, with Delhi and the National Capital Region, most of the vegetables and the meats are from the farmlands of Haryana, Rajasthan, and UP. Cities like the NCR are some of the densest settlements of humans ever in the history of the world, a majority of whom are not involved in agrarian activities. Hence, along with food insecurity unplanned growth, increased crowding and disinvestment in public works also means an increased chance of disease transmission, social mal-adaption, other health complications, destruction of biodiversity, and an increased dependence on non-renewal resources, among other things. Furthermore as 'growth' becomes the imperative for development the natural limitations of the finite world struggles to sustain current economic logics. As Julie Livingstone explores through her plenary parables; many of the problems of modern economics is because it is based on consumption driven growth. The idea of an ever-increasing infinite growth trajectory dependent on the finite has, therefore, been wagered on human ingenuity and technology to extract the most economic value from the natural resources available to us. Hence, as human society industrialised so did the foods we eat. Resulting in an over dependence on fertilisers, modified seeds, and pesticides to produce 'cheap food for urban poor in order to keep labour cost low' [1].

[1] Raj Patel and Jason W. Moore in their book – 'A History of the World in Seven Cheap Things', discusses the nature of Capitalism in a period they describe as the 'Capitalocene'. It discusses the relations between humans and nature, in order to make sense of the present in order to foresee what is to become of our future.

This ‘capitalist agriculture’, as referred to by Raj Patel (*Stuffed and Starved: Markets, Power and the Hidden Battle for the World’s Food System,* 2007), is an ecology of cash agriculture with the single-minded focus on profit and a drive to keep food prices low as it is in the interest of capitalists to be able to feed working families in order to prevent unrests as well as to keep work cheap. One might argue that the logic of any one thought is never so clearly foresighted but the argument prevails. Food is as much a political issue as it is an economic topic of discussion. Throughout the world inflation of essential food commodities is a concern for most low and middle-class households. It has resulted in the fall of kings and kingdoms – an instance of which is incapsulated within the apocryphal of Marie Antoinette asking the revolting masses to eat cake since they could not afford bread. India in the 1980s was dominated by onion politics, where the price of this humble vegetable became the bone of content that made and unmade governments. Countries around the world has seen uprisings due to food price; Venezuela, Turkey, Burkina Faso, Côte d'Ivoire, are just some of the countries where uprisings were motivated due to increasing food price, even the Arab Spring was motivated due to same

The depopulation of the countryside has been complemented by the swarming mass of people moving into the cities and towns. Many of whom end up in less than desirable living and working conditions. The ‘dark satanic mills’ of Victorian England is replicated today in the sweat shops of Bangladesh, the mineral mines Africa, the shipbreaking operations in Pakistan, the iPhone assembly factories in China. The settlements in urban centres that house these low paid workers are equally deplorable; the slums of Nigeria, Mumbai, Dhaka are a spectre of poverty, disparity, and disenfranchisement. Yet, the residents of such places form a bulk of the workforce who make the cogs turn on the complex machine that is the city.

India’s push for development in its agriculture sector in the 1960s incentivised the use of Chemicals (pesticides, weedicides, and artificial fertilisers) and machinery. The effects of which can be quantified today in the number of cancer patients from the areas dedicated for this ‘revolution’ in food production. Albeit, food shortages in India are a thing of the past, the abundance displayed in the supermarkets are a contrast to the poverty of the countryside.

An anecdote my father loved to narrate was that – “…growing up in an obscure hilly town in north-east of India the in 1960s, even the gifting of a single egg was precious”. Today the fumes of the capitalist engine reach even the most isolated settlements. The self-sustaining families of yesteryears have been made a participant in this market economy ever vulnerable to the shifting prices. The story of Antibiotics and the Chicken is a product of such propensities of the capitalist market economy- that is, cheap products with hidden costs. Hence the title of the thesis, the ‘Capitalising off of Antibiotics’, antibiotics have and continues to remain central to the success story of the meat industry. This presents a real threat to the security of our food as well as to our health.

Those who study water have a saying, ‘we all live downstream’. While accurate as a physical observation it is also allegorical of the web of associations, an interconnected-ness that we share as inhabitants of this planet. Just as the corruption of water has consequences for those dependent on it down the stream, so too does other natural resources we presently exploit to sustain our society, inevitably we incur a debt on our future.

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ACRONYMS:

ABR – Antibiotic Resistance
AFO – Animal Feeding Operation
AGP – Antibiotic Growth Promoter
AMR – Antimicrobial Resistance
AMRSN – Antimicrobial Resistance Research & Surveillance Network
AR – Antimicrobial Resistance
ARGs – Antibiotic Resistant Genes
AST – Antibiotic Susceptibility Testing
AUR – Antimicrobial Use and Resistance
CAFO – Concentrated Feeding Operations
CBF – Contract Broiler Farming
CDDEP – Centre for Disease Dynamics, Economics & Policy
CDSCO – The Central Drugs Standard Control Organization
CSE – Centre for Science and Environment
DPCC – Delhi Pollution Control Committee
ESBLs – Extended spectrum beta lactamases
EPA – Environmental Protection Agency
ESKAPE – **E**nterococcus faecium, **S**taphylococcus aureus, **K**lebsiella pneumoniae, **A**cinetobacter baumannii, **P**seudomonas aeruginosa, and **E**nterobacter species
FAO – Food and Agricultural Organisation of the United Nations
FCR – Feed Conversion Ration
FDA – Food and Drug Administration
FSSAI – Food Safety and Standards Authority of India
GAP – Global Action Plan
GLASS – Global Antimicrobial Resistance Surveillance System
GNI – Gross National Income
HAI – Hospital acquired Infections
ICMR – Indian Council of Medical Research
IDSA – Infectious Diseases Society of America
ILO – International Labour Organisation
LMIC – Low-Middle Income Countries
MCD – Municipal Corporation of Delhi
MDR – Multidrug Resistant
MIC – Minimum Inhibitory Concentration
MMWR – Morbidity and Mortality Weekly Report
MoHFW – Ministry of Health and Family Welfare
MRSA – Methicillin Resistant Staphylococcus aureus
MtB – Mycobacterium tuberculosis
NCDC – National Centre for Disease Control
NCR – National Capital Region, India

NDM	– New Delhi metallo-β-lactamase
NIH	– National Institutes of Health
OECD	– Organisation for Economic Co-operation and Development
OIE	– Office International des Epizooties (presently WOAH – World Organisation for Animal Health)
PCR	– Polymerase Chain Reaction
PhRMA	– Pharmaceutical Research and Manufacturers of America
SARS Cov-2	– Severe acute respiratory syndrome Corona Virus-2
SEARCH	– Surveillance for Emerging Antimicrobial Resistance Connected to Healthcare
Tb	– Tuberculosis
UN	– United Nations
UNICEF	– United Nations International Children’s Emergency Fund
USAID	– U.S. Agency for International Development
USDA	– United States Department of Agriculture
VISA	– Vancomycin-Intermediate Staphylococcus aureus
VRSA	– Vancomycin Resistant Staphylococcus aureus
VRE	– Vancomycin-Resistant Enterococci
WHO	– World Health Organisation
XDR	– Extensively drug-resistant

Introduction: Capitalizing off of Antibiotics: The case of Poultry Factories in the National Capital Region of India

"The whole problem of health in soil, plant, animal and man is one great subject."

-Sir Albert Howard

Once considered as 'wonder drugs', antibiotics are no longer the 'magic bullets' (Zauberkugel) that Paul Ehrlich once envisioned. His notable invention of an arsenic based compound (Salvarsan) "capable of specifically killing certain microbes"[2] was one of the first instances of targeted therapy (Valent, et al., 2016, p. 112) and had predated other similar drugs, but in due time most have become and are becoming inefficacious. In purview of the threat posed by antibiotic resistance the Office of National Statistics (ONS) in the UK had even lowered their life expectancy projections of the UK by about a year (Rudgard, 2017), which is not an unusual task in itself, but it was the first time that the ONS believed that antibiotic resistance could be responsible. This is unprecedented as historically antibiotics (and vaccines) have been responsible for extending life spans by reducing mortality and morbidity due to bacterial infections (Ventola, The Antibiotic Resistance Crisis, 2015).

Antibiotic resistance is considered as one of the gravest threats to global health, food security, and overall development presently. While the impacts of COVID-19 were seen and experienced by everyone beginning in late 2019, resulting in millions of deaths, antibiotic resistance ensures to be a slower burn – speculated to result in far graver outcomes. This is because as antibiotics become less effective a growing number of infections and infectious diseases become harder to treat, leading to increased mortality, increased medical costs, and longer recovery periods. Hence, antibiotic resistance is as much a social problem as it is a biological one, however, it is very difficult to find a social science niche in an area primed for technicians of science (other than behaviour studies). But as Hannah Landecker writes "antibiotic resistance presents a critical problem of *what to think* in and beyond biomedical science" (Landecker, Antibiotic Resistance and the Biology of History, 2015, p. 20). Therefore, in the backdrop of this statement this research frames antibiotic resistance as a

[2] Paul Ehrlich had synthesized the first ever antimicrobial drug arsphenamine (Salvarsan) in 1909, which was an agent used to treat syphilis. It was an idea that stemmed from staining bacteria and tissue cells (Schwartz, 2004) which inspired Paul Elrlich to study chemicals which could "seek out and specifically destroy invading microbes or tumour cells" (Valent, et al., 2016, p. 112)

problem of the antibiotic economy. That is, the financial and productive benefits accrued by antibiotic use entangles food production in complexities and solutions to which remain a 'wicked problem'. In framing the problem as such we can develop a new way to visualise antibiotics which may provide a deeper understanding of the circumstances to which effective intervention may be designed.

The antibiotic economy under analysis in this case shall be the poultry industry in the National Capital Region of India (NCR), with references to other agricultural uses of antibiotics. Besides the fact that antibiotic use in agriculture began with poultry, the use of antibiotic is also most alarming in this same industry (especially in India). Additionally, the poultry industry serves as a definitive case study for understanding antibiotic misuse. This is because of increasing demands for poultry products in India, its deep entanglement with the market, and the shortcomings of regulatory frameworks that hope to dissuade and control its use. It has become even more significant to study antibiotic resistance in the NCR of India because in the past few years India has become ill-famed as the "antibiotic capital of the world" (Bhutia, 2016) (Aggarwal, 2019). This tag has been placed primarily due to the massive consumption of antibiotics (in human health as well as use in animal health) and also large medicine production capacity of the country, furthering the consequential problem with antibiotic resistance. New Delhi has also had the unfortunate honour of having an enzyme that makes bacteria resistant to a broad range of beta-lactam antibiotics named after it[3]. But more importantly India presents us with a unique circumstance; already burdened with a high incidence of infectious diseases, the country India also has a very vibrant but disparate healthcare industry, with low government spending on healthcare contrasted by a bourgeoning of private healthcare institutions, and a thriving pharmaceutical industry. India is also one of the most populous countries in the world and has observed huge internal migration to urban centres often pushing existing infrastructure to its limits.

In terms of urbanisation - a UN report estimated that about 34 percent of Indians currently live in urban areas (UN World Urbanisation Prospects 2018 Report). The report also stated that India has the largest rural-population but it is estimated that by 2050 India will have added approximately 400 million people to its urban settlements. This engages a huge strain on food systems, and given the depletion of natural resources and instances of extreme weather conditions, food security and environmental sustainability continues to be recurring topic of discussion. This is a shift away from the post-independent agenda for food

[3]The NDM, or the New Delhi Metallo-beta-lactamase is one of the most formidable enzymes that makes bacteria resistant to a broad range of beta-lactam antibiotics.

sovereignty, wherein many revolutions in food production resulted in a self-sustaining food production economy. One such revolution endeavoured to develop an independent poultry industry within the country.

Presently, India is the third largest producer of poultry products, exporting to countries like Oman, Japan, Maldives, Vietnam, Indonesia, Vietnam, etc. (APEDA, Ministry of Commerce & industry, Govt. of India. 2018). In the year 2018-2019 alone India exported six lakh (six hundred thousand) metric tonnes of poultry products to these countries (*ibid*). Moreover, domestic poultry consumption in India is expected to rise by about 600 per cent by 2030 compares to the year 2000 (Boeckel, et al., 2015). So when we add all these factors: prevelant high infectious disease burden, antibiotic resistant bacteria, increasing urban crowding (sanitation, hygiene, increasing food demand), low public health spending, an enormous unregulated food industry, and a substantial export economy - it translates into an epidemiologically significant composition. This presents as an even more so significant concern for public health considering bacteria's ability to transfer[4] resistant genes to previously susceptible bacteria. As antibiotic-resistant bacteria circulate in human and animal populations through food, water and the environment its transmission continues to be influenced by trade, transport and travel of humans, animals and animal products. Therefore, a study of the poultry industry presents a window into the various intersections of urbanisation, food production, trade, and its impact on the health of the population.

Delhi specifically does not produce much of its own food but depends on its neighbouring States to provide everything from vegetables and fruits to eggs, meat, grains and even water. It is for all purposes an urban island dependent on supplies which are routed through wholesale markets (*mandis*) from where it gets distributed to local markets throughout the city. There are vegetable *mandis*, vegetable and fruit *mandis*, and a separate market for the sale of poultry products and other meats as well. Most poultry products come from neighbouring Haryana and from Punjab to meet the increasing demand for meat in Delhi, resulting in birds being routed into one of Asia's biggest chicken markets, Ghazipur Murga Mandi in Delhi. While the market is itself unhygienic, environmentally polluting, and a repository for resistant bacteria the farms from where they are reared and supplied from are equally precarious.

[4] Bacteria can transfer resistant gene from one to another horizontally forming resistance to antibiotics which it has never been introduced to (Boto, 2009) (Burmeister, 2015). This is significant in considering the prospects for the emergence and re-emergence of infectious diseases (Morens & Fauci, 2013) (Mukherjee, 2017).

In February 2018, news reports in national as well as international newspapers reported on a study conducted by the Bureau of Investigative Journalism (Davies & Walsh, 2018). The study found that hundreds of tonnes of the antibiotic *Colistin,* described as an antibiotic of last resort[5], had been shipped to India for the routine treatment of animals, chiefly for use in poultry production. Earlier studies by the Centre for Disease Dynamics, Economics & Policy (CDDEP) found that unregulated use in Indian broiler and layer farms could possibly be contributing to the emergence of resistance in clinically relevant antimicrobials (Brower, et al., 2017). Since then, studies across India have shown resistance profiles in *C. jejuni* (Khan, Rathore, Abulreesh, Qais, & Ahmad, 2018), *E. coli* (Hussain, et al., 2017), *Salmonella. S. Typhimurium* (Gautam, Kakatkar, Karani, R., & Bandekar, 2017).

However, while such studies present us with a picture of the extent of antibiotic use in India they remain localised studies, and therefore, do not capture the full extent of the problem at a national level. Nevertheless, there have been attempts made to establish an 'Antimicrobial Resistance Surveillance & Research Network' in India in order to understand the extent and pattern of the problem. The surveillance network is designed with the ICMR (Indian Council of Medical Research, New Delhi) as its 'super-administrator' (Walia, et al., 2019) six nodal centres across India and currently sixteen regional centres.

As for environmental pollution, studies have isolated multi-drug resistant bacteria in some of India's major rivers and water bodies revealing the extent of the problem (Ram, Vajpayee, & Shanker, 2007) (Azam, Jan, & Haq, 2016) (Dhawde, et al., 2018). Another report published by the Indian Council of Medical Research (ICMR) showed that of the 207 stool samples collected from healthy individuals from a semi-urban community in Chandigarh, India, 146 were found to be populated with antibiotic resistance isolates (Gupta, et al., 2019)[6], that means about two-thirds of the samples were found to bear resistant bacteria. With specific regards to poultry farms, a study conducted by the Centre for Science and Environment (CSE) in 2017 showed high prevalence of multidrug resistance in poultry environment comprising of poultry litter, poultry farm soil and nearby agricultural land soil (Khurana, Bhushan, Sinha, & Nagaraju, 2017). These findings were based on 47 samples (35 samples were collected from 12 broiler farms across nine districts) which were collected from four North-Indian states, i.e., Uttar Pradesh, Rajasthan, Haryana and Punjab in 2016-2017.

[5] Besides colistin, the antibiotics reserved exclusively for human use are fourth- and fifth-generation cephalosporins, polymyxins (both colistin and polymyxin B), carbapenems and oxazolidinones (linezolid), fosfomycinaztreonam, tigecycline and daptomycin (WHO, 2017).

[6]Of the 207 samples 146 isolates belonging to the *Enterobacteriaceae* family were obtained, of which presence of *E. Coli* resistant to Cephalosporin was the highest at 63.2% (Gupta, et al., 2019, p. 278).

In order to unpack what all these studies mean from a global/public health perspective it is important to understand what is at stake. Antibiotic resistance has been likened to a 'silent pandemic', a 'silent tsunami' (Chaudhry & Tomar, 2017) made up of an escalating failure of antibiotic treatments for previously curable infections and a stark absence of public awareness. However, it is not for lack of trying; initial academic and popular literature describes antibiotic resistance efforts as a 'battle', a 'war' on bacteria. Such attempts have been criticised (Mendelson, Balasegaram, Jinks, Pulcini, & Sharland, 2017) suggesting that communication (or the lack thereof) may be a part of the problem of why prudent use promotion efforts has so far not been successful (Kodish, 2018). But with increasing efforts placed into disseminating information and education on the issue[7] there is an increasing awareness of antibiotic resistance. However, it makes the issue no less complex, the ABR problem is plagued by a scarcity of data (Founou, Founou, & Essack, 2017) (Bebella & Muiruc, 2014) (Allegranzi, et al., 2011), a drying antibiotic pipeline (Luepke & Mohr, 2017) (Morel & Elias Mossialos, 2010), the numerous bacteria responsible for causing infectious diseases (WHO, 2017), and the global reach of the problem (Höjgård, 2012). This makes it imperative to look at issues and the causal connection to, among other things, hygiene, healthcare systems, markets, urbanization, globalization, agriculture and the environment.

That having been said, the literature on antibiotic resistance is far more expansive than the narrative above would have you believe. For this reason, it becomes an imperative to highlight, contextualise as well as define some important concepts, beginning with the subject of this thesis itself: '**antibiotic resistance**'.

[7] Since 2015 the WHO has been observing 'World Antibiotic Awareness Week' in order to increase awareness and encourage best practices among the general public, health workers, and policy makers. There have also been regulatory policies enacted across 123 countries (WHO, who.int, 2018) with surveillance programmes in 105 countries.

Chapter I

Antibiotic Resistance

In 1966, an editorial written in the New England Journal of Medicine noted that due to non-specific routine use of antibiotics the value of antimicrobial use in prevention will eventually be lost to us (NEJMed, 1966). The editorial emphasised a growing concern in the increasing difficulty and delays in healing infections from burns, wounds, site of operation, and systemic sepsis after surgery in hospitals. The cause of this resistance is tracked to a myriad of problems regarding overuse, underuse, and misuse resulting in what has come to be considered as 'an evolutionary arms race' (another militaristic term) (Veterinary Record, 2013) (Ragheb, et al., 2019). Therefore, in a very Darwinian sense the logic of evolution is operating in an alarming way (from an anthropocentric perspective), altering disease causing organism to overcome antibiotics, considered the backbone of modern medicine. The fact is, that when antibiotics fail so will the conveniences of surgeries, chemoprophylaxis, and modern medicine in general (Furness, 2012) (Sheth, 2016) (Wiffen, 2018). For this reason, we are asked to become 'stewards'[8] of this precious commodity (Edward J. Septimus, 2011) (Bartlett, 2011) (Shira Doron, 2011) (WHO F. O., Global Framework for Development & Stewardship to Combat Antimicrobial Resistance: Draft Roadmap, 2017), to use it judiciously and appropriately.

That having been said, it should be mentioned that antibiotic resistant bacteria have always been present in nature. However, development of resistant mechanisms to medically important antibiotics through selective pressures from human and animal applications are what is of concern to the health community. (Davies & Davies, Origins and Evolution of Antibiotic Resistance, 2010). Its potential to complicate future epidemics and other secondary infections (MacIntyre & Bui, 2017) is why antibiotic resistance is considered to be one of the biggest threats to global health and food security.

Nevertheless, as stated earlier bacteria resistant to toxins occur unsurprisingly in nature (Martínez, 2008) (Aminov, 2009) (Heather K. Allen, 2010) (D'Costa, et al., 2011), and has been a long-standing problem. For instance, bacterial resistance to Salvarsan[9] even predates

[8] By stewardship they mean: to "preserve antimicrobial medicines by taking measures to promote control, appropriate distribution as well as appropriate use" (WHO, 2017, p. 4). But here again practitioners do not agree as to what is the right way to use this scarce resource in order to prevent bacteria from developing resistance.
[9]Arsphenamine an arsenic based compound, also known as Salvarsan was introduced at the beginning of the 1910s as the first effective treatment for syphilis, later replaced by penicillin.

the discovery of Penicillin by Alexander Fleming (Silberstein, 1923), and penicillin resistance genes have been found to have existed before Fleming ever discovered penicillin (Kashuba, et al., 2017)[10]. But it is the rate at which previously non-resistant bacteria are evolving to become resistant due to anthropogenic activities that is concerning (Tripathi & Cytryn, 2017) (Zhu, et al., 2017) (Pruden, Arabi, & Storteboom, 2012) (Rita L. Finley, 2013). Among which, the use of antibiotics in agriculture is one of the greatest contributors to the development of antibiotic resistance. However, there are no simple answer as to how infectious agents build resistance as there are a range of biochemical and physiological mechanisms which may be responsible (Davies & Davies, 2010). What is clear from the existing literature is the extent of use in industrial food production and the threat it presents to antibiotic susceptibility.

A high-profile review commissioned by the United Kingdom government compiled by Lord Jim O'Neill and his team, props up in many journal articles on the subject. It provides us with a shocking revelation of the human costs that are involved in AMR crisis. The review titled, "*Antimicrobial Resistance: Tackling a crisis for the health and wealth of nations*" (the AMR Review) (O'Neill, Review on Antimicrobial Resistance Antimicrobial Resistance: Tackling a crisis for the health and wealth of nations, 2014) estimated that deaths attributable to AMR compounds to 700,000 each year, and by 2050 this number would rise to 10 million deaths each year (*ibid.* p.4). What the review emphasises for, through the numbers and its somewhat debatable title, is the fact that action is required urgently. This has been the chorus call by most clinicians and researchers since the inception of antibiotics. However, almost 80 years after the widespread use of penicillin in the Second World War, and further a century's knowledge of bacteria's propensity for developing resistance, we are supposedly in a more precarious position than ever before.

Reflecting on this situation, a term that has taken over the imagination of the popular press, and social media outlets is that of 'super-bugs' and the 'post-antibiotic' era. It is a term used to describe drug-resistant microbes (bacterial, fungal, viral, parasitic), the therapeutic options for which are very limited, accompanied by extended hospitalisation and therefore increased cost to the patient (Davies & Davies, 2010). Nevertheless, metaphors describing antibiotic resistance describe are very bleak and ominous future (Brown & Nettleton, 2016), often signalling the end of modern medicine and apocalyptic interpretations of the 'post-antibiotic'.

[10]The study by Elena Kashuba, et al (2017) found that isolated ancient bacteria strains of Staphylococcus hominis species unearthed from permafrost had a close relation to modern bacteria of the staphylococci species which had genes that were resistant to different groups of antibiotics (beta-lactams being one of them).

A report by The Infectious Disease Society of America (IDSA), '*Faces of Antimicrobial Resistance'* (Infectious Disease Society of America, 2018) highlights narratives to demonstrate what the post-antibiotic may look like. One of the stories is of a woman whose root canal procedure resulted in a *C. Diff.* infection, despite being under antibiotics she went into septic shock and died soon after. Another was of a fifteen-month-old baby who died within 24 hours of an undiagnosed *MRSA* infection. Such stories are reminiscent of a time before antibiotics. Hence, the concept of risk - which populations are more susceptible? The risk of developing an antibiotic resistant infection was largely a problem associated with health care settings, like hospitals, rather than acquired from the community (Larson, 2007). But more cases are being identified from the community in the past decade (*ibid.*), an explanation for which could be because we are actively looking more into this epidemic. Nonetheless, ecological contamination by antibiotics continues to be a major cause of bacteria developing resistance. Individual use of antibiotics as medicines, ointments, cleaning products, etc. is significant, but the largest users of antibiotics continue to be for agriculture use (Silbergeld EK, 2008).

Hence, the problem presents itself as a structural one, one that is ingrained into the fabric of the prevailing political economy of food production and healthcare; especially concerning in low and middle-income countries. Herein lies the complexities associated with the use of antibiotics and other antimicrobials. This fact is made further evident from the array of stakeholders who are involved in mitigating this crisis. Traditionally, interdisciplinary efforts to mitigate AMR have involved public health, human and veterinary medicine, agriculture stakeholders, and policy makers. However, in most countries these sectors do not present themselves in organised silos but involve actors and organisations that fall into informal or semi-formal sectors, which can be considered as non-traditional stakeholders. Furthermore, non-traditional use antibiotics extends to the production of ethanol, horticulture produce, antifouling paints, food preservation, beauty products, and animal feeds. Therefore, the extent of antibiotic misuse is not limited to individuals and a few industries, but is a product of a system that failed to limit the complex interaction between humans, technology and nature in the pursuit of economic gain.

1.1 Tragedy of the Commons

In early 19th century, British economist, William Forster Lloyd illustrated a hypothetical to argue that human beings are selfish and given a shred resource people would act in their own self-interest. This was an answer to the question he asked regarding why the cattle grazing in the commons were comparatively smaller and stunted. Also, why the commons in itself were 'bare-worn' compared to adjoining privately owned enclosures. Hence, using the example of cattle herdsman he forwarded an economic problem of overconsumption, underinvestment, and depletion of a common pool resource. Made popular by the ecology movement, the commons came to extend to the larger ecology, the earth as a whole being over exploited for human greed.

The commons argument, used in the case of antibiotics, propose the problem as an overexploitation of antibiotics leading to its subsequent inefficacy resulting in catastrophic consequences for all. Antibiotics as a 'commodity' has been sold as a medicine, with an attribute of profit making and business attached to it. As a product of the market, it is subject to market pressures, and considering that business abandons unprofitable products antibiotics were no different. Its inherent quality made them unprofitable for Big Pharma, low prices supplemented by low volume of sales (Plackett, 2020).

As government funded research in the US increasingly resulted in private patents, public interests were replaced by private industry interests[11]. Furthermore, with private players increasingly interested in the 'knowledge economy', many of which can financially compete with governments, it has led to a slow decline of funding in research for public benefit. The argument is that government funded research, whose research were dedicated to the public domain through government ownership, were a "treacherous quicksand pit in which discoveries sink beyond reach of the private sector" (Eisenberg, 1996. p. 1664). Hence, to save government funded research discoveries from obscurity it was argues that they should be developed into commercial products by offering patents for private appropriation.

The repercussions of which is private funding, and increasing commercialisation. Hence, new knowledge which could otherwise be used for the betterment of the society (Washburn, 2007) becomes a privatised judgement of maximising returns on investments. Considering the fact that a 2017 study estimate puts the cost of developing a new antibiotic at around 1.5 billion USD (Towse et al., 2017). Meanwhile, industry analysts estimate that the average revenue

[11] As an aside, it must be noted that it is important to discuss drug development from a US perspective as the top antibiotic producers are all companies headquartered in America. Pfizer, Merck& Co., Johson & Johnson, Abbott Labs, Eli Lilly & Co. And increasingly many more biotech companies are setting up offices in the New Jersey area due to the proximity from the FDA office. As Katherine Eban explores in her book '*Bottle of Lies'*, the first-to-the-post awarding of patent filing for drugs at the FDA encouraged the proximity of pharma business in the area. FDA approvals are coveted as they are considered a premier institute in the regulation and supervision of food safety, dietary supplements, tobacco products, over-the-counter and prescription animal and human medications, vaccines, medical devices, etc.

generated from an antibiotic's sale is roughly $45 million per year, which from a business perspective is nowhere near the amount needed to justify the investment.

The above illustration can be quintessentially understood as a perfect criticism of the theory of tragedy of commons. The problem with simple stories for complex realities is this, while alluring and logical at first, the idea that the corruption of the commons is to be blamed on the selfish nature of people should be situated in context. Storytelling has been, and remains, a great tool for engaging and teaching the community

The situation presently is such that public interests are in friction with industry interests, and with the blurring of lines between academia and industry the problem has become more critical. This distortion of previously set outlines between academia and industry is said to have developed with the rise of biotechnology and the passage of the Bayh-Dole Act in 1980 (ibid.). Which is said to have been critical for the support and growth of the transfer of technology from publicly funded research in universities to private industry (Boettiger & Bennett, 2006). One of the criticisms to this is the fact that patents applied are at most times influenced by commercial gains, and access to publicly funded technologies are prevented.

The situation is one of a misinterpreted adoption of the philosophy of objectivism, embodied in the personification of companies as individuals advocating self-interest. Viewed in the backdrop of the transformative opinion of healthcare, as espoused at Alma Ata, the idea of health has watered down to become an opportunity for profitable gains. Aided by the liberalist policies of the 1970s, the desire for economic growth preceded the need for social development. The Alma Ata spirit descended into oblivion, having been situated in a decade where the Keynesian economics of the 1930s gave way to the Thatcherite and Reganomic policies of reduced government spending and increased unrestricted free-market activity. The market had also pervaded into healthcare, transforming health into a commodity to be provided to those who can afford it. The synthetic biology community in this aspect has been developing concept and models of microorganic systems for environmental, industry, and medical purposes with an ideology of openness to some degree. It is anticipated that such strides could lead to a new movement in innovative creation and discovery. Such that it could take up the challenge of filling in many aspects of preventive, palliative and rehabilitative care, however, at a far more accessible, farther-reaching, quality grounded care. Especially new studies that shine a light on the intimate relationship between humans and microbes in various habitats in the human body and environment, and the necessity of these microbes for the maintenance of human health.

1.2 The Human Microbiome

One such ecological understanding seems almost augmented with increasing research on antibiotic resistance has been the microbiome studies. It moves away from the decades spent on vilifying bacteria. Under the predominant ‘germ theory’ paradigm, bacteria had become synonymous with disease and filth, taking the sanitary movement closer to sterility and asepticism. However, microbiome studies attempt to change this prevailing narrative as bacteria have been found to be beneficial, at times even essential, for human nutrition, health and immune development. While some are considered harmful to humans it must be contextualised that bacteria live on, around, and within us. There is an equilibrium that maintained between different bacteria in our bodies, which under the right environment ensures that the body remains healthy and accrues other benefits as well. Such post-Pasteurian (Paxson, 2008) ideas are becoming more recognised and has fostered research and discussion on the microbiome. The fact that we have about the same number of bacteria in the human body as there are human cells (Sender, Fuchs, & Milo, 2016) evoke questions regarding if we are more human or bacteria. Such concepts and research on the human microbiome and microbiota have made us reinterpret our relationship with bacteria. There are also studies which suggest that the disruption of this ecology, by the use of antibiotics, in early age leads to the development of obesity and allergy later on in life (Ahmadizar, et al., 2016) (Hirsch, J. Pollak, L. Bailey-Davis, & Schwartz, 2017).

The microbiota is a collective terminology for describing the vast number of microbes which colonise our body[12]. It is, in a sense, a symbiotic relation in which both organisms benefit in some way or the other. Some scientists understand this relation in an extreme sense wherein they suggest that the human body is in fact a collection of human and microbial cells and genes (Rogers, 2011) (Zhao L. , The Tale of our other Genome, 2010) which blend together to make a “superorganism”. This human superorganism is a paradigmatic shift in understanding the human body which transcends beyond “the traditional limitations of our own flesh and blood to include our resident microbial communities” (Sleator, 2010, p. 215). This concept also advocates the notion that the microbiota acts as a virtual organ (Holmes, Li, Marcheci, & Nicholson, 2012) (T.F.O'Callaghan, R.P.Ross, C.Stanton, & G.Clarke, 2016) (American Society for Microbiology, 2011). Which due to the characteristic ability of the microbiota to “function as a collective to influence other organs within the host and, in turn,

[12] The microbiome often refers to the collection of genes contained within a community of microbes, while the term microbiota is used to refer to the organisms themselves, however, the terms are generally used interchangeably. In this sense, the human microbiome consists of the trillions of organisms harboured by each person, a vast majority of which is in the guts.

to be responsive to the secretions of other host organs" manifests itself as an organ ((Lyte, 2010) as cited in (Clarke, et al., 2014, p. 1222)).

This finding is a major contribution to the ecological theory, which has also been used to understand the human-microbial ecosystem and its role in human health and disease (Elizabeth K. Costello, 2012). Such studies are based on the 'human microbiome hypothesis' (Strachan D. P., 2014), which proposes that humans are an ecosystem by ourselves, and studies on the microbiome suggests that our intestines contain an order of magnitude more than the number of bacteria anywhere else on the body (Sender, Fuchs, & Milo, 2016). Hence, the hypothesis arose that the consumption of antibiotics and the subsequent disruption of the gut microflora may have unintended health consequences (Hunter, 2012) (Yoon, 2018). Basically, bacteria help educate the immune system, and the diversity of bacteria in our guts protects us by discouraging the colonization by few pathogenic bacteria, they also synthesize food (microbial digestion), etc. These conclusions compliment the 'Hygiene hypothesis'[13] which states that a lower incidence of infection in early childhood could be an explanation for the rise in atopic diseases in the 20th century (Strachan D. P., 1989).

The microbiome is an important aspect to consider while discussing antibiotics as it destroys long held notions and highlights our relationship with bacteria to make us rethink about traditional ideas of health and disease. On the other hand, the microbiome is also known to be an 'amplifier of AMR' (Shahi, Redeker, & Chong, 2019) for two reasons: firstly, because of the inability of commonly prescribed antimicrobials to precisely target specific microbial species resulting in decreased bacterial diversity and increasing the potential to cause an overgrowth of resistant bacteria (*ibid.*). Secondly, the human gut microbiome's ability to act as a transporter of Antibiotic Resistance genes (Bengtsson-Palme, et al., 2015)[14].

The study on the effects of antibiotics on the microbiome will remain significant as global antibiotic therapy paradigm continue to favour the administration of antibiotics orally. While the human microbiome constitutes an important aspect of antibiotic resistant research, the larger global-public health issue with antibiotic use revolves around the unregulated use of antibiotics in livestock farming, its use in plant agriculture has not been as significantly

[13] The "Hygiene Hypothesis" is a theory that suggests that an environment can be "too clean", which denies the immune system the opportunity to be effectively stimulated or challenged during the child's maturation, thereby unable to respond to threats later on in life and leading to autoimmune and allergic diseases (Okada, .Kuhn, Feillet, & Bach, 2010).

[14] In 2010 – 2013 a study was conducted wherein 35 Swedish Students returning from exchange programs in Central Africa or the Indian peninsula showed increased abundance of genes encoding resistance to widely used antibiotics.

covered, especially in India. As larger amounts of antibiotics come to be used in agriculture the selective pressures leading to antibiotic resistant bacteria developing in the guts of animals become critical discussion points. As reflected in studies which show resistant to antibiotics could be exchanged between taxonomically diverse bacteria (Barlow, 2009)(also known as '*horizontal transfer*') through the exchange of DNA (Domingues, Nielsen, & Silva, 2012). This fact becomes very pertinent as resistance which develops through sustained antibiotic use in livestock or plant agriculture could breach the species barrier (Chang, Wang, Regev-Yochay, Lipsitch, & Hanage, 2014). As antibiotics used in agriculture are excreted through urine and stool into the environment, and further dispersed through animal fertilizer, ground waters, vectors and surface runoff our exposure to resistant bacteria becomes that much more probable (Smith, Harris, Johnson, Silbergeld, & Jr., Animal antibiotic use has an early but important impact on the emergence of antibiotic resistance in human commensal bacteria, 2002).

However, the current discourse on antibiotic resistance tend to simplify the problem by revolving discussions around prescription practices, behaviour modulation and its relation to inappropriate use, investments in drug discovery and drug development. These are important avenue to consider but does not appreciate the full extent of the problem. In surveying these very different accounts on AMR we find different futures being constructed in our relation with the microbial world (Brown & Nettleton, 2016). This ecological understanding of our relationship with the microbial world has important implications for both public health and the development of strategies and measures for managing drug resistance. Antibiotics are a crucial tool in order to restore an ecological equilibrium between the microcosm that inhabits our bodies, but increasing use has increased the frequency of antibiotic-resistant bacteria and antibiotic resistance mechanisms in the environment.

1.3 Antibiotic Pollution vs Public Health (One Health Considerations)

Pollution from to antibiotic use, disposal, untreated effluents from pharma companies and its proliferation in the environment, is thought to be leading to increasing susceptibility of catching resistant infections, or reducing the efficacy of existing antibiotics for prevalent bacterial diseases. The scale of antibiotic use has led to unprecedented levels of anthropogenic pressures changing the ecology of the environment. For instance, antibiotic pollution in India has been isolated from major rivers, lakes, tube-wells, hand-pumps, etc., (Azam et al., 2016) (Akiba et al., 2015) (Poonia et al., 2014) in China antibiotics were even found in residents' tap water in the Provinces of Nanjing and Jiangsu (Huang et al., 2015).

Furthermore, despite a plethora of research dating back to the 1950s on the harms of antibiotic pollution and warnings by public health experts in India, the Union Ministry of Environment, Forest and Climate Change on August 16th 2021, removed all limits which specify the discharge of antibiotic effluents and residue (see: Environment (Protection) Second Amendment Rules, 2021). Instead, the amendment to the Environment (Protection) Rules of 1986, provide for all antibiotic effluent to be classified as a hazardous waste but without any explicit capping. This goes against the caps put in place by the Union Government in January 2020, for 121 types of antibiotic residue in pharma effluents. It is thought that such a decision was taken as India is trying to wean away from dependence on Chinese pharmaceutical active ingredients capping would discourage innovation as result in higher cost of operations for companies producing pharma products (Vishnoi, 2021).

The short-term economic competition in comparison to the eventual environmental pollution would be economically very expensive, as infection become more difficult to treat hospitalisations and bed times will increase. Environment pollution by antibiotics poses a grave threat for public health, especially in LMICs where infectious diseases are still very prominent, access to quality healthcare is limited, and where public works are lacking. In the Social lives of medicine, the authors discuss the life cycle of medicines as they are created and dispensed to people. The new meanings medicine incorporates as they are used and valued differently by different people, however, they do not discuss the what after.

As unused antibiotics are often shared with others or disposed, however, the individual harm pales in comparison to industry pollution. The Osman Sagar Lake near the city of Hyderabad, India, has become the dumping ground for the discharges from the Medak industrial zone, the heart of India's antibiotic manufacturing industry (Siddiqui, 2016). However, there is a lack of research and data on the nation-wide extent of ABR in India. Antibiotic pollution through human activity includes plant and animal agriculture, improper disposal of unused antibiotics, hospital sewage disposal, through human excrement, but pollution from antibiotic manufacturing contributes to considerably stronger concentrations of antibiotic resistant genes in the environment (Larsson & Flach, 2021).

Presently, all approved antibiotic classes so far, that is, natural, semi-synthetic or synthetic compounds, have been met by resistance in at least some of the pathogens they target. This suggests that external environments already harbour resistance factors for all antibiotics that will ever be developed, nevertheless, there has not been any study with evidence of a direct transmission of resistant bacteria to humans from environmental exposure (Huijbers et al., 2015). A more recent study showed a similar finding, but highlighted a gap in the research, wherein, infections caused due to exposure to antibiotic polluted environments remain unresearched (Stanton et al., 2022). However, the most researched mode of transmission of resistant infection from the environment to humans was through consumption and ingestion of contaminated foods.

That being said, a more concerning effect of antibiotic pollution could be its impact on the soil ecology – resulting in reduced biomass, impacting plant germination, yield, and potential ecotoxic effects on plant functions. Nevertheless, recent work has investigated a range of pristine, non-human impacted environments, from permafrost soils to caves, to determine the human-independent extent of antibiotic resistance Hence, given the complex ecological role that antibiotics likely play in microbial ecosystems, it is not surprising that antibiotic resistance is in fact an ancient phenomenon. As a rule, resistance genes are readily found in such environments and have informed our understanding of the 'natural' resistance state of microbial ecosystems. But from a public health point of view, pathogens carrying resistance genes against multiple classes of antibiotics, often referred to as 'superbugs', are of special interest. Especially considering their presence in supposedly sterile places of medical care.

1.4 Hospital environments:

Of the numerous environmental hotspots of special interests for antibiotic resistance, such as -water treatment facilities, pharmaceutical manufacturing wastes, concentrated feeding operations, and other such antibiotic intensive areas - resistant 'bugs' in hospitals are one of the foremost concerns for human health. Hospital environments and other extended care facilities are of high interest due to the extensive use of antibiotics, dispatching of invasive treatments and procedures, and the presence of highly resistant bacteria only heightens the risk to most modern medical procedures and treatments.

Nosocomial infections, or hospital-acquired infections are a particularly burdensome problem, and a high indicator for increased mortality or extended length of hospitalisation (morbidity). Of the various pathogens MRSA (Methicillin-resistant Staphylococcus aureus) is the most commonly identified among patients in hospitals. Mostly considered to be a hospital acquired (HA) pathogen, there have been some cases of community acquired strains as well. The other common antibiotic resistant organisms in hospitals are Clostridium difficile (C.

diff), Vancomycin-resistant Enterococcus, and multidrug resistant gram-negative bacilli (Mehrad et al., 2015; Mulvey & Simor, 2009; Struelens, 1998).

Hospitals, which are antibiotic-rich environments, allows for bacteria to selectively mutate and cross colonise from one patient to another. A driving force for which is the widespread use of antibiotics as treatment or as a prophylactic, additionally, use of broad-spectrum antibiotics as compared to narrow-spectrum monotherapy favours selection of resistance in certain infections.(Struelens, 1998). Furthermore, inappropriate disposal of hospital waste allows for the proliferation of resistant bacteria in the environment as well, especially untreated sewage. That being said, studies on hospital waste water have shown that antibiotic-resistant-genes could not be completely removed by on-site treatment (Zhang et al., 2020). Generally, membrane bioreactors (MBR), which is a combination of a suspended growth biological treatment and size-exclusion membrane filtration, plays an important role in removing ARGs, but its effectiveness on ARG removal is still limited (Zhang et al., 2020). In countries and medical institutions with no filtration the effects would only be more serious, studies from low-income countries show a significant abundance of resistant genes in hospital wastewater. The risks to human health present itself when wastewater from hospitals is released into river systems, leaked into ground water sources, or tainted water used for the irrigation of crop fields (Markkanen et al., 2022).

Hospital acquired infections are considerably more serious keeping in mind the population of patients who are either immune compromised, recently operated, require insertion of life-saving devices (ventilators, vascular lines, GI tubes, urinary catheters), and the possible transfer to the community. Considering that resistance is a fact of evolutionary biology the only way to tackle this issue is to improve sanitation and hygiene practices of the institution, reduce broad-spectrum treatments, reduce prescription of antibiotics, and invest in the development of new antibiotics. Most of the above come under the hospital antibiotic stewardship model, which has been an advocated method for reducing overuse and misuse in hospitals.

1.5 Concentrated Feeding Operations:

Not to belabour this point, but the industrialisation of livestock production and the widespread use of antibiotics for non-therapeutic purposes have intensified the risk of contracting resistant organisms. Refuse from these animals are generally loaded with antibiotic residues, which when multiplied to a whole livestock operation amplifies the chances of farmers contracting infections, animals themselves contracting infection, and the transfer of microorganisms through improper waste disposal, pollution of local water bodies, channels and ground water, and in many cases through contaminated meat. In 2019, a study from Mumbai, India, showed that samples collected (chicken liver and eggs) from 12 different location within Mumbai were found to contain multi-resistant bacteria. A bacteria isolate of which was resistant to all of the 12 antibiotics it was tested on (Amoxicillin, azithromycin, ciprofloxacin, ceftriaxone, chloramphenicol, erythromycin, gentamicin, levofloxacin, nitrofurantoin and tetracycline.) (Bandyopadhyay et al., 2019). Of the twelve antibiotics azithromycin and erythromycin are a macrolide class[15] of antibiotics which the World Health Organization had listed as an antibiotic of critical importance and of the highest priority.

While use of antibiotics can be eliminated by improving animal welfare systems[16], the practice is generally considered labour and capital intensive, which then impacts the price of meat. The following domino effect of transferring the cost onto the customers are a potential risk for producers whose competition may otherwise be using antibiotics to fulfil the minimum requirements. The possibility of infection from animal contact are more considering our intake of meat bought from supermarkets, butchers, and wet markets. Wet markets are of a special concern, considering the fresh culling of animals, the maintenance of the contact surfaces, and also the untreated wastes from such operations. A study from Hong Kong found that wooden cutting boards harboured microbial species typically associated with hospital nosocomial infections, such as Klebsiella pneumoniae (Lo et al., 2019).

Animal waste which is commonly used as a fertiliser, if used untreated, can also lead to contamination of plant agriculture. Considered as 'the external costs of CAFOs', concentrated feeding operations and its establishment mostly in rural areas put their communities at higher risks. Rural communities are farming communities, their contact with animals, crops, and the fertilisers, pesticides, and other chemicals required for farming activities are greater. Additionally, CAFOs and their location in rural communities expose

[15] Macrolides work as a bacteriostatic, mainly through inhibiting with a broad spectrum of activity against many gram-positive bacteria, but depending upon their ring structure they are either considered either critically important or not as important.

[15] Animal welfare is a holistic concept that emphasizes the importance of the overall condition of the animals, from physical to the mental health of the animals. It is based on the overall criteria of improved nutrition, environment, behaviour, and therefore health of the animal.

them to higher levels of air pollution from harmful gases emanating from the animals. Therefore, in studies it has been shown that respiratory illnesses are common among workers in CAFOs. Also, that the adverse effects (water pollution, air pollution (ammonia, hydrogen-sulphide, particulate matter, and endotoxins)) of CAFOs are still significant more than five kilometres from the site, and the bigger the operation the more the severity (Gurian-Sherman, 2008).

Pollution through wastewater irrigation or manure fertilisation results in ingestion or uptake by crops and other plants which led to the translocation of antibiotics in the plants (mostly following the path of transpiration higher concentrations were found in leaves) at levels much lower than the acceptable daily intake (Pan & Chu, 2017). Ingestion of antibiotics below the minimum inhibition concentrations (MIC)[17] may select for resistance and cause imbalance in the gut microbiome. Hence, the air, water, and the soil are vectors of resistant infection for the rural populations involved in animal care or living near high density animal operations, or crops, fruit production requiring antibiotics. Another source of infection is the groundwater, which generally is a major source for water used in rural homes, untreated and exposed to seepage these sources are major vectors (Chakraborti et al., 2011).

Indian poultry farms are equally responsible for the polluting the environment – most concerning of which is pollution of air with poultry dust containing bacteria and bacterial toxins. Furthermore, studies from rich industrialised countries show that use of chicken litter as a cheap fertiliser substitute is hazardous as bacterial, protozoan, viral and fungal contaminants in them make them a potential health hazard (Kyakuwaire et al., 2019). In India, the Central Pollution Control Board's environmental guidelines for poultry farms (2021) mentions 'antibiotics' only two times, once in reference to poultry feed and the other on antibiotic use.

In Haryana, India, unlicensed versions of ciprofloxacin are easily available without any labels at the veterinary medicine outlets, imported from China medicine suppliers in Haryana are also known to source this ciprofloxacin from wholesale drug markets in Delhi. Furthermore, feed mixed with antibiotic growth promoters do not need prescription, and veterinarian

[17] Dr./Prof. Yogendra Kumar Gupta, renowned pharmacologist and Principal Strategy Advisor for Global Antibiotics Research Development and Partnership (GARDP), in a seminar on poultry and antibiotic resistance, stated that this concept is now changing to consider Mutant prevention concentration (MPC) instead of Minimum Inhibitory Concentration. (One Health Poultry Hub roadmap series Webinar on Poultry and Antibiotic Resistance)

services are sought in these operations only when cases of high-mortality are observed (CSE, 2014). Another lab study conducted by the Centre of Science and Environment in 2017 sampled 12 poultry farms in four different States of India – Haryana, Uttar Pradesh, Rajasthan and Punjab. The study, whose objective was to understand the extent of antibiotic resistance in the poultry environment and then establish movement of resistant bacteria into the environment through waste disposal, found that antibiotics were used in all farms (Tripathi et al., 2017). They also concluded that high multidrug resistance was found in the poultry environment and the nearby agricultural soil as well (*ibid.* p. 22).

Large industrial animal rearing operations have many supplementary industries as well, from feed production, medicine and veterinary care, animal transport, slaughter houses, and the final processing for consumers. While exposure to pathogens in this industry is inevitable, studies have shown that workers in this industry have been exposed to new strains of old pathogens, in so doing modifying the risk to these workers (Neyra et al., 2012). Largely, antibiotic-resistant infections of farm and slaughter-house workers has remained an unrecognised work-related environmental risk. Pathogen exposure through inhalation, ingestion, dermal contact may cause acute illness and propagate the spread of antibiotic-resistant pathogens to immediate family or the community (*ibid.*).

Hence, in these ways antibiotic pollution is a hinderance to public health efforts and becomes a magnifier of morbidity and mortality. However, an important question is whether we can transition from antibiotic-dependence in agriculture? Whether alternative methods can be as productive at such cheap production costs? Organic farming and farming that involves animal welfare practices are labour-intensive which makes them cost more at the shelf. While we will explore these questions more in the discussion section it is crucial to understand the cost-cutting function that antibiotic use provides, when expert opinion (veterinarian or doctor consult) is removed from the equation antibiotic use becomes even cheaper. Hence, to understand this relation between food production and how antibiotics became a surety for industrial food production, we need to delve deeper into the mechanisms of modern farming.

Chapter II

Wicked Problems:
How the political economy of antibiotics fits into this framework

The span of stakeholders that constitute the antibiotic resistance problem are broad, ranging from doctors and scientists to patients, public health officials, farmers, to retail sellers. It speaks to the immense complexity of the issue, and the difficulty in addressing it. This is due in part to the scale of the problem, and in part to the involvement of many different players with varying interests and agendas. Which, along with the involvement of the organisational complexity of the healthcare industry and institutions, have to incorporate the complexity of the agricultural supply chains. These factors make it difficult to establish a shared understanding of the nature of the problem and to develop strategies to address it.

This complexity is further highlighted when we consider that the problem spans from the microscopic to the macrosocial. It encompasses the interactions among bacteria, among individuals, among industry and government, and finally the interactions between each of these components. This complex web of interactions reacts and changes like a continuous feedback loop that is further made unique according to geography and the social-political-economic environment. The result is that no single actor can unilaterally determine an effective strategy for addressing the antibiotic resistance problem. However, antibiotic resistance can be seen to have historically proliferated due to commercial interests of the pharmaceutical and the agricultural industry. This points to a greater role of social, economic and health system constraints despite the literature on ABR having a huge behavioural component (Haenssgen et al., 2018).

Hence, given the many challenges associated with the antibiotic resistance problem, a conceptual framework must similarly account for the numerous dimensions to serve as a guide for actors to understand the extent of the problem as they attempt to address it. The first step in confronting a complex problem is to define its key dimensions and identify the main sources of its complexity. For instance, most social science research relies heavily on the knowledge produced by the natural sciences and medicine on AMR, thereafter, the definitions of the problem emphasise on interdisciplinarity. Hence, there is no cohesive discourse on the subject while the scale and complexity of AMR demand cohesive and targeted inter-departmental and inter-governmental cooperation. Mostly due to the interconnectivity of issues and the integration of global trade systems.

2.1 Social Science Dimensions of ABR

In 2014, the UK Economic and Social Research Council proposed that 'social science can contribute to the measurement, modelling and understanding of antimicrobial resistance and its geographical and social distribution, and to the development and evaluation of strategies to mitigate it' (SESRC Working Group, July 2014, p.1). This however is a thin and peripheral engagement of social science, one that is dictated by the overshadowing natural and medical sciences (Frid-Nielsen et al., 2019). Nevertheless, since the problem of antibiotic use has been verbalized to be a human condition, one that is dictated by human habits, expectations, and conduct; the field of antibiotic resistance is primed for social science research. Despite this fact, social anthropological and economic studies remain limited despite academic and practical demand for it (*ibid.*).

Thereby, situating the problem within a broader social, historical, and economic context is at times missing in lieu of descriptive and policy dimensions. The WHO Global Action Plan on Antimicrobial Resistance acknowledges that AMR is a complex issue and calls for a systems approach to address the problem, however, social science dimensions are engaged mainly for the purposes of messaging to the community while a 'dominant role reserved for the behavioural sciences' (Hofstraat et al., 2021). A field of science often criticised for being reductive and failing to account for social, historical, political and structural factors; producing results that more heterogenous than might be apparent (IJzerman et al., 2020).

Systematic reviews on antimicrobial resistance research in social science fields further show that other than policy and institutional research, there has been a considerable contribution of social sciences to the domains of surveillance and risk assessment (Frid-Nielsen et al., 2019; Lu et al., 2020). However, "most social science research on AMR is currently subsumed in public health or medical journals…", which "risks never being exposed to and engaging with core social science debates and scholarship." (Frid-Nielsen et al., 2019. p. 9). Such steps are considered necessary as the sustainable success of solutions depend on exploring the drivers of antimicrobial resistance. (Minssen et al., 2020).

A majority of the articles on antibiotic resistance highlight socio-economic issues such over-the-counter use, access to healthcare, increased expenditure on treatment, education and awareness, etc. (Murray et al., 2022) (WHO, 2019) (Tillotson, 2016) (Lee et al., 2013) (Levy & Bonnie, 2004) (Franco et al., 2009) while overlooking the undercurrents of structure and systems under which they prevail. In fact, the foundations of modern public health were founded and accounted for such concepts prior to the present reductionist biomedical paradigm of healthcare.

2.2 Political Economy of Antibiotics

Therefore, such an interdisciplinary topic equally requires a framework that assimilates concepts and methods of different social science disciplines. In this way, the political economic framework shares similarities to the ecological model, which generally is considered as an all-inclusive concrete framework to account for the reciprocal interaction of behaviour and environment. For instance, as Harvard ecologist Richard Levins insisted in his article "Is Capitalism a Disease?" that, with any major change in the way of life of a population (such as population density, patterns of residence, means of production), there will also be a change in our relations with pathogens, their reservoirs, and with the vectors of disease" (Levins, 2000). Engels viewed ill-health as a by-product of capitalism, which he viewed as exploitative but also a consequence of the social relations of production (Sell & Williams, 2019)**.**

The political economy model describes five levels of influence on behaviour: individual, interpersonal, organizational, community and policy. It borrows from sociology, economics, as well as political sciences to understand multidimensional processes in society and provide an integrative analysis of the same. Thereby, in phrasing antibiotics under a political economic framework – a commodity of capitalism: 'antibiotics', are transformed into an assay of commercial relationships, and as a relationship of substitutes and complements "that interacts with health at multiple scales and via a range of 'vectors' that must be engaged, examined and understood" (Sell & Williams, 2019). The policy and economic dimensions of health are inexorably linked to the corporate appropriation of science and technology as a means to increase profits, which in turn has provided increasing evidences for connecting to the daily life experiences of individuals and communities. Furthermore, political cultures have been demonstrated to influence science and its technologies as a co-product of the context they are embedded in (Begemann et al., 2018).

For instance, in the East, we see a concept develop in the second half of the 19th century, wherein individual health and disease prevention were inexorably linked to the survival of the nation. Influenced by American and European government's attention and investment on health and public welfare the Meiji government of Japan drafted the National Medical code (1875). This provision would eventually become a foundational element for the development of the Japanese empire in the 20th century (Rogaski, 2004). Such collective ideas develop in the West among medieval and pre-modern societies, where, in the absence of cures, 'negative externalities' forced collective coping mechanisms of urban dwellers (Ewert, 2007). For instance, accumulation of organic rubbish, smells, and pollution of water in medieval European towns determined the opposite to be what the concept a quality of life should embrace. Furthermore, the bubonic plagues of the 14th century AD were a watershed moment for European city planning, sanitation, and hygiene, just as Cholera was for the 19th century. It inevitably established a "web of engineering, education, policing, and laboratories that linked the health of the individual to the health of the nation" (Rogaski, 2004. p.136). Limited mastery over disease at the times pushed for the augmentation of preventative measures; which involved the management of wastes and airs to control for pestilence and ill-health based on the medical and natural-philosophical theories prevalent at the time

Antibiotics have now become a pervasive part of our society as modern life continues to hang precariously between a confrontation of the microbial world and the world of human physiology. Considering the fact that it too was a product of politics having been discovered through public funding for a war economy, it found new utility as a commercial commodity during the subsequent peacetimes, and whose future has been hinged on providing further utility to pharmaceutical corporations. Big pharma, under the germ theory paradigm, capitalised on the fears of the public (and propagated through advertising) to push domestic hygiene products (Campbell & Deane, 2019) changing our relationship with bacteria. On the other hand, new utilities were discovered for antibiotics which provided alternative sources of revenue for pharma companies. ABR is not a unique problem, it fundamentally suffers from an incompatibility of motives and reality, in other words a problem of socialised costs in opposition to privatised profits. Which brings us to the question – why are antibiotics so difficult to regulate?

Antibiotic resistance as a Wicked problems

Antibiotics were introduced to the world as a public good when Alexander Fleming decided not to claim ownership of his discovery. Thereafter, pharmaceutical companies commoditized and created demand beyond actual need for it through commercial promotions. As the pharmaceutical companies went in search of new customers it rebranded, combined and regreened publicly funded discoveries and also found new markets. A 1982 Oxfam study found that intensive promotion by pharmaceutical manufacturers led directly to overprescribing and misuse of antibiotics becoming widespread in the global South. Thereafter, the World Health Organization attempted to regulate the behaviour of multinational corporations in developing countries to a limited accomplishment (Chorev, 2012). Mostly due to weak domestic regulations, lax procurement rules, insufficient inspection capacities, which allowed multinational companies to bypass any attempts made to regulate them.

Once introduced, antibiotics fill-in for key structural and institutional limitations exacerbated by a 'financialised capitalism' which has radically changed and shaped health outcomes, more critically in lower to middle income countries. Such themes are explored by Susan K. Sell under what she considers as "**structural pathogenesis**"(Sell & Williams, 2019)., which is an account of how the capitalistic political economy interacts and shapes global health at multiple levels "via a range of 'vectors'" (*ibid.,* p.2), that constitute intersections between socio-cultural, political-economic and institutional relationships. By association, the problems related with antibiotic use, therefore, is a response to the living conditions imposed upon by the dominant economic traditions. Behavioural literature on antibiotic use speaks to this notion as well; as macrosocial conditions of life such as time, money, and access remain central to the antibiotic-use argument. Burgeoning corporate control over policy and society through privatization, deregulation, shrinking states and freeing markets. Which have led to reduced responsibilities of the State for social protections and social needs in lieu of increased inequalities and poorer quality of life. Studies correlate this motif by identifying associations of neoliberalism with the production of contemporary social determinants of health vulnerabilities (Giroux, 2008; Brenner & Theodore, 2010; Irwin & Scali, 2010; Sakellariou & Rotarou, 2017; Schrecker, 2016; Sweet, 2018; Viens, 2019; Navarro, 2020).

Hence, antibiotic-use is not a problem but a symptom (physical manifestation) of conditions, a mere proxy for the true underlying causes. While potentially manageable at the individual level, health related behaviours resonate with a system of values and beliefs (Glass & McAtee, 2006) that enables us to "ignore the more difficult, but at least equally important, problem of the social environment which both creates some lifestyles and inhibits the initiation and/or maintenance of other" (Becker, 1993, p. 4) The social environment which encompasses proximal and distal constructs of the combined roles of society, economy, and biology (Yen & Syme, 1999). AMR manifests itself along these crossroads making it a complex problem requiring collaborations among multiple domains, sectors, and expertise for which the existing policy-making structures are inappropriate or insufficient. It points, therefore, to a tangled articulation of complexity and uncertainty that once defined as such may provide possible solutions that are more holistic and reforming than the current discourses on ABR policy objecctives.

The concept of wicked problems was developed in the context of social policy research (Rittel & Webber, 1973). The term was used by Rittel and Webber in contrast to what they described as "tame problems"; i.e., a benign problem that is solvable through stepwise techniques that could be used on multiple problems resulting in comparable effectiveness. By this logic, relativistically, most societal problems are one form of wicked problem or another. However, it can be argued that they exist on an array of complexity based on "cognitive complexity or the diversity and irreconcilability of the actors or institutions involved"(Alford & Head, 2017, p. 397). Thus, the concept of wicked problems, among other functions, provide an impression of 'scale' of the problem in order to inform the proportion of response required. Hence, such labels associated with ABR are important, as a descriptive, critical, as well as a sensitizing tool (Lönngren & van Poeck, 2020), equally, for providing a far more comprehensive understanding thereby informing better policy considerations. Furthermore, if another dimension of 'time' is considered, that is, the limited time available for this problem to be solved (drying antibiotic pipeline and increasing antibiotic resistance) then some consider this to be a 'super-wicked problem'(Conley et al., 2018).

Therefore, in merging the concepts of 'political economy'; which provides linkages, and 'wickedness'; that informs solvability it provides a greater understanding of antibiotics as infrastructure. An infrastructure contingent on a social and historical construct, composed of a network constituted of other elements, characteristically relational, and asymmetrically poised and managed (Danholt & Langstrup, 2012). Which brings to the fore the ubiquitous nature of antibiotics - as a structure on which other activities depend upon.

Solutions sought for through the collaborative approach under the 'One Health' concept can be understood to be a response to this wicked problem. However, the political economy of antibiotics informs us that the current overarching definition of the problem suffers from a lack of fundamental comprehension. Joseph Malins, a temperance activist and writer in the late 19^{th} century AD wrote a poem about what we can assume as - abstinence from alcohol consumption. It nonetheless informs us about the limitations of reductive reasonings which still holds relevance presently. Titled - "A Fence or an Ambulance" (1895), the poem speaks of a dangerous cliff from where many a person fell to their deaths, the towns people decided something was to be done about this. Some called for a fence around the edge of the cliff, while others called for an ambulance down in the valley:

“'For the cliff is all right, if you're careful, ' they said,

'and if folks even slip and are dropping,

it isn't the slipping that hurts them so much

as the shock down below when they're stopping.'”

And so, day after day more people fell off the cliff and the ambulance drove in and out to rescue the victims. That is until someone remarked:

“'…It's a marvel to me
that people give far more attention
to repairing results than to stopping the cause…”

As he rallied for the cause of the fence the majority of the townspeople shouted him down, calling him foolish. The poem ends with the poet stating:

“Attend to things rationally.

Yes, build up the fence and let us dispense

With the ambulance down in the valley.”

Intrinsically, public health spending does not seem to augment economic growth since it is essentially an expense. But the correspondence between the two has instead shown to be collective and circular (Malik & Bhattacharyya, 2019), i.e., in a very simplistic logical way, higher income begets better health, and healthy people earn more. This non-linearity, therefore, urges for the fence as well as the ambulance, but it also requires us to question why so many people continue to climb the cliff despite its dangers.

2.3 Conceptualisation

Given the above deliberations, the central argument of this thesis begins with the established proposition that the discovery of antibiotics allowed for humans to fight back against the invisible world of microorganisms effectively for the first time. It expedited recovery from diseases which were debilitating and lethal, and provided an alternative to, if not an end to, treatment by *heroic medicine*[18]of the middle-ages (Rosen, Miracle Cure: The Creation of Antibiotics and the Birth of Modern Medicine, 2017). In due time the properties of antibiotics were discovered to be valuable in agriculture production as well, ensuring food supply by protecting produce from bacterial diseases and acting as growth promoters, thereby preventing crop/livestock loss, ensuring food security while also promoting food safety. On the other end, it also meant that farmers became more dependent on antibiotics, hence it transformed became institutionalised as an implement, a tool of agriculture. Thereafter, increasing urbanisation has also led to a shift in the population from majority food-producer to majority food-consumer (Lançon, May, 2016) (Lusk, 2017). Urbanisation complemented by high growth in incomes have also resulted in increasing demands for high-value products like meat, fish, fruits, etc. (Delgado, Rosegrant, Steinfeld, Ehui, & Courbois, 1999).

Hence, increasing pressures on food have furthered the need for industrial farming which is considered to be the main driving force behind the increased use of antibiotics (Gustafson & Bowen, 1997) (Landers, 2012) (Manyi-Loh, Mamphweli, Meyer, & Okoh, 2018). Currently, in the EU and the US, over 75% of all antibiotics are used in agriculture (OECD, 2016), and in the BRICS countries antimicrobial consumption are projected to experience a 99% growth in by 2030, largely due to the continued expansion of factory farming (Boeckel, et al., 2015). This is significant as the development of molecular epidemiologic tools have since discovered that resistant bacteria originating on farms are finding their way into humans (Heilig, Lee, & Breslow, 2002). And of the many different pathways through which bacteria tend to develop resistance, antibiotics used in agriculture has been noted as one of the most significant reasons. But why is it that antibiotics are so profusely used in agriculture? In order to understand this, we must explore the histories of how, when and why antibiotics were found to be beneficial for the production of food; and why is it that we are still unable to phase out its use today.

Hence, the central argument of this research posits the view that antibiotics has become institutionalised in society as an '**infrastructure'** (Chandler C. I., 2019)**.** A prerequisite that

[18] History of medicine A popular term used to describe the draconian medical practices of the 18th-19th centuries that included bleeding, blistering, purging among other practices.

has facilitated in the delivery of high-yielding products, at a fraction of the cost, and has become a necessity for which there is no congruous substitute. Lastly, and most importantly, the prevailing narrative that attempts to tackle this issue is flawed, as it is based on the logic of 'liberal medicine', which produced the problem in the first place. Therefore, this thesis argues that antibiotics replaces time, labour, and capital; hence, its entanglement with socio-economic and political domains makes it a prime candidate for inherent as well as extraneous complexity and contradiction.

The "One World – One Health" concept (and fittingly "one medicine") serves as a useful tool to understand the problem of antibiotic resistance, by rationalising our existence as part of the larger ecosystem it recognises that changes to environment directly or indirectly impacts human health. This in itself is not a new concept (Evans & Leighton, 2014), alternatively, the term 'one medicine' was coined by Dr Calvin Schwabe (Gyles, 2016). In his book, Veterinary Medicine and Human Health (1964) he advocated for a collaboration between human and veterinary public health to address zoonotic disease concern. However, even this is not a new idea, as the German physician Rudolf Virchow proposed the same around 1855 (Brown C., 2003).

However, the conceptualisation of the problem, I argue, is better captured in the complexity concept of '**wicked problems**. In so doing the argument proposed is that - a resolution for antibiotic resistance is beyond the clean-cut mediation as proposed in the current literature. It is instead an issue that transcends multiple dimensions, constituencies, departments, and interpretation, and is by default resilient to resolution. Hence, the definition of '**Wickedness**' encapsulates the uniqueness, irreversibility, and lack of definite solution that ABR possesses.

The two concepts of antibiotics as **infrastructure** and antibiotic resistance as a **wicked problem** work together to indicate the confounding scale of the problem, both in theory and in reality. With regards to poultry, the elaborate food chain networks associated with it adds another dimension within the scope previously discussed, of economy; consumption, growth, industry, and individual actors, and of healthcare; environmental pollution, food safety and food security. The fact is, through the use of fertilisers, pesticides, genetic manipulation, hormones we have engineered means to increase yields and decreased their growth time. In this way we have industrialised farming itself, and as a hallmark of the modern era, antibiotics have become established as a crucial component of modern medicine as well as agriculture.

Furthermore, the debate around pesticides also apply to antibiotics (certain antibiotics are also used for pest management) and its impact on the ecosystem and human health has traversed the line from being routine to becoming a perplexing problem apropos to ecological complexity. Studies have also drawn on this parallel in search of solutions and lessons learnt from pesticide use and its resistance to be valuable for application in antibiotic resistance (Nichter, 2008). There is even research which postulates the possibility that the mechanisms microbes employ to resist, tolerate and degrade pesticides may drive microorganisms to develop antimicrobial resistance (Ramakrishnan, Venkateswarlu, Sethunathan, & Megharaj, 2019), something of a 'cross resistance' mechanism (Rangasamy, et al., 2017).

Regardless, antibiotics with its deep entanglement with the market, make it particularly difficult to regulate. Hence, it is crucial to understand the interlinkages between antibiotics and the spaces in which it performs multiple functions, in order to understand the complex interactions within the huge range of its influence.

These themes are common in many analytical papers on this crisis because of the importance of the resource in question. There can be parallels drawn to the act of committing self-harm (suicide) through our actions resulting from the loss of antibiotics as part of our medical arsenal, but this rejects the pre-antibiotic era and the history of infection treatments. Nevertheless, this concept of the end of modern medicine is revisited from many angles. However, in order to capture the undercurrents between antibiotics – antibiotic-resistance – agriculture – capital – health – and policy my research will comprise of three interrelated theoretical concepts; of antibiotics as '*things'*, as a '*commodity*' and as '*risk'*, in order to further develop the existing conceptualisation of antibiotics as infrastructure. This, I argue, is important as to engage with antibiotics and antibiotic resistance wholly we need to interrogate it at different levels, the larger socioeconomic-cultural aspects of antibiotics as well as the microscopic biological impacts of those socioeconomic-cultural interactions.

Hence, while antibiotic resistance is encapsulated as a problem of wicked proportions, the concept of biopolitics will be engaged to elaborate our relation to the microscopic. Therefore, the thesis aims to explore these concepts from within the framework of Heather Paxson's *'microbiopolitics*' and Stephanie R. Fisher's post-humanist interpretation of biopolitics. While both their concepts were conceived from Foucault's biopolitics, Paxon built upon it to mean - the creation of categories of nonhuman biological agents; the anthropocentric evaluation of such agents; and the elaboration of appropriate human behaviours given our entanglement with microbes engaged in infection, inoculation, and digestion (Paxson, 2008).

Through her thesis she explored the public health concerns with unpasteurised milk in the US and extrapolated it into the control over microbes, the drawing of boundaries between humans and microbes, the politics over and governance of the microbial world.

On the other hand, Stephanie R. Fishel's post-humanist interpretation of biopolitics provides a solution-oriented understanding of entanglement and sympoetic organisation[19]. Highlighting new ways of engaging (politically or otherwise) with the crises of the Anthropocene (Fishel, 2017. p. 21-27). Both ideas navigate the intersecting spaces between humans and microbes, which modulates between 'hygienic' principles to 'commensal' logic within the germ theory paradigm. As such antibiotics inhabit the intersections between human and the microbial, the microbial being a living, evolving agent acting upon selective anthropogenic pressures to present new dimensions of conflict.

As a 'thing', antibiotics, are tangible and liberating. However, divorced from its relation to experts (doctors and veterinarians) it becomes an item, which considering its latent potency, becomes primed for misuse. Additionally, self-medication which is an attempt on the patient's part to assume diagnostic and therapeutic activities upon themselves, removes one part of the health equation, i.e., the patient-doctor interaction. In the process redeeming some level of independence, albeit from a less-informed perspective. The convenience of the local pharmacy and the pharmacist, who in many cases is the only available 'health-worker', forces people to depend on such non-conventional prescriptive transactions. Antibiotics have been popularly understood synonymously as a short-term magic *fix-all*. However, increasing reports of the perils of misuse have changed that label of antibiotics.

According to Bill Brown's *Thing Theory* he states, "We begin to confront the thingness of objects when they stop working for us… (When) thing(s) really names less an object than a particular subject-object relation" (Brown B. , 2001). This concept provides us with an interesting perspective of our relationship with medicine as well as the object-subject relation between antibiotics, humans, and bacteria, and how that space opens new avenues for an ecological discussion on emerging ideas of cohabitation with the microbial world. In many aspects this concept is similar to Chandler's idea of 'antibiotics as infrastructure' (Chandler C. I., 2019).

Ulrich Beck's concept of the new '*risk-class'* provides a critical understanding of how modernity reacts to this newly named 'thing'. Beck's theory then allows for the critique of modernity and of modern medicine which help us envisage the 'more-modern' (Beck, Living

[19] As opposed to self-organising, Sympoietic systems are evolutionary, unpredictable and adaptive.

in the world risk society, 2006) post-antibiotic medicine. Risk perception; which is a subjective judgement informed by internalising outside information, which in turn influences behaviour, is also an important dimension while considering reaction to potential hazard. A recent report, published by the United Nations Office for Disaster Risk Reduction, determined that humanity is spiralling into self-destruction due to a "prevailing perception of risk…of optimism, underestimation, and invincibility." (Reduction, 2022, p. 17). The report highlights risk as a subjective term dependent on income, for instance, the ability of people to endure, and rebound from disasters. And while the report deliberates largely on climate change as a threat to sustainable development, the takeaways with its parallels to antibiotic resistance risk as a complex issue premised upon vulnerability can be extruded. As a risk, antibiotic use is a dodgy affair, and resistance; which affects individuals, becomes a matter of societal concern.

Finally, of antibiotics as a *commodity*, as a thing that has pecuniary value by itself, and also insures other products. In this way, it also allows for the conception of antibiotics that is removed from its normative function as a medicine (cure for illness) to its non-normative function as an indemnifier of capital for other products. As a commodity, antibiotics are a marketable thing, an item of exchange, segmented by **Product** (Cephalosporins, Penicillins, Fluoroquinolones, Macrolides, Carbapenems, Aminoglycosides, Sulfonamides, Glycopeptides, etc.), **Spectrum** (Broad Spectrum Antibody and Narrow Spectrum Antibody), and **Geography** (North America, Europe, Asia-Pacific, Middle-East and Africa, and South America). As such the global antibiotic market size in 2020 was 37.35 billion USD, and growing substantially every year.

Before the Second World War penicillin was a protected war secret, and a rarity in the medical world. It transformed into a commodity after pharmaceutical companies in America were contacted through the Rockefeller Foundation to mass produce penicillin for the war-effort as the pharma companies in Britain were overburdened by wartime demand for other medicines (Bernard, 2020). Eli Lily and Pfizer were persuaded to mass produce the drug, and by March 1945 penicillin was released fir commercial distribution to the public (Quinn, 2013). As more companies saw the effectiveness of penicillin to cure battlefield infections during the Second World War. Soon after these companies scaled up production to industrial levels to meet an expected popular demand. Correspondingly antibiotics (commodity) and its relation to availability has been delved into in the literature, signalling to resource poor geographies and the scarcity of quality antibiotics leading to avoidable deaths (Carlet &

Pittet, 2013; Daulaire et al., 2015; Isabel Frost et al., 2019; Iskandar et al., 2021; Shafiq et al., 2021).

As a commodity and as a material thing, antibiotics take on cultural and symbolic meanings once made publicly available. They begin to possess meanings and values, changing from inception in sterile labs to public use for care giving, healing, transforming in to tokens of healing and hope (Whyte et al., 2003). Hence, by looking at antibiotics as if they lead an economic and a social life, we get to understand how antibiotics are valued culturally, economically, and politically. In doing so, antibiotics had become invisible in the crucial 'boring' role it played in our everyday lives, it is only in its obstinacy that antibiotics have received the attention that it has now. This is characteristic of other such things that we interact with daily, and that which shapes our thoughts and actions inconspicuously, and conspicuously when they fail, such is the nature of infrastructure.

2.4 Antibiotics as Infrastructure

Other than the ecological understanding of ABR, there have been other attempts made to develop descriptive and practical analogies, not only to understand our relation with antibiotics but also to convey its importance and significance. One such way has been to extend the idea of antibiotics as 'infrastructure'. Proposed by Professor Claire Chandler (London School of Tropical Medicine and Hygiene), this theory proposes that antibiotics are analogous to conventional infrastructure, it is only until they break down that they become visible (Star, 1999). In doing so, it transforms discussions of complexity and ecology in to vivid imaginings of the spatial organisation of mutually dependant elements that together facilitate important functions in the present society. It also points to the entrenchment of antibiotics as constituting intangible spaces in physical, material, which could be insightful into providing an understanding of - what might be at stake "when shifts come in our ability to use these medicines" (Chandler, Hutchinson, & Hutchison, 2016). They argue that the politics of catastrophism which revolve around antimicrobial resistance is demonstrative of the importance these medicines have (*ibid.* p.16), not only medically but economically as well. Considering the demands to food production and the importance of antibiotic use in food security, and the reliance of modern healthcare on it antibiotics commands a significant role in our everyday life. As crucial branches of our society become even more reliant on antibiotics the prospect of losing them becomes an issue of serious concern.

Antibiotics are also a commodity, a shared resource, suffering from '*a tragedy of the commons*' (O'Brien, et al., 2014) (Hollis & Maybarduk, 2015). Its use in non-medical activities such as in agriculture, animal husbandry, bee-keeping, aquaculture, horticulture, food preservation, etc. (Manten, 1963) (Meek, Vyas, & Piddock, 2015) are significant for the production of consumable goods, and therefore the economy. As an economic commodity, as well as a health artifact; ensuring the health of the labour force who are engaged in the creation of market goods, antibiotics traverses the space of being just another item of the market. This is also reflected in the literature, as one of the significant concerns regarding antibiotic resistance is the amount of time it would require for someone to recover from infections (if at all), which translates into loss of labour (RAND Europe, 2014) (Naylor, et al., 2018). Additionally, costs attributed to extended hospital stays (Mauldin, Salgado, Hansen, Durup, & Bosso, 2009) are economically significant, especially from infections caused by ESKAPE bacteria[20] especially in developing countries (Founou, Founou, & Essack, 2017) as it contributes to an attributable economic loss to hospitals, countries and their national growths (Adeyi, et al., 2017). In this way antibiotics have become crucial, almost infrastructural to modern society, transforming it into a keystone of modern living. It is also this status which antibiotics came to hold that make its use particularly difficult to control.

ABR is a mutating problem of an anthropogenic origin, made worse by a system structured on the use of antibiotics to feed humans, heal, and prevent diseases. In a piece published in The Wire, Maryn McKenna, the author of the book 'Big Chicken', logically extends the established idea of 'antibiotics as fire extinguishers' to 'antibiotics as infrastructure'. This is an echo of the proposal argued by Clare Chandler, when she invoked Bowker and Star's term - 'infrastructural inversion' (Bowker & Star, 1999), to write about antibiotics. The rational employed here is that when unravelling the woodwork, which we take for granted, antibiotic use reveals the entangled social, political, and economic frames that modern life is dependent upon. Hence, AMR arose as a result of this dependency (Chandler, 2019). This argument therefore calls for a systems approach intervention.

By making visible where, how, and at what quantity antibiotics make modern life possible we can begin to appreciate how important and crucial it is to be judicious in its use. Hence, the title of the thesis hints to this aspect. If anthropomorphised, the impact of capitalism on antibiotics may seem like a Marxian concept of an economy build on the exploitation of antibiotics (labour), and to some extent this is true. Modern living is made possible due to the

[20]***E****nterococcus spp.,* ***S****. aureus,* ***K****. pneumoniae,* ***A****cinetobacterbaumannii,* ***P****seudomonas aeruginosa and* ***E****nterobacter spp.*

benefits accrued from the intrinsic qualities of antibiotics, especially in LMICs where health, hygiene and sanitation infrastructures are relatively weaker. However, as tempting as a proposal as it may be, the impression that is employed here is more basic. It is to propose that the benefits from the unique properties of antibiotics make possible for the insurance of investments made in intensive agriculture, in this case poultry farming. Hence, it is this property of antibiotics which the market bank upon which make it difficult to make any headway into its control. This infrastructural quality of antibiotics is what makes it critical for healthcare and also for the food chain.

In the article by Professor Clare Chandler, she proposes an analysis of antimicrobials as "material, affective and political infrastructures" in an effort to render the work of these medicines (Chandler C. I., 2019). She states that there is a necessity for this 'infrastructure' (a good useable system) and due to this inherent quality of antibiotics is made invisible (Bowker & Star, 2000, cited in Chandler C. I., 2019, p. 9). Hence, she concludes by stating that in "rendering visible in this moment the ways in which our lives are contingent upon antimicrobial medicines: to define and deliver health care; to enable productivity of work forces, industrialisation of food (and) other commodities; as well as making possible particular social and political values in the context of modernisation, urbanisation and globalisation" (Chandler C. I., 2019, p. 10) antibiotics can be considered as infrastructure. By stating so, she proposes a shift from individual behaviour approaches to looking in to structural, and relational dimension of AMR (Willis & Chandler, 2019).

As it stands presently, antibiotics are often considered as 'quick fixes' for providing care, increasing productivity, and an excuse to encumber the responsibility of inequality on to it (Willis & Chandler, 2019). The last point is very significant especially considering the structural dimensions –as self-medication and over the counter sale of antibiotics may also act as a 'signifier', which reveal a weak health system infrastructure. Buying off-the-counter medication is a cheaper, a more convenient alternative to visiting a doctor (Alhomoud, Aljamea, & Basalelah, 2018). This relation of resource to the determination of health suggests that compounding issues, related to class, determine infection susceptibility. Quick fixes, like silver bullets reduces the complexity of a problem to its lowest common denominator, often simplifying interventions by the use of certain technologies. People with lower income have to deal with a triple-jeopardy; that is, no job security, low wages, and most importantly high work environment risks making them more susceptible to health problems. Studies on over-the-counter reliance for healthcare in India (especially of prescription-only-medicines), show that age, gender, income, and poor lifestyle were the predictors of OTC medication (Panda et al., 2017a). However, the study concludes that it is due to 'perceptions' of accessibility and affordability of healthcare that influences OTC medication, which is highly debateable. A study by Phalke et al. reported prevalence of self-medication in rural population of state of Maharashtra in India to be 81.5% (Phalke et al., 2006). While the prevalence of self-medication in Urban Delhi was found to be 92.8% (V. Kumar et al., 2015). These two are one of the wealthiest States in India, with significantly better infrastructure (health or otherwise) than most other States, despite that a study conducted at Behrampur, a city in the coastal district of Ganjam, Odhisha, found the prevalence of OTC medication use to be 18.72% (Panda et al., 2017b). Overall, proximity, the quick transactional nature of pharmacy sale, the economic incentives for both parties, and the skipping of complex hospital navigation (Adhikari et al., 2021) Lack of easy access to public healthcare facilities, Economic and time constraints, lack of stringent laws, scanty inspections, safeguarding commercial interests were factors influencing OTC sale of medicines, the latter of antibiotics (Kotwani et al., 2021).

The economic and time constraint factor is a significant concern of the labouring public, especially in low-and middle-income countries (LMICs). To seek relief quickly in the least time possible is a major consideration in purchasing antibiotics over the counter for the lower economic classes. Mostly, because the threat of a prolonged hospital treatment puts a heavy strain on their limited means (Kotwani et al., 2021) and also incapacitates them from working in order to earn. A comparative study published in 2019 also confirmed a corresponding relationship between socio-economic conditions as a determinant of antibiotic resistance. The study concluded that: "The prevalence of invasive infections caused by the WHO top-ranked antibiotic-resistant bacteria is inversely associated with GNI per capita at the global level" (Savoldi et al., 2019, p. 3619)

Literature related to antibiotics published by the WHO, ILO, and the World Bank also frame the problem of ABR as a burden to health care and a threat to economies (because of loss of work days due to prolonged illness *vis-à-vis* antibiotic resistance). Hence, the concept adopted by Claire Chandler must be considered, when she suggests that we have made antimicrobials as infrastructure "that undergirds complex livelihoods in landscapes of scarcity, uncertainty and inequality." The imagining of people exclusively as an economic unit and the present solutions developed to address AMR, which hinges on behaviour, fails to incorporate such dimensions of complexity. In many ways, it is a moral and ethical failure, on which there should be much more conversation than that which currently exists. Antibiotics became infrastructure when they gradually replaced laboursome and capital-intensive investments in farming, public works and provision for basic healthcare. Additionally, the rapid adoption of medicines in the 19th century gave way to expectations on technological quick fixes.

2.5 Research Design

Methodology and Methods

Considering the above postulations this research suggests for a qualitative study design can fulfil the requirements of this expansive topic. Hence, the research is exploratory in nature and incorporates an ecological perspective; in order to encompass the complexity as well as the range of factors that influence antibiotic use. Therefore, this study into the poultry sector incorporates a **political economic in-depth case-study method** as a peek into the deeper issues of global health interfacing with economic concerns, social values, and policy frameworks. In so doing unravelling the invisible nature, characteristics, and networks of antibiotics. A political-economic analysis provides the tools necessary for asking the kind of questions this research hopes to uncover, beginning with the basic – How and why did we come to this situation? And thereby, through an iterative and ongoing process, inform the socio-economic and political processes that are promoting or blocking sustainable change in antibiotic use. Hence, through forming a deeper understanding of the political contexts and the overarching economic logic under which antibiotics operates aspects of barriers to change, exercise of power and decision-making would be uncovered.

As such political economic studies require a mix contextual and sector knowledge in order to understand the processes that create, sustain, and transform these relations over time and spaces. Hence, the poultry industry provides these exact conditions required for the purposes of this study, especially with regards to the interactive relationship between institutions, populations, and individuals. The utilisation of a political-economic concept could also highlight epidemiological patterning in identifying vulnerable populations and thereby aid in the designing of interventions.

Hence, interviews with stakeholder as well as subject specialists would tap into existing knowledge and narratives to identify gaps and therefore improve analysis. But this would be based on an in-depth understanding on the available literature on the subject and other corresponding topics. For which, in-depth literature review was conducted and combined with semi-structured interviews with stakeholders and experts and supported by groundwork research undertaken in several markets across the National Capital Region of India.

Finally, in order to collect data required for the purpose of the study separate theme based open-ended interview schedule has been adopted: for different expertise. Respondents were approached by a mix of snowballing approach as well as purposive expert sampling in the area of Antibiotic resistance research, animal health and specifically those in the poultry industry, and Food and agriculture systems experts. Altogether, there were twelve interviews conducted in total, but two interviews fell out of the purview of the requirements for this research. While they were experts in their respective fields the focus of the interview failed to provide exclusive insights into the structural contexts and processes of the subject. Furthermore, expert interviews were triangulated with the help of document analysis and observation of the research field (Döringer, 2021).

This ‘problem centric’ informal interview method served to allowed for the sharing of internal points of views, other than purely established talking points. Lastly, the Harvard sociology department’s expert interview guidelines were used as a blueprint for designing, conducting interviews and analysing data (Dept. of Sociology, Harvard Univ.). The list of experts and their affiliations were as follows:

Respondent number	**Role/ Affiliation**	**Mode**
1	Senior Department of Animal Husbandry and Dairying	Personal
2	Veterinarian/Member of Empowered Committee for Animal Health ECAH/ Consultant to the Poultry Association of India	Personal
3	Senior Professor/Medical anthropologist,	email
4	Health systems and Health Policy expert/AMR research expert	Telephonic
5	Veterinarian/Livestock policy advocate/Founder, Livestock resource centre	Telephonic
6	Programme Dir. Public interest research and advocacy organisation/ Food Safety & Sustainable Food Systems Expert	Personal
7	Dept. Microbiologist	Personal, Telephonic
8	Public health specialist, Animal husbandry and Veterinary services	Telephonic
9	Principal Scientist/Agricultural Policy/Science and technology expert	Personal
10	Oncology Pharmacist/Co-founder pharmacy education online resource/Asst. Professor of Pharmacology	email

Table 1 List of Experts & their Affiliations

Secondary Data

As such, the literature on Antibiotic resistance and antimicrobial resistance from the medical research database PubMed showed 191446 and 220840 articles respectively (2019). In order to narrow the search results MeSH terms were employed, but broadened thereafter through Pearl growing or Citation mining method. Further refining was done through **Covidence** for primary data screening after which thematic similarities were analysed in Excel.

The secondary data required for the purpose of study have been collected from the following sources:

1. Various publications and articles on and complementary to the topic.
2. Seminars and Conference on Antibiotic Resistance
3. Annual reports of the Department of Animal Husbandry and Dairying (New Delhi)
4. Various reports and studies of the Department of Animal Husbandry (New Delhi), Ministry of Health and Family Welfare (MoHFW), ICMR, CSE, CDDEP, Poultry Hub, FAO, and WHO.
5. Books and periodicals related to the subject.
6. Dissertations and Thesis in the related field.
7. Internet journal archives such as the NCBI's PubMed.

Primary Data

Pre-pandemic market research was conducted in and around Delhi in 2017 and 2018. This comprised of interviews across Delhi with butchers (Dwarka, Dabri Mor, Humayunpur, Munirka, Lajpat Nagar, Amar Colony) and poultry whole-sellers (Ghazipur poultry market). After which the area of research was selected and fieldwork was planned for early 2019. Hence, the methodology invoked was to be a mixed approach, with field work in the NCR regions that rear chicken in industrial scales. Interviews of farmers and whole-sellers and interviews with experts in the field of antibiotic resistance were planned and journalled for the beginning of 2019. However, that had to change due to the SARS Cov2 pandemic, subsequent lockdowns hindered any attempts for an extensive fieldwork. Therefore, the methodology was changed to comprise solely of expert interviews aided with extensive secondary research.

Pandemic: Exploratory research was conducted in Nagaland during the lockdown to understand the structure of poultry markets. It was a fact-finding exercise to establish the food chain networks that traced supply provisions from the periphery to the urban settlement of Dimapur, Nagaland. Commercial poultry farms were visited in the state of Assam as well as model farms of the Nagaland Veterinary department, this was followed by interviews with state officials as well as department biotechnologist. This provided an understanding of medium scale commercial poultry rearing practices, feed provisions, veterinary medications, and avian epidemiology.

Post-covid: Research methodology was altered to incorporate post-findings to be supplemented by interviews with experts specialising in agriculture, medicine, public health and antibiotic resistance.

Selection of Experts: There is a significant body of work on antibiotic use in poultry conducted by various persons, government departments and independent national and international organisations. Initial correspondence with FAO officials has been conducted in order to gauge their interest in the topic as well as request updated India specific data. From the correspondence it was established that the FAO, in India specifically, have been conducting surveys on the use of antibiotics on livestock farming but were not looking into plant agriculture yet. Additionally, discussion over email was conducted with Brandon Dyson, co-founder of 'tl;dr pharmacy' (an online pharmacy education website) and a board-certified , residency-trained pharmacist. The discussion was to enquire about separating the media frenzy from the real problems of antibiotic resistance.

Furthermore, departments of the NCDC, Ministry of Health and Family Planning, Department of Biotechnology (Ministry of Science and Technology) were approached several times in order to obtain data, however, there has been no response so far.

Additionally, initial interviews were also conducted with the, Dept. of Agriculture, State of Nagaland, India, in order to establish a preliminary understanding of the poultry industry and to establish workability of research design. That being said, it is understood and must be stated that that the circumstances in the Near Capital Regions will differ from that of the State of Nagaland, India

Selection of factory farms: Factory farms are also known as concentrated animal feeding operations (CAFOs), which are an industrial method of raising farmed animals. While elsewhere the term is used to signify the industrial farming of a plethora of animals for meat, in India it is synonymously used to refer to the poultry farming model. Therefore, the poultry factory farms, specifically those that supply poultry to the National Capital Region of India (NCR), would be the subject of this thesis.

Furthermore, the poultry sector engages in three main types of farming operations, viz., i.) Layer farming units engaging in the production of eggs, ii.) Broiler farming units meant for production of meat, and iii.) farms that produce both eggs and chicken. For this study the main emphasis would be placed on the latter two.

Research objectives

1. To research the deep entanglement of urbanisation, its relation to the industrial production of food, and its dependence on antibiotic use in agriculture. That is, to unravel the structural and relational dimension of AMR through the analysis of the poultry industry.
2. To understand the developments in society which made us become so dependent on vertical intensive agriculture.
3. To explore the concept of the antibiotic economy; particularly antibiotics as Insurance and antibiotics as infrastructure, and how this association obfuscates any policy deliberation aimed at prohibiting its use.

2.6 Area of Study

The area of study are the areas under the collective term '**NCR**', i.e. The National Capital Region of India. This is comprised of the geographical region of Delhi and several districts surrounding it from the states of Haryana, Uttar Pradesh and Rajasthan. While Delhi was the preferred area of investigation the food chain logistics showed that meat, broiler chicken in particular, was largely sourced from the adjacent State of Haryana in the following districts of Jind, Panipat, Hisar, Fatehabad, Sirsa, Karnal, Kaithal and Yamunanagar. Additionally, Ghazipur Murga Mandi, a whole-sale chicken market in East Delhi, is the central hub from where retailers source all the chicken across Delhi. These corresponding areas are to be the central focus of this study.

2.7 Research Question

The main aim of this thesis is to understand how the interaction of urbanisation and increasing food demand have a bearing on antibiotic use in farming. Hence, it seeks answer to:

i.) What are the factors responsible for the high prevalence of antibiotic use in the poultry industry? In so doing it hopes to understand:

ii.) How dependent on antibiotics are our food systems? If so, then what are the complexities involved in phasing out antibiotic use in agriculture?

iii.) How are the prevailing policy formulations and guidelines tackling the issue of antibiotic resistance?

iv.) What are the shortcomings in the current discourse on antibiotic resistance and therefore what are the alternative approaches being conceived?

Secondary questions:

i. How antibiotic use reveal the changed/changing relation we have with the invisible world of ‘bacteria’ and what this means for modern medicine?

ii. Can modern food systems sustain global demand sustain without the use of antibiotics in food production?

iii. What could such an approach mean for establishing practicable antibiotic regulations?

Why are these research questions important?

In his sociological works, Ulrich Beck describes a paradigmatic shift from modernity to a “second modernity.” He argues that man-made, unwanted side-effects of modernity challenges the very basis of modernity itself. In so doing, it produces societal uncertainties which is leading to a new age where we must come to terms with the consequences of our actions (Beck, Risk Society: Towards a New Modernity, 1992). This ongoing process is called “reflexive modernization”. One such result of this process results in societies being forced to change through a reflexive chain of unplanned events. For instance, it was the knowledge of bacteria and germs which first encouraged preventative measures, thereafter the use of antiseptics and the development modern technologies like antibiotics. Which then led to an over reliance and dependence on.

Reflexively, research in social science focused on behaviour places the onus onto the individuals rather than rethinking the systems that cause it. This is inquisitively analogous to or an echo of Plato’s allegory of the cave. For instance, the current literature suggests that individuals who buys antibiotics over-the-counter or the farmer who gives antibiotics to their animals is a deviant, responsible for aggravating the antibiotic resistance conundrum. But we need to asks whether the conditions and circumstances that prevail compels such behaviours in the first place. Access and cost of healthcare, economic and social status and considerations of the patient, among other things, are important factors to be understood.

In a similar way, antibiotic use in agriculture is crucial for the producers and farmers in order to prevent disease and loss of profit. Antibiotics are also a cheaper option than to go for other biosecurity solutions. Furthermore, considering the increasing demands for cheaper meat the usage in poultry farming is not likely to reduce. Hence, reflexive regulations have failed to curb antibiotic use. Therefore, these questions approach the problem holistically, in so doing it attempts to understand our dependency on antibiotics in order to provide viable resolutions.

A good place to start looking for solutions to the AMR problem may lie in recounting the events which led them to the present situation. As E. H. Carr said of history, 'history offers a dual function, to enable men and women to understand the society of the past and to increase their mastery over the society of the present' (Carr, 1987). While there has been no precedence to AMR in the past, the events that have led to it are a cautionary tale of where it went wrong, and where renewed focus needs to be placed. Hence, lets begin by understanding the intrinsically linked history of antibiotics to animal rearing.

Chapter III

History of Antibiotic use in Agriculture

Antibiotics are either natural or semi synthetic combination of molecules which either destroy bacteria or slow their growth. Its discoveries in the early 20th century marked the dawning of new capabilities in medicine and significantly revolutionised healthcare as we know it. It was preluded by paradigmatic shifts in disease causation theories and the dawning of the 'germ theory' era. An era that was aided and established through successive discoveries of Antony Leeuwenhoek, Spallanzani, Louis Pasteur, Joseph Lister and Robert Koch. Their respective research firstly made visible the invisible world of microbes after which associations were made between disease and specific microbes. So began a new era in medicine, resulting currently in the establishment of the concept of aetiology and immunology.

One of the first microbes to be studied was Bacillus anthracis, a spore-forming bacteria that causes anthrax. Like most associations in this thesis, it was its connection to food (anthrax infections among livestock are particularly fatal) that made the cause of anthrax such a curious subject to be studied. At least it did for Robert Koch, who having moved with his wife from one village to another found themselves in the East Prussian village of Wollstein (Wolsztyn, Poland). While he found himself among farmers in muddy villages, Joseph Lister was establishing antiseptic principles and saving women from obstetric deaths due to microbes in Scotland. On the other hand, Louis Pasteur was shaking the foundations of medicine in France by preaching that microbes cause disease, however, at this time in history there was no proof of this fact. On his twenty-eight birthday Koch's wife, Emmy, presented him with a microscope, as a means to keep her otherwise bored and demoralised husband occupied. Robert Koch, meanwhile in an obscure village, spent his time diving into the lenses of his microscope, looking into slides after slides of curious imperceptible universes, rather aimlessly.

At this same time anthrax was a worrying disease for famers, a disease that propped time and time again throughout Europe, killing livestock in the hundreds at times. Robert Koch finding himself among farming folk hunted for fresh carcasses done in by this disease, and began peering in to clotted samples of sheep and cow blood. What he saw would have been rod-shaped microbes joining to form thin filaments. But to make sure these were the culprits responsible for anthrax he compared them to blood samples taken from healthy animals, and found these to be absent in them. Koch's experiments were just beginning, he was determined to establish an association that these little rods under his microscope grew, bred, multiplied and eventually killed its hosts. In so doing he was inadvertently developing the foundations to his now famous postulates.

He began to use mice in his experimentations, firstly making certain that these rod-like organisms were absent in them. Thereafter, inoculating them with his now collection of blood samples from diseased animals. On finding these mice dead and stiff the next morning he would excitedly collect another sample from the poor mouse and indeed found them to be replete with the anthrax bacteria. In 1876 he would publish his findings on anthrax, thence was established the foundations of modern bacteriology.

The next step was to find answers regarding the "ultimate cause of diseases", hence in 1894 he made his way to Magdeburg to attend the annual meeting of the *Deutscher Vereinfüröffentliche Gesundheitspflege* (German Society for Public Health) and proposed a collaboration to find answers and the reason to many unresolved questions (Hardy & Hård, 2013, p. 320). Robert Koch had realised that their theory (bacteria) had limitations as it did not have answer as to why only some came down with sickness despite being equally exposed to bacterial agents, why were some agents more virulent than others. Hence, questions on irregularity of infections among populations equally exposed to these agents brought about a collaboration between the 'hygienists' (public health reformers) and the bacteriologists and adopted an agenda that made infectious disease their common enemy instead of each other (Hardy & Hård, 2013, p. 322).

The European public health reformers of the early 1800s contributed greatly to stemming infectious diseases through their association of disease to 'filth' and their sanitary agenda influenced huge investments towards public heath works. While, inadvertently reducing the transmission of dangerous microorganisms their reasonings were founded on an invisible enemy. Koch was the first to uncover this invisible perpetrator through his work on anthrax, in due time he would go on to expose and link the bacteria responsible for tuberculosis in 1882, and cholera in 1883. Hence, in a time of ambiguity the germ theory provided increasing evidence for the cause of disease and presented a "…guide to the prevention of disease through
modification of individual and collective behaviour" (Tomes, 1999, p. 6). In so doing, gave way to growing awareness among individuals paving the way for the reformation of personal hygiene. In other words, these early associations of disease to bacteria gave rise to an obsession with hygiene and an aversion to dirt, which Nancy Tomes refers to as the "private

side of public health” (Tomes, 1999, p. 6) in America. Similar developments in European society were underway as well, and since there was no cure yet prevention was the word of the times.

The period between 1870 to early 1900s was tumultuous for the field of medicine. Koch and his contemporaries were discovering disease associations to invisible ‘animacules’ to a congregation that was not ready for a reformation. However, by the 1920s we see the establishment of ‘modern medicine’ principles being adopted more widely in the West. The discovery of Salvarsan in 1910 and Prontosil in 1932 also helped induce public adoption of germ theory, given that they were the first ‘magic bullets’ that preceded penicillin.

It was only in the early to mid-20th century through experimentation with livestock and antibiotics that the benefits of utilising antibiotics as feed-additive were discovered. Antibiotics were found to induce beneficial responses on chickens by improving their growth and preventing infection through prophylactic use. These factors eventually led to an intensification in the use of antibiotics in the production of the animal/meat industry and concurrently led to the concentrated mass scale animal farming that we have come to normalise presently.

The use of antibiotics, specifically sulphonamides, were first advertised by pharmaceutical manufacturers like Wellcome, Bayer, and May & Baker as early as 1939 at veterinary fairs (Kirchhelle, 2018). This corresponded with the demands of the war industry as food production became crucial as part of the war-time efforts during the Second World War. Hence, large scale mass production and use of antibiotics for securing food supplies was as important as treating wounded soldiers. It is estimated that by January 1945, 4 million sterile packages of penicillin were being produced in a month through commercial scale fermentation (Quinn, Public Health Then and Now: Rethinking Antibiotic Research and Development; World War II and the Penicillin Collaborative, 2013). To put this in perspective just four years earlier in 1941 U.S. made-penicillin was used in the treatment of the first ever patient for septicaemia (blood poisoning), and this treatment alone exhausted half the available supply of penicillin in the entire United States (Fletcher, 1984) (Schindel, 1957).

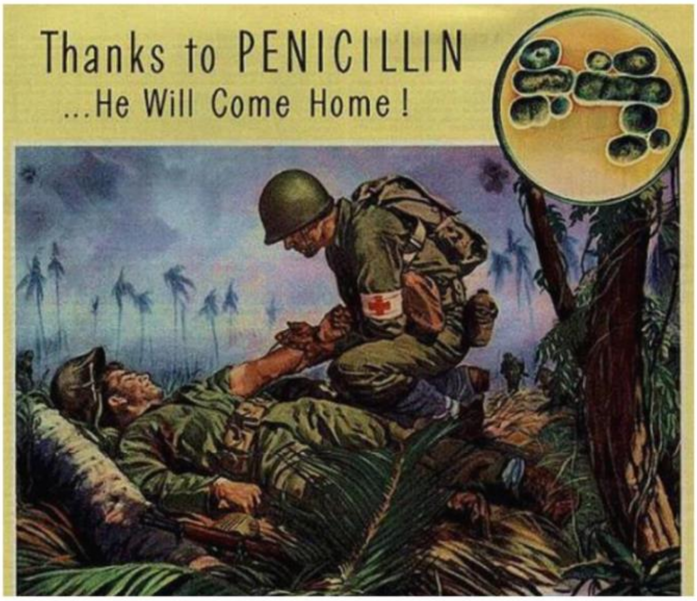

Image 1 Penicillin! Life Magazine, August 14, 1944.

In the later part of the war antibiotics were made available to veterinarians who reconstituted it with saline, which was then used to treat diary-cows suffering from bovine mastitis (Gustafson & Bowen, 1997) (Kirchhelle, 2018). This was necessary in order to ensure milk supply during the war era. However, right after in the post-war period it led to debates concerned with food purity. For instance, milk was initially considered pure if it had a low bacterial count, which in the late 1950s changed to mean purity "by its freedom from technological adulterants and to understand antibiotic residues as a potential public health threat" (Smith-Howard, 2010, p. 329).

It is also this period which is considered as the 'golden era of antibiotic discovery'[21].Between 1940 and 1970, after the discovery of penicillin, almost half of the drugs commonly used today were discovered (Lewis, Comment: Recover the lost art of Drug Discovery, 2012) (Davies J. , Where have all the antibiotics gone?, 2006). This was made possible through a new strategy adopted by microbiologist Selman Waksman[22], by testing soil microbes for bacteria with the ability to produce their own antibiotics (Brown & Wright, Antibacterial drug discovery in the Resistance Era, 2016). Where earlier antibiotics were discovered by screening chemicals in dyes which had synthetic molecules that were absorbed by bacterial cells and not human cells, the new antibiotics were discovered from naturally thriving chemicals available in complex microbial ecosystems. Chlortetracycline, a wide-spectrum antibiotic from *Streptomyces venezuelae*- was one of these 'natural antibiotics' which was found in a soil sample from Venezuela, in 1947 (Nelson & Levy, 2011) (Jukes, 1985). This particular antibiotic is significant in this narrative as its discovery wields a significant departure from how meat was traditionally farmed. It features in one of the most historically

[21] This was also the era from when food activism gained momentum; primarily as a part of the counterculture movement opposing the testing of nuclear weapons, the war in Vietnam, and to a large extent opposing confining structures and ideologies, food was a way of communicating ones' identity to a set of beliefs (Johnson, 2012).

[22] Selman Waksman was a co-discoverer of Streptomycin in 1943, which was the first antibiotic used to treat tuberculosis.

significant experiments which set off a cascade of changes, "from drug resistance to factory farming". And according to Maryn McKenna antibiotics "created modern agriculture and changed the way the World eats". In her book, 'Big Chicken', McKenna simplifies the findings from the study that discovered the 'growth promoting' quality of antibiotics. The study conducted by Thomas H. Jukes, E. L. R Stokstad and their team tested the effects of diet on 'animal protein factor'[23] (Stokstad, Jukes, Pierce, Jr., & Franklin, 1949) and found that chicken fed on mash (the growth medium in which *aureomycin* had been brewed in)[24] weighed almost a third more that those that have not been. More specifically, the experiment attempted to identify which vitamins had to be added to the chicken feed to allow birds to thrive on a manufactured diet. It was later discovered that the very effect that antibiotics had in disease prevention in livestock was also the very thing that stimulated their growth.

Jukes' discovery was significant in itself, but even more for the pharmaceutical company that Jukes worked for, Lederle Laboratories. They marketed the by-product (the mash) as a vitamin supplement in animals feed, and as a New York Times report (April, 1950) stated it was 'cheap' and without side effects (McKenna, 2017, pp. 43-44). This was also a period that was experiencing post-war growth and prosperity in America, leading to increasing demand for food, hence, from the demand side explanation suggested that as incomes increased so did their demand for protein (Wilford, 1973) (WHO, Global and regional food consumption patterns and trends). From the supply side: farmers greatly benefitted from Lederle's product, Lederle's announcement of antibiotic's effect on growth led to a boom in their sales in late 1949. Hence, their incentive to push more sales.

In 1950, the New York Times proclaimed that aureomycin's "unsuspected nutritional powers" would have "enormous long-range significance for the survival of the human race". Ironically, Thomas Jukes' discovery of the growth supplement properties of antibiotics at Lederle happened by accident due to what could be considered as one of the first instances of antibiotic pollution. The prelude to the Thomas Jukes story is that in the late 1940s, anglers who fished in the Hudson River, New York, near Lederle Laboratories, noticed that the trout

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[23]It was a term formerly used for a growth factor in livestock, which was found to be present in meat and fish. It was later found that it was due to the presence of an intrinsic factor which makes it possible for the absorption of vitamin B12.

[24]If I could borrow Maryn McKenna's analogy, the way an antibiotic is made is very similar to how beer is brewed (McKenna, 2017, pp. 40-41) an organism which makes the product you want is added to a mix of water and sugar, it ferments and the by product is extracted. After the alcohol is removed the bottom of the still is leftovers of grain (sugar) and hops which was re-capitalized as farm feed. So, the same was done and is done in antibiotic production, the mash which had small concentrations of antibiotics was used by Stokstad and Jukes in their experiment. More precisely, their mash contained dried mycelia of *Streptomyces aureofaciens* containing chlortetracycline residues.

they were catching were getting bigger every year. Thomas Jukes got word of this, who thought it might have something to do with the massive piles of run-off from the Lederle factory that was pumping out vast amounts of their hit product - aureomycin (Roberts P. , 2008).

Even before Jukes' discovery the global food system was undergoing massive transformations. As historically established methods of farming and processing were being replaced by newer industrial model of production even in the poorest nations. A model of farming that could generate far more from fewer inputs was overall compelling, and was promising in contending with the uncertainty of food production. While this was simpler for grain and vegetables this task was far more complicated for complex animal biology. This is where antibiotics filled in the gap, and was instrumental in transforming the agricultural landscape post-World War II. It also marked the beginning of the modern food economy (*ibid.,* 2008).

This post-war trend, in many ways, was fuelled by the scientific and technological advancements made for the purposes of winning the war. The **microwave**, another invention of the war, transformed the supermarkets as well. Frozen 'convenience' foods, processed, pre-packaged foods increasing in popularity and opened another segment of the food economy. These advancements and more led to food production becoming centralized to large factories, making them abundant, cheap, and non-perishable ushering in a techno-age of food requiring technological interventions without any impression of the consequences.

While India did not take to these changes immediately, considering the socialist policies it followed in the decades following its independence, similar post-war trends observed in America was observed in post-liberalised India as well (Rampal, 2018). Growth and prosperity that followed India's economic reforms had resulted in the emergence of a strong middle class as the main consumer of fruits, fish, meat, dairy products and vegetables—which was a marked shift from the earlier staple-based consumption. Since 1991, improving socio-economic conditions have led to increased demands on food and other goods, thereafter leading to the accumulation of significant pressures on natural resources (Gerbens-Leenes, S, & MS., 2010). Antibiotic use in India for farming, aquaculture, in food processing operations and food preservation thereafter have followed a similar trajectory to that of the West, but without the robust infrastructure and institutions of regulations and regulators as is in the West. Nevertheless, the idea supplanted from the West was to modernise farming techniques and undertake huge engineering projects to increase land harvestability

3.1 The Industrialisation of Agriculture

The preliminary use of antibiotic in agriculture was not only viewed as a solution to counter overpopulation and hunger. For American policymakers and researchers, the global export of yield-increasing technologies like antibiotics was also perceived as a way of defending Western values against the looming Communist threat during the Cold War (Kirchhelle, 2018). Hence, it was also a battle for which system (capitalism vs communism) with their bespoken agrarian policies would triumph over the other. This is what Stephen J. Dubner, author of Freakonomics and host of Freakonomics Radio, classifies as the 'farms race', both nations clashed to distinguish themselves as having a superior system over the other, with government policies designed to deliver "high volume standardised agriculture" (Dubner, 2019). This development, it would seem, resolved to quieten the diverging views opposing industry to agriculture[25] in its capacity for raising incomes of population, by the industrialisation of agriculture altogether.

Nevertheless, a system to produce high volumes of standardised agricultural goods requires the design of a 'fail-safe system', or "a feature which could counteract the effect of an anticipated source of failure" (Merriam-Websters Dictionary). In the case of meat production this failure could mean loss of animals to disease and sickness, and as Dr Class Kirchhelle argues in his article, the story of antibiotic proliferation is intimately connected to "the industrialisation and integration of global agricultural production…as rising meat consumption and the farm as factory became powerful symbols of Cold War" (Kirchhelle, 2018, pp. 2, 4). One can surmise from the above observations that antibiotics do have the characteristics which make up a fail-safe feature. In its capacity to lower infections and cure diseases it was very beneficial for farming, especially a system of farming which involved the rearing of livestock using highly intensive methods. One could also argue from here that the benefits accrued from its use during this period gave way to the normalisation, if not the standardisation, of antibiotic use in agriculture post-Cold War. First approved for use in the USA (1951), the use of antibiotics in animal feed was approved for use by each European state who approved its own national regulations by the 1960s.

Hence, the industrial model of intensive farming of animals came to be exported from America to other countries. Also known as factory farming, industrial livestock production is

[25] This is a part of a theory, "the theory of Unbalanced growth", which proposed that investment in strategic sectors (eg. either industry or agriculture), instead of all sectors simultaneously, would through the effect of 'linkages' lead to the automatic development of the neglected sector. (Akamatsu, 1961) This was proposed as a solution for the efficient use of limited resources especially in developing countries.

a production approach which seeks to maximize output, while minimizing production costs. It had its origins during the Industrial Revolution as improved farming methods were developed to provide cheap food to burgeoning underpaid factory workers moving into urban cities. As rural populations emptied out into cities fewer people were involved in agriculture, therefore, there was a need to improve food production. It is argued that this falling proportion of workers in agriculture enabled the proportion working in industry and services to rise, which necessitated improved agricultural production which eventually made the industrial revolution possible.

In a similar fashion, post-World War II stability and increasing globalisation of the late 20th century can be considered as another economic transition that gave way to the present agricultural practices. Presently, large scale farming as a whole is highly dependent on synthetic chemicals (pesticides, herbicides, fertilisers, and antibiotics). Of these, antibiotics stand out from the rest as they are used by both humans as well as animals and plants, this shared pharmacopeia is what the concept of 'One Health' epitomises.

Nevertheless, as family farms give way to industrial enterprises such cost-profit benefits become even more crucial to the enterprise of growing our food. Furthermore, as large populations of the world migrate from the rural areas to the urban centres as a response to economic changes, so will the pressures on food production change as well. The pressures on food production are considered to be increasing due to burgeoning urban populations as well changes in their diet and consumption (Satterthwaite, McGranahan, & Tacoli, Urbanization and its implications for food and farming, 2010).

That having been said, urban residents are primarily net-food-consumers, and shocks on the agricultural markets have a great impact on them (Matuschke, August 2009), especially on unabsorbed urban inhabitants, i.e., people living in slums. Hence, food security becomes a very important aspect for economic development and population health, and in it, sustainability becomes a central issue. The chicken in this equation plays a vital role as a source of cheap protein and a viable economic activity.

3.2 The creation of the Modern Chicken

The chicken has since established itself ubiquitously as the most domesticated animal on earth (Peters, Lebrasseurc, Dengd, & Larsonca, 2016). From its beginnings as a wild fowl in the jungles of Southeast Asia (Hiromi Sawai, 2010) (Miao, et al., 2012), its domestication (around 2000 BCE) and its diffusion across West Asia, China and the rest of the world, the chicken has undergone many changes due to selective breeding. The impact of which has morphed the chicken into the modern chunky, meaty, docile bird which is epitomized by 'the broiler' chicken. We can observe the transformation of the chicken to its modern avatar from a 1945 agricultural competition called "the Chicken of Tomorrow" (Arnold, 1948) (Davis, 1996, p. 157) (Wiehoff, 2013) (Coe, 2014) (McKenna, 2017). This was a series of competitions for farmers sponsored by the Atlantic and Pacific supermarket chain in partnership with the USDA. The aim was to produce a chicken with a broad breast, plump thighs, from which large drumsticks can be sourced, "all (while) costing less instead of more" (McKenna, 2017, p. 151).

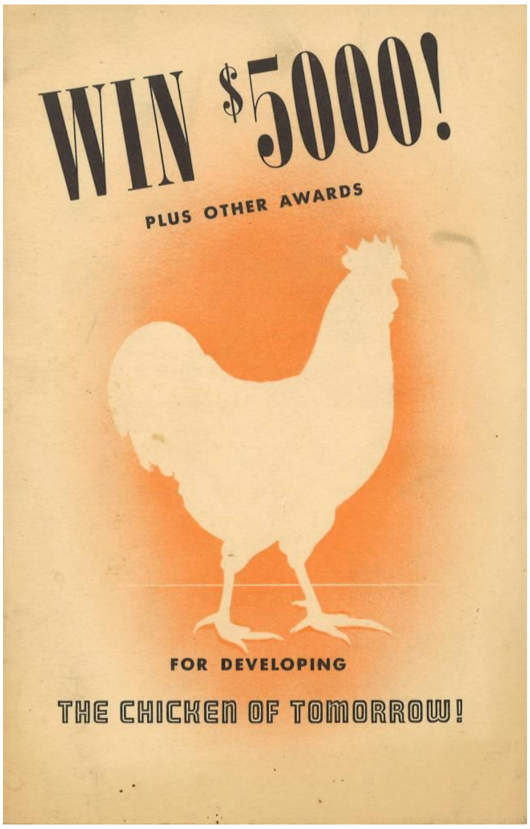

Image 2 Chicken of Tomorrow Poster, , John E. Weidlich Collection at USDA

Presently, chicken is so widely consumed and in such proportions that it is argued that the modern chicken's distinctiveness from its ancestors, will undoubtedly become fossilised markers of the Anthropocene[26] (Bennett, et al., 2018). The reason why chicken has become so popular is because it has the distinct quality of being accepted across cultural boundaries. But the chicken for the most part does not evoke strong reactions unlike other meats such as beef or pork. The other fact is that chicken is a cheaper source of protein; this and other factors (Low production costs, high feed conversion ratios) make it one of the most consumed meats in the developing countries, and the world as a whole (OECD; FAO, July 2018).

[26] The current geological age, a period during which human activity has been the dominant influence on the climate and the environment.

It began as a strategy to provide cheap protein in the stability of the post-war age, the chicken of today is almost four times the mass of its ancestors (Zuidhof, Schneider, Carney, Korver, & Robinson, 2014). Such progression in their mass had been made possible due to, among other things, the growth promoting property of sub-therapeutic dosing of antibiotics. Growth enhancement with antibiotics (sulphonamides) was first observed by P. R. Moore and his colleagues (Moore, et al., 1946). They began with the already establish knowledge that Sulpha-drugs were known to alter intestinal flora in animals. In their paper they state their surprise, "Rather unexpected results were obtained with streptomycin in that increased growth was observed when this compound was fed together with adequate amounts of folic acid" (*Ibid*. p. 438)

However, it was only later, with the discovery by Jukes and his colleagues at Lederle Laboratories (Jukes, 1985) that Aureomycin stimulated significant growth in livestock. This laid the foundation of antibiotic use as a growth promoter. Considering that chickens today require only about one-third the time, with a threefold reduction in feed amount to produce a two-kilogram broiler (Havenstein, Ferket, & Qureshi, 2003, pp. 1506-1507) it shows how they have been altered to become a commercial product. This becomes an even more attractive business investment once the 'factory farm model' or the 'Animal Feeding Operation' model (AFO)[27] becomes standardised in poultry farming. These operations have incredibly large numbers of animals and are fed a specific diet; the main goal of which is to produce animals to sell for slaughter. There are similar operations for other meats as well, such as beef and pork.

The term 'factory farm' is itself an ironic juxtaposition, not only according to the kind of image they provoke but what they indicate. One firmly footed in the language of industry and manufacturing; the factory still provokes dreary Dickensian images of overcrowded workhouses. While on the other hand the farm, romanticised by the prospects of open fields and fresh air, transported to the side of Wordsworth's Solitary Reaper and her melancholic songs. The factory farm largely refers to a business model, the approach and process of intensive or industrial farming to supply to our industrial food system. It has also led to the commodification and standardisation of our food, wherein the market is inclined to accumulate cheap food resources for the consumer while maximising profits is upheld as a primacy (Vivero-Pol, 2017), forgoing more important qualities such as nourishment. Hence,

[27] An AFO is a lot or facility where animals are kept confined and fed or maintained for 45 or more days per year.

the multidimensional features of food are reduced to an economic variable which justifies the means by which magnitude of production supersedes quality.

In many ways, the industrialisation of farming is a product of necessity, given the foundations of modern economics and its dependence on cheap food to sustain cheap labour. As EP Thompson indicated in his essay "Moral Economy of the English Crowd" (1971), that capitalist and state legitimacies are thrown into question when this becomes impossible for a large proportion of the working population. This becomes an increasingly important feature to consider as world population increases and food security and sustainability become keywords for the sustenance of population wellbeing. This is by no means a justification of a consumption pattern supported by “an industrial operation focused on maximizing economic return” (Cassuto, 2007, p. 59) and made possible by the use of agrochemicals. Rather it is a criticism of how the current economic system encourages a pattern of production and consumption wherein the cost to the environment is external to the profit calculus of the industrial food system (Patel, R. & Moore, Jason. W.,)

In 2020, about 33 billion chickens were raised worldwide, some for - meat others for egg production, these ‘modern chickens’ are cheaper, bigger, more productive, but replete with health problems. The relative ease in growing them, teamed with the its potential to bring about rapid economic growth through employment generation and sale of meat makes it one of the fastest growing industries, especially in LMICs.

3.3 Poultry Farming in India

In the 1950s the poultry industry in India was basically a cottage/rural enterprise. The first commercial chick in India was hatched in November 1962 at the Delhi-based Rani-Shaver Poultry Breeding Farms Pvt. Ltd. (Sulaiman, 2003). But within just three decades in the 1990s with the beginning of integrated approach and the entry of foreign technology we see the emergence of corporate farms and an emphasis on cost control and efficiency through automation in operation. This was the beginning of a full-scale vertical integration coupled with entry into export world. This was also when growth in the poultry industry went through an uncontrolled expansion, with a shift from egg production to largely concentrating on chicken farming. Such operations required large amount of feed and antibiotics which till the present is replete with problems.

For instance, a 2017 report by National Environment Engineering Research Institute (NEERI) which raised concerns about the inhumane, unhygienic, and harmful aspects of poultry farming across the State of Haryana (CSIR-NEERI, 2017). This is significant as most of the poultry products coming in to Delhi are from its neighbour. The CSIR-NEERI report recommended a need to provide subsidy or tax exemptions to discourage layered battery-cage rearing of birds, it highlighted the potential for major health hazards to both human and animal health, furthermore a need to regulate antibiotic use, and in no uncertain terms stated that such farming practices pose an unacceptable risk to the environment and to public health.

In February 2018, news reports in national newspaper as well as international papers reported on a study conducted by the Bureau of Investigative Journalism (Davies & Walsh, 2018). The study found that hundreds of tonnes of *colistin* had been shipped to India for the routine treatment of animals, chiefly chickens. Colistin had not been used for treating humans due to its toxicity. But in a situation marked by an already drying antibiotic pipeline and increasing antibiotic resistance it had been designated as one among a few (fourth generation Cephalosporins) antibiotics which were to be kept as reserves.

Earlier studies by the Centre for Disease Dynamics, Economics & Policy found that unregulated use in Indian broiler and layer farms could contribute to the emergence of resistance in clinically relevant antimicrobials (Brower, et al., 2017). The study mentioned above highlight a trend which is worrying, especially bearing in mind the dissemination of resistant bacteria into the environment. A study from Punjab showed that drug resistance is far more common in broiler operations, ranging from twice to twenty times more likely, also the chances of developing multi-drug resistance was found to be more probable in boiler chicken farms (Laxminarayan, et al., 2017).

In India, poultry enterprises are still mostly small but with growing per capita incomes, a growing urban population, and falling poultry prices these factors have been instrumental in driving an expansion in the poultry market. In retrospect the ‘broiler’ chicken was not known in India until the 1970s but the broiler chicks which were ready for the market in just 60 days were more efficient and had tender meat, this made them become significantly popular. The concept of backyard farming also shifted to commercial enterprises. In India, poultry farming can be grouped into three categories i.e., small family farms, developmental poultry farms, and commercial poultry farms. Family farms are mostly maintained for personal consumption, but it is the latter two that may require some elucidation.

3.3.1 Developmental poultry farms

Developmental farms refer to village or unorganized poultry production, this enterprise operates in a small scale, using less capital and traditional technology. The unit volume of production through these means are generally low due to the above constraints. However, the concept of developmental poultry has been very relevant for India's rural areas as they have been earmarked as an activity which could enhance cash earnings of rural poor population as well as contribute to food securitisation. Hence, poultry farming has been included in various Central and State Government sponsored programs, such as Integrated Rural Development Program (IRDP), Special Livestock Production Program (SLPP), Tribal Development Program (TDP), etc. in order to popularize poultry farming in rural areas.

3.3.2 Commercial poultry production

Commercial / industrial poultry production on the other hand refers to large-scale enterprises where the number of birds per unit is large enough to reap the maximum advantages of technological improvement. These enterprises present various economies of scale of operation and, are thus, able to absorb the fluctuations in the demand and supply as well as bear the operation cost of such a capital-intensive venture. The growth of this sector has remained highly significant over the years. However, it has been confined to some pockets of the country.

Nevertheless, as small producers of chicken exit the market in developing countries there has been a consolidation of that space by large companies, followed by an increased technical investment in livestock farming. It is these operations which benefit from both technical and allocative economies of scale which is expressed through the genetic improvement of animals and alteration of their feeds (Narrod, Tiongco, & Costales, 2007). Under the operation described above, disease control becomes an important factor for businesses, for which producers use sub-therapeutic levels of antibiotics. Hence, the use of antibiotics in livestock farming serves three purposes; for growth promotion, disease prevention, and treatment. But cumulatively it protects investment, and unless an alternative which is both economically viable and effective is offered antibiotic use will continue. As it is, studies have shown that antimicrobial (antibiotic, antifungal, antiviral) use in poultry farms was the highest (138 doses/1000 animal-days) among low- and middle-income countries (Cuong, Padungtod, Thwaites, & Carrique-Mas, 2018),and in the absence of any uniform policy in India on antibiotic use indiscriminate use of antibiotics in animal farming will continue.

As the discussion around animal products have shifted from animal welfare to other elements of production, it has failed to grasp the complexities of antibiotic use. Regulations on its use (in agriculture) fails to perceive the intimate relationship between overlapping domains of economics, animal health and welfare. This will be an important area to address if we are to move towards reducing antibiotic use in food animal production. The primary focus presently is in reducing the use of antibiotics that are important to human medicine and to move away from administering antibiotics to large groups of animals through their feeds. However, there are instances where individual treatment is impractical, and instances in which bulk-feeding antibiotics to livestock or poultry is the best approach to treating an outbreak in the flock.

Also, with respect to India as with many other tropical countries, there is an added complexity of its tropical climate which favours the proliferation of a multitude of disease pathogens, vectors, and pests. Hence, from a producer's perspective the presence of disease in a livestock production system not only reduces the efficiency of the resources used in production but also necessitates the use of veterinary remedies.

Commercial factory farms in India have become a full-fledged industry. Transformed within four decades - companies such as Venkateshwara Group (Venky's), Suguna foods ltd., Sky Lark Group, etc. are examples of highly organised, large-scale enterprises that provide a majority of poultry products to urban and peri-urban areas as well as internationally. Of the many varieties of chicken the broiler chicken industry, which is the most widely popular variety of chicken, came about through the import of original stock in 1974.

Year	Milestones
1962	Meat-type strains imported from Israel
1970	All India coordinated research project (AICRP)
1974	Import of Cobb strain
1980	Entry of private sector, pure line stock, multiple-batch farms, urban markets
1995	Introduction of CBF, all-in-all-out batches, rural-based production and urban marketing, improved biosecurity
2000	Growth of CBF, hatcheries, feed mills, feed additives
2010	High-capacity farms with low margins, entry of broiler breeding giants, growth performance matching world standards – 2.2 kg at 37 days with 1.6 feed conversion ratio (FCR)
2014	Institutionalization of CBF

Table 2 Major milestones in the Indian broiler sector (Sasidhar & Suvedi, 2015, p. 7)

The structure of India's poultry industry varies from region to region but integrated large-scale producers now account for a growing share of output in the West and Southern regions of the country. These integrators have all aspects of production, including rearing of grandparents and parent flocks, day-old broilers, contracting production, compounding feeds, and veterinary services. Furthermore, these large integrators are mostly concentrated around big cities. Correspondingly, three-quarters of India's poultry produce is consumed by the one quarter of its population living in urban and semi-urban areas. India particularly is a country of interest with reference to food security and urbanisation, as of 2011 there were about 46 cities with more than a million residents (2011 Census), correspondingly losing farming labour at about 2000 per day (The Economist Intelligence Unit, 2018). Hence, increasingly profitability is becoming a central to the attracting more farm producers. Furthermore, projections estimate that India's meat consumption will rise to 9 kilos (per person per year) by 2050, from a current base of 3 kgs as of now (*ibid.* 2018) signalling huge pressures on the ecosystem as well the use of farming supplements such as fertilisers, herbicides, pesticides, and concerningly antibiotics as well.

Chapter IV

Feeding a city: Urbanisation and its impact on Antibiotic Resistance

The dominant place that food has in our lives is evident in the everyday activities that surrounds it and is composed of it. Religious practices across the globe have elements of food preparation, presentation and representation; festivals are organised celebrating the sowing and harvest of food, and our very evolution in to civilisation building beings has been predicated on our ability to 'domesticate' plants and animals. In the process, we have engineered means to increase yields and decreased their growing time. We have decreased the loss of crop by tweaking their genes, artificially fertilizing the soil and using by pesticides, and have preventing agricultural diseases by using antimicrobials. In this way we have industrialised farming itself, and for these practices there have been much criticism, especially from people arguing for a more ethical, sustainable, non-polluting, eco-conscious way of farming. There is none as archetypal in influencing this adjustment in attention than that of the contribution of Rachel Carson. Rachel Carson in her seminal work 'Silent Spring' (1962) writes about the indiscriminate spraying of pesticides in America, specifically DDT, in agricultural fields and its impact on environmental, and thereby, human health as well.

The use of antibiotics in food production is in many ways similar to when DDT was used in the 1950s and 60s. DDT or dichloro-diphenyl-trichloroethane, was the one of the first synthetic insecticide to be developed in the 1940s. It was just as important a feature of the war arsenal during the Second World War as were other instruments of warfare just as antibiotics were. DDT was used for combating insect borne disease such as typhus and malaria during and after the war. In a similar way, antibiotics production was amped up during the war, it was so precious that soldiers who were treated with it had their urine collected, crystallised and reconstituted penicillin from it was used to treat other soldiers who were wounded. Their use was immediately recognised during the Second World War, after which they transition to it being used during peace times in very indiscriminate ways. Specifically, in agricultural.

While the effects of using pesticides can be visualised, by killing insects, small mammals, birds; the effects of antibiotic misuse are not as straightforward. But a simple explanation is as follows: bacteria are not all bad, there are many commensal 'bugs' that live on, around, and in us. There is a balance between different bacteria, which under the right environment ensures that the body remains healthy. When one contracts a bacterial infection, it is generally considered as a proliferation of a harmful strain of bacteria. Hence, after diagnosis and lab culture an antibiotic is prescribed, whose function could destroy said bacteria or stop the proliferation of more bacteria, thereby halting the ongoing infection. However, antibiotics do not work as precisely and efficiently, some antibiotics have been likened to a 'carpet bomb' (broad-spectrum antibiotics), as the drugs attack indiscriminately, neutralizing the good bacteria in addition to the bad ones. In the process some bacteria remain which are 'resistant' to the drug and they proliferate. There have also been studies conducted that show that this resistant quality could be exchanged between taxonomically diverse bacteria (Barlow, 2009)(also known as '*horizontal transfer*') through the exchange of information in their plasmids (Domingues, Nielsen, & Silva, 2012).

Nevertheless, bacteria resistant to toxins occur unsurprisingly in nature (Martínez, 2008) (Aminov, 2009) (Heather K. Allen, 2010) (D'Costa, et al., 2011), and has been an long-standing problem. For instance, bacterial resistance to Salvarsan even predates the discovery of Penicillin by Alexander Fleming (Silberstein, 1923), and penicillin resistance genes have been found to have existed before Fleming ever discovered penicillin (Kashuba, et al., 2017)[28]. What is of concern is the rate at which previously non-resistant bacteria are evolving to become resistant due to anthropogenic activities (Tripathi & Cytryn, 2017) (Zhu, et al., 2017) (Pruden, Arabi, & Storteboom, 2012) (Rita L. Finley, 2013). Among which, the use of antibiotics in agriculture is one of the greatest contributors to the development of antibiotic resistance. However, there are no simple answer as to how infectious agents build resistance as there are a range of biochemical and physiological mechanisms which may be responsible (Davies & Davies, Origins and Evolution of Antibiotic Resistance, 2010).

A common feature in most journal articles on antibiotic resistance is a high-profile review commissioned by the United Kingdom government. Compiled by Lord Jim O'Neill and his team entitled, "*Antimicrobial Resistance: Tackling a crisis for the health and wealth of nations*" (the AMR Review) (O'Neill, 2014), the review estimated that deaths attributable to AMR compounds to 700,000 each year, and by 2050 this number would rise to 10 million deaths each year (*ibid.* p.4). What the review emphasises for, through the numbers and its somewhat debatable title, is the fact that action is required urgently. This has been a chorus for most researchers since the inception of antibiotics. However, almost 80 years after the widespread use of penicillin in the Second World War, and further a century's knowledge of

[28] The study by Elena Kashuba, et al (2017) found that isolated ancient bacteria strains of Staphylococcus hominis species unearthed from permafrost had a close relation to modern bacteria of the staphylococci species which had genes that were resistant to different groups of antibiotics (beta-lactams being one of them).

bacteria's propensity for developing resistance we are 'supposedly' in a more precarious position than ever before.

Reflecting on this situation, a term that has taken over the imagination of the popular press, and social media outlets is that of 'super-bugs'. It is a term used to describe drug-resistant microbes (bacterial, fungal, viral, parasitic), the therapeutic options for which are reduced, accompanied by extended hospitalisation and therefore increased cost to the patient (Davies & Davies, 2010).

The discovery of antibiotics allowed for humans to effectively fight back against the invisible world of microorganisms effectively for the first time. It expedited recovery from diseases which were debilitating and lethal, and provided an alternative to, if not an end to, treatment by *heroic medicine*[29] of the Middle Ages (Rosen, 2017). The cause of this resistance is tracked to a myriad of problems regarding overuse, underuse, and misuse resulting in what has come to be considered as "an evolutionary arms race". Therefore, in a very Darwinian sense, the logic of evolution is operating in an alarming way (from an anthropocentric perspective) altering organisms that are known to cause disease. And antibiotics, considered the backbone of modern medicine, are failing in their abilities to fight against bacteria which they previously were effective against. Hence, it is argued that when antibiotics fail so will the conveniences of surgeries, chemoprophylaxis, and modern medicine in general (Furness, 2012) (Sheth, 2016) (Wiffen, 2018). Therefore, we are asked to become 'stewards'[30] of this precious commodity (Edward J. Septimus, 2011) (Bartlett, 2011) (Shira Doron, 2011) (WHO F. O., 2017), to use it judiciously and appropriately.

Additionally, the fact that antibiotics are considered as a commodity, a shared resource, has brought up debates on whether resistance has developed as a result of and due to '*a tragedy of the commons*' (O'Brien, et al., 2014) (Hollis & Maybarduk, 2015). Or due to its use for non-medical activities such as in agriculture, animal husbandry, bee-keeping, aquaculture, horticulture, food preservation, etc. (Manten, 1963) (Meek, Vyas, & Piddock, 2015). Coupled with this is the scarcity of new antibiotics, it is scarce because the business model for the research and development of anti-infectives is challenging.

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[29]Heroic medicine has been a popular term used to describe the draconian medical practices of the 18th-19th centuries that included bleeding, blistering, purging among other practices.

[30] By stewardship they mean: to "preserve antimicrobial medicines by taking measures to promote control, appropriate distribution as well as appropriate use" (WHO, 2017, p. 4). But here again practitioners do not agree as to what is the right way to use this scarce resource in order to prevent bacteria from devising ways to overcome its potent ingredients.

Antibiotic-resistant microbes are now artificially distributed throughout the biosphere, generations of which have developed through selection pressures from human applications (Davies & Davies, Origins and Evolution of Antibiotic Resistance, 2010), cultured principally from our healthcare and food industry. Additionally, bacteria can also transfer resistant-gene from one to another forming resistance to antibiotics to which it has never been introduced to. Subsequently, many well-intentioned restrictions and rules have been proposed and recommended for combating antibiotic misuse, however, we err on the side of delaying the inevitable.

Hence, antibiotics and their consumption are intimately connected to environmental health and population health. This concept becomes even more pertinent when we consider the fact that antibiotics used for agricultural purposes is, in part, considered a major threat to global health by the WHO and the CDC. Also since, infectious disease prevention is of a primary concern, considering a most pressing developments in drug resistance tuberculosis, MRSA, foodborne diseases, hospital-acquired infections, and the burden of opportunistic infections, increasing urbanisation and its pressures on food production are becoming major drivers of antibiotic resistance.

4.1 Urban Agriculture: A Significant Factor in the Dissemination of Antibiotic Resistance

Urbanization is one of the key drivers of change in the world. It is a challenge not only for urban areas but also for rural areas. In 1900, there were close to 6.7 rural dwellers to each urban dweller worldwide; now there is less than one and projections suggest that by 2025 there would be close to three urban dwellers for every two rural dweller (Satterthwaite, McGranahan, & Tacoli, 2010). With urbanisation comes increased pressures on resources, such as food and water supply; and the added problems concerning waste management and crowding leading to unsanitary often disease prone areas. A UN report estimated that about 34 percent of Indians now live in urban areas (UN World Urbanisation Prospects 2018 Report). The report also stated that India has the largest rural-population, but it is estimated that by 2050 that India will have added 416 million urban dwellers. Another study suggests that by 2025, 60 percent of Indians are likely to live in cities. As is already, Mumbai was projected to become the world's largest megacity in 2015 with 28.2 million residents, with Delhi in the eighth place: with 17.8 million population (United Nations: Department of Economic and Social Affairs, 2000). A 2014 revision of the same report shows Tokyo followed by Delhi, and Mumbai in sixth place, Kolkata in fourteen places, together they account for 60.45 million residents (United Nations: Department of Economic and Social Affairs, 2014).

Most cities in developing countries have great difficulties coping with this development and are unable to create sufficient formal employment opportunities for the poor (Lucas, 1997) (Cole & Sanders, 1985) (Todaro, 1980) . They also have increasing problems with the disposal of urban wastes and managing of waste water, and maintaining air and water quality. In this scenario urban agriculture provides a strategy to provide employment, reduce urban poverty and food insecurity and enhance urban environmental management. Alternatively, urban agriculture plays an important role in enhancing urban food security, it also contributes to local economic development, poverty alleviation and social inclusion of the urban poor and women in particular, as well as to the greening of the city and the productive reuse of urban wastes.

Another report by the Food and Agricultural Organisation (FAO) outlines that global food demand is set to increase by at least 60 percent by 2050, and global meat consumption alone will double as populations grow, especially in developing countries (FAO, The State of Food and Agriculture: Climate Change, Agriculture and Food Security, 2016). Hence, the Food and Agricultural Organization of the United Nations (FAO) has identified urban and peri-urban agriculture as a farming system that can contribute to domestic food supply, nutritional security, jobs, and improving urban ecology as well as sanitation. Thereby suggesting the potential of urban agriculture to achieving poverty alleviation, food security and sustainable urban development. The FAO defines urban and peri-urban agriculture as an industry located within (intra-urban) or on the fringe (peri-urban) of a town, a city or a metropolis, which grows and raises, processes and distributes a diversity of agriculture products, using largely human, land and water resources, products and services found in and around that urban area. It has also been defined as any “agricultural enterprise located within or on the fringes of a town, a city or a metropolis, which grows or raises, processes and distributes a diversity of food and non-food products” (Addo, 2010, p. 497),

While food and nutritional insecurity are often considered a rural phenomenon, there is increasing insecurity, largely among the urban poor, as the percentage of urban population growing their own food is miniscule. Furthermore, social and financial factors including non-availability of food, price fluctuations, and poverty disrupts the pillars of urban food security, i.e., access, affordability, utilisation and stability. Hence, there is considerable undernourishment and deficiency of calorie intake in India’s urban areas. Urban agriculture or peri-urban agriculture is not only touted as a solution to this problem but is also considered as a sustainable solution to the growing challenge of wastewater and solid waste management. However, wastewater used for urban agriculture in the city represents a high risk for spreading bacteria and antimicrobial resistance among humans and animals (Bougnoma, et al., 2019) (Bougnom & Piddock, 2017).

More concerning still is urban and peri-urban livestock agriculture in India. Cows are a frequent sight in Indian cities, but more still are goats and pigs especially around slums, and the ever-present stray dogs. These populations of both food-producing animals and stray animals in cities exacerbate public health hazards as the transmission of zoonoses, vector-borne diseases, and environmental pollution. At present, public health hazards due to urban animal husbandry practices are considerably under-estimated.

4.2 Changing Food consumption in India

Culture and tradition, as is in most developing countries, play a very crucial role in the determination of food patterns in India (Devi, Balachandar, Lee, & Kim, An Outline of Meat Consumption in the Indian Population- A Pilot Review, 2014). The fact that a large population of Indians are lacto-vegetarians, India is considered to have one of the lowest per-capita consumptions of meat in the world (ICFA, 2018). With an average per capita consumption of 3.1 kgs per year it is much lower than the global average of 17 kgs per year, and of India's protein consumption two-thirds are expected to come from poultry (*ibid.*). However, India is still considered as a major contributor to the meat export market, especially of poultry meat; and China, the United States, India and Brazil, it is estimated, account for over three-fifths of global antibiotic use in animal production (OECD/FAO, 2018).

India is also considered as the largest producer of milk and second-largest producer of fish, for all these markets driven production the non-therapeutic use of antibiotics is high (Kakkar, Walia, Vong, & Chatterjee, 2017). As for poultry, within a span of 25 years, the egg production in India has gone up to 70 billion from a few millions and the broiler production has gone to around 42 million tons in 2016.

On average, the top 5% of India's richest urban population spend the most on food and consume 1.5 times more pulses, 2.6 times more milk products, 2.4 times more eggs, fish and meat than the mid-40 to 50th percentile urban group (Household Consumer Expenditure Survey, NSSO, 2017). Compared to the poorest 5% rural population the top percentile spends three-and-a-half time more on pulses, 23.8 times more on milk products, 14.5 times more on eggs, fish, and meat, and 61 times more on fresh fruits.

An analysis of consumption patterns compiled by the FAO show an increase in the calorie intake of Indians. In 1961 the average intake per day was 2010 kcal compared to 2458 kcal in 2011 (FAOSTAT). In terms of food spending by 2025, meat and poultry are estimated to account for 30.7%, bread, rice, and cereals at 23.8%, and fruits at 16% of the total food spending in India (Deolitte & CII, 2021).

Research Paper	Findings
Brower, Charles H., et al. (2017) "The prevalence of extended-spectrum beta-lactamase-producing multidrug-resistant Escherichia coli in poultry chickens and variation according to farming practices in Punjab, India". *Environmental Health Perspectives* 77015, 1.	1,556 isolates of E. coli obtained from cloacal samples of 530 birds were tested for susceptibility to 11 antibiotics
Shrivastav, Arpita, et al. (2016) "Study of antimicrobial resistance due to extended spectrum beta-lactamase-producing Escherichia coli in healthy broilers of Jabalpur." Veterinary World 9.11, 1259	ESBL-producing E. coli in poultry was 33.5%.
Samanta, I., et al. (2014) "Prevalence and antibiotic resistance profiles of Salmonella serotypes isolated from backyard poultry flocks in West Bengal, India." Journal of Applied Poultry Research 23.3: 536-545	the prevalence of Salmonella species in healthy chickens and their environment was 6.1%, and they were 100% resistant to ciprofloxacin, gentamicin, and tetracycline
Singh, Renu, et al. (2013) "Antimicrobial resistance profile of Salmonella present in poultry and poultry environment in north India." Food Control 33.2: 545-548.	The prevalence of Salmonella species was 3.1%, and they were moderately resistant to various antibiotics: Ciprofloxacin: 11.5% Gentamicin: 7.7% Tetracycline: 23.1%
Naik, V. K., et al. (2015) "Isolation and molecular characterization of Salmonella spp. from chevon and	The prevalence of Salmonella species in chicken meat samples

chicken meat collected from different districts of Chhattisgarh, India." Veterinary World 8.6, 702	was 7%, and they were 100% resistant to erythromycin but 100% sensitive to ciprofloxacin.
Kaushik, Purushottam, et al. (2014). "Isolation and prevalence of Salmonella from chicken meat and cattle milk collected from local markets of Patna, India." Veterinary World 7.2 (2014): 62-65.	The prevalence of Salmonella species in chicken meat samples was 23.7%, and they were 100% resistant to ampicillin, moderately sensitive to ciprofloxacin, and highly sensitive to ceftriaxone
Kar, Debasish, et al. (2015) "Molecular and phylogenetic characterization of multidrug resistant extended spectrum beta-lactamase producing Escherichia coli isolated from poultry and cattle in Odisha, India." Infection, Genetics and Evolution 29 (2015): 82-90	ESBL-producing E. coli in poultry was 9.4%.

Table 3 Evidence of Antibiotic Resistance isolates in poultry

Hence, despite India's reputation as a predominantly vegetarian country the consumption of animal protein is increasing, and primarily chicken as it falls in a socio-cultural island. Considered a universally acceptable meat in India, with no religious taboos attached to it, chicken consumption in India has been increasing with improving socio-economic conditions. India is an emerging economy and the poultry industry is but one of the sectors that saw tremendous growth. On the other hand, the affordability, taste, versatility and ease of cooking makes chicken a preferable choice (Devi et al., 2014), mostly among the young population (15 – 25 years) (Subashree A, 2022). Additionally, the demand for chicken for preparing traditional dishes like biryani, tandoori meats, butter chicken, etc. have become complimented with the establishment of Western fast foods like McDonalds, KFC, Burger King, etc. While meat consumption in India varies with religion, culture, and region, there has undoubtedly been a corresponding uptick overall due to rising urbanisation, increasing disposable incomes, globalised cultural influences (Devi et al., 2014). Currently, food culture in India faces a dissonance between traditional and 'Western' mainly in urban centres.

4.3 Urbanisation pressures on food production

Land scarcity in many countries have been leading to increasing inclination towards intensive agriculture. New forms of urban agriculture, while ingenious still have to prove their penchant for sustainability; hydroponics, aquaculture, terraced greenhouses, urban farms, have propped up in congested cities but serve a particular clientele. That having been said, the demand for protein rich animal foods still requires space and considerable planning. Above all, the prices of food items need to be stable. Urban populations, as such, are net food buyers and spend a considerable amount of their income on food. Furthermore, urbanisation complemented by high growth in incomes have resulted in increasing demands for high-value products like meat, fish, fruits, etc. (Delgado, Rosegrant, Steinfeld, Ehui, & Courbois, 1999). Hence, in their paper Delgado, *et al*, argue that a revolution is underway, driven by demand side pressures. They also warn that governments and industry should be prepared as this 'revolution' would stretch "the capacity of existing production and distribution systems and exacerbate environmental and public health problems" (*ibid.* p-1). This statement, while made almost two decades ago, is still as substantial as it was then, maybe even more so.

While demand side pressures play a major role in the production of livestock it is the way production systems have reacted that is the subject of this thesis. The fact is modern intensive (mass produced variety) livestock farming is shepherded on the backbone of antibiotic use. For one, it is arguably the single most important and singly one of the most widely used medical intervention of the present era (Heilig, Lee, & Breslow, 2002)

Such market tendencies have increased the risks of contracting resistant bacteria in the community and from healthcare institutions. Such a global health catastrophe joins the ranks of other global risks such as global warming and nuclear fallout in situating the problem as a by-product of the pursuit of benefits that have become essential to societies and communities. But these risks are experience asymmetrically by certain sections of the community more than others, however, discussions on the topic of individualistic risk have increased exponentially. Such changes can be attributed to a shift in late modernity which has come to be organised around information, technology, consumption and new risks.

Chapter V

One Health and the new Risk class

"Antibiotic therapy, if indiscriminately used, may turn out to be a medicinal flood that temporarily cleans and heals, but ultimately destroys life itself."

Felix Marti-Ibanez, 1955

a. The new risk-class

b. The Complexity of ABR and its Challenges: A Wicked Problem

c. Covid19 pandemic parallels with the silent ABR pandemic

The term "**One Health**" is fairly new; however, the essence of the concept has long been recognized and hinted at since the 1800s. Presently, the term has been brought around to address the problem of increasing zoonosis, and is a popular term in the lexicons of public health, animal health, and other auxiliary departments. Especially, with the antimicrobial resistance discourse and concerns relating to the shared pharmacopeia hindering decades of progress of effective treatments to antique illnesses. The "One World – One Health" concept (and fittingly "one medicine") serves as a useful tool to understand the problem of antibiotic resistance, by rationalising our existence as part of the larger ecosystem it recognises that changes to environment directly or indirectly impacts human health.

1800s:

Many drugs used to treat animals are the same as, or similar to, drugs used for human health care. Concurrently, many diseases transfer from animals to humans, and through our globetrotting ways we transfer diseases to foreign fauna as well. One Health emphasises this concept, it is an approach that recognises that the health of people is closely connected to the health of animals and our shared environment. Such a notion has been conceived *ad infinitum* as a 'basic condition of life on earth'. Hippocrates identified the interdependence of Health in his book 'On Airs, waters and Places. Virchow in the 1800s recognised the linkages between animal and human health when he discovered that the human disease trichinosis could be linked to the parasitic worms in raw or undercooked pork (Kahn, 2008). This, along with other evidences from the time led him to postulate the idea of zoonosis. That is, a disease or infection than can be transmitted from animals to humans. Sir William Osler, a Canadian physicians and pathologist, was greatly influenced by Virchow as he studied under him in Berlin. He continued this line of thinking and famously coined the phrase ‘One Medicine’ (R. Cardiff, 2008), a theme he lectured to both veterinary and medical students in the Montreal Veterinary college and McGill University, Montreal.

1900s:

Jonas Salk and his polio vaccine found its foundation in the research of veterinarian Daniel E. Salmon, who worked with physicians in the early USDA Bureau of Animal Industry. Their research was monumental as it was discovered that heat-destroyed pathogens could be used for immunising animals and humans against live pathogens (Thomas P. Monath, 2010). Other cornerstone research in establishing human-animal disease interlinkages include John McFadyean (1853-1941) who established that Bovine Tuberculosis impacted human health, thereby challenging Koch’s assertion that there was no association between milk and milk products and the transmission of Tb to humans.

However, the concept of One Health lost substance in the early 1900s. In 1961 the US Government published a document titled ‘Veterinary Medical Science and Human Health’, it was compiled by the Subcommittee on Reorganisation and International Organisations as part of their international health study. In it they concluded that veterinary medicine is “an indispensable element od research in problems of human health” a clear illustration of which is in the research involving viruses (p. XVIII-XIX). Calvin W. Schwabe wrote in 1964 that ‘herd medicine’, which was a fundamental concept of veterinary medicine, had been borrowed by physicians. As the descriptive terminology ‘herd factors’ had become increasingly popular and applied to “population phenomena of epidemiological importance” (Schwabe, 1984, p. 34). In his book Veterinary medicine and human health, he about wrote about how veterinary medicine and human health are interrelated. Additionally, he wrote on veterinary medicine its significance public health, social science, and also mentions the importance of ecology as well. Stating that “disease may either be a form of or a consequence of ecological imbalance”. This position reinitiated the position of environment in the concept of One Health, and he is known for coining the term ‘One Medicine. His work revitalised the waning interest in this concept of a unified approach to understanding human health and tackling zoonotic disease.

2000s:

Throughout history, the detrimental recurrence of zoonotic diseases has been recoded. The Plagues of the dark Ages, Malaria and colonialism, the Spanish flu during the early 20th century, and in current history HIV/AIDS, Ebola, SARS, SARS-CoV-2 are all examples of zoonotic diseases. The fears of antibiotic resistance have renewed this fervour to establish a unified concept of health. This was considered in order to stem the use of antibiotics which are the same for veterinary medicine as well as for humans. The complications that arise out of this commonality is considered to be the 'most urgent health risk of our time' and that which 'threatens to undo a century of medical progress' (WHO Chief, Tedros Adhanom Ghebreyesus). Hence, the concept of *One Health* has been embraced, among other interventions, to provide solutions to this problem, while adding another dimension of food along with human, animal, and environmental health.

Aligned with the above values, on the 29th of September, 2004, the Wildlife Conservation Society brought together a group of human and animal health experts for a symposium titled "Building Interdisciplinary Bridges to Health in a 'Globalized World',". This symposium was held at the Rockefeller University, New York City. Attendees to this symposium discussed the movement of diseases among humans, domestic animals, and wildlife and set 12 priorities to combat health threats to human and animal health. These priorities came to be known as the "Manhattan Principles," formed the basis of the "One Health, One World" concept which called for an international, interdisciplinary approach to prevent disease. The principles outlined a holistic approach which also spoke of maintaining ecosystem integrity for humanity's benefit, their domesticated animals, as well as to preserve biodiversity which serves as a foundational support for all life on Earth.

On December 4th, 2007, a two day 'International Ministerial Conference on Avian and Pandemic Influenza' was held in New Delhi, India. Representatives of 111 countries and 29 international organizations came together and encouraged governments to build linkages, for pandemic preparedness and human security, between animal and human health systems. Then in 2008 two important events solidified the call for the 'One Health' approach agenda. The first being the 'International Ministerial Conference on Avian and Pandemic Influenza', in Sharm el-Sheikh, Egypt. In which a strategic framework for reducing the risk of infectious diseases through human-animal confluence was endorsed. The other event was a product of

the 2007 New Delhi conference, where in 2008 international organisations (FAO, OIE, UNICEF, WHO, UNSIC, and the World Bank) came together to develop a document titled "Contributing to One World, One Health: A Strategic Framework for Reducing Risks of Infectious Diseases at the Animal-Human-Ecosystems Interface".
In 2009, the One Health Office was established at the CDC, in order to serve as a point of contact for external animal health organisations. Furthermore, a technical meeting held in Canada on March of the same year, was attended by experts from 23 countries to discuss the strategy and objectives of One Health.

2010 was a busy year, In April 71 countries along with representatives from international stakeholders adopted a declaration which forwarded the case for implementation of One Health. Then in May the CDC, WHO, OIE, and the FAO came together in Stone Mountain, Georgia, USA, the experts from which identified clear action plans to move One Health from concept to implementation. The UN and the World Bank also recommended the adoption of the One Health approach in order to respond to a broad range of emerging and existing threats. In August the same year the European Union committed to operate under the One Health framework. In 2011, the first International One Health Congress was held in Melbourne, Australia.

Two of the major objectives of One Health is i.) Research - to identify the most effective way to promote health, and ii.) Education – for increasing awareness and to develop a workforce trained in the principles of One Health (Gibbs, 2014). Other One Health concerns involving animal-human interface and ecosystem preservation relate in many ways to the animals reared or hunted for inclusion into the food production and consumption chains. The problem in this sector has been the lack of collaboration between animal health and human health (inclusive of food safety) institutions (Wielinga & Schlundt, 2014). With the industrialisation of food and its subsequent stretching of distance between farm-to-fork through globalisation, the problem of food safety has become a global problem. However, differing levels of safety standards and functional inspection offices within and across countries make this a challenging prevention mechanism. Food is a significant vehicle for many zoonotic diseases, and while human intervention through medicine has reduced events of transmission it has also shaped unforeseen consequences.

However, consequences are dependent variables, one's class, caste, gender, age, weight, genes have a significant bearing on the health outcome of a person. If we are to consider gender as a variable; there are more women working in the health industry making them more prone to contracting infectious pathogens, control over and access to resources are largely limited for women, caring for livestock in agricultural setting are largely carried out by women, and most drug trails are mostly done on men. Compound these factors with economic strife and then we can clearly see that while all are at risk of contracting antibiotic resistant pathogens, some are more vulnerable than others. Such distinctions are important to make while drafting policy interventions. In line with this ideation, infectious disease literature must be revisited as many diseases, thought to have been brought under control or pushed to the margins, threaten to remerge.

Despite possessing the tools for its elimination most developing countries continue to have high mortality and morbidity due to infectious diseases. Furthermore, studies on ABR in LMICs show considerable evidences for concern (Bagcchi, 2021; Byarugaba, 2004; de J. Sosa et al., 2010; Farrar, 1985; Hart & Kariuki, 1998; Hassan, 2020). If we consider the chronic disease burden in developing countries to this equation then the task at hand seems even more formidable.

5.1 The New Risk Class

"Poverty is hierarchic, smog is democratic"

(Ulrich Beck, 1992, p. 36)

This above statement by German social scientist Ulrich Beck, was his analysis on the risks of modern society. Simply stated, it means that some problems are hierarchal wherein class-based inequalities determine life chances (Curran, 2018). Money and position can buy people freedom from certain risks; however, some risks are a 'democratising force'. This is what Beck discusses in his book "The Risk Society". According to him, one of the dominant themes of our culture today is a shift from a class society to a risk society. He argues that as a result of industrialisation, risks are global and any attempt to externalise risks, for example - to other countries, is likely to have a boomerang effect. In a later lecture he gave in 2006, he revisits this concept noting that "the narrative of risk is a narrative of irony" (Beck, Living in the world risk society, 2006). It is ironical because highly developed institutions of modern society …attempt to anticipate what cannot be anticipated" (ibid. p.329).

While smog is democratic, the exposure to the ill-effects of smog can be said to be discriminatory, with air purification technologies smog becomes a greater threat to the health of the poor, the ill-of-health, the old and very young; those that cannot afford such technologies. Hence, Ulrich Beck's definition of risk was that of a changing, evolving concept that changed with the industrialisation of societies, and in industrialised modernity Beck considers nature and society to be interwoven. That is, natural exploitation has a direct impact on society and changes in society has an impact on nature (Beck, 1992). While risk is inherent in any society, the development, modernisation, and industrialisation of that society brings with it new risks. For instance, the invention of the automobile created the risk of car accidents. Concurrently, the discovery and mass production of antibiotics removed a major risk of death due to bacterial infections, and reintroduced the same risk in a society overtly dependant on antibiotics. In medicine 'risk' refers to a factor which modulates the probability of a disease or event occurring or worsening in the individuals in whom it is present (João Costa, 2011). This definition when applied culturally leads to a conceptualisation of risk as the outcome of a combination of material conditions and sociocultural processes as well (Fox, 1999). The new risk class definition follows a constructivist approach to risk that argues that "in late modernity, social and political order are threatened by unprecedented anthropogenic risks, resulting from scientific and industrial development" (Capurro, 2020). The discussion on risk is the ever-increasing number of them, hence, according to Beck 'risk management' is the main feature of modernity. Beck contains within his definition of risk the chaos and uncertainty discussions of postmodernism.

Beck's analysis rejected class analysis of society but presented a risk-class as an egalitarian distribution of risk in the modern world. According to him, modern society has been increasingly occupied with debating, preventing and managing risks that it itself has produced. Hence, Beck's analysis considers risk as side-effect of modern life, affecting people equally despite class differences, has its merits, it is not always a suitable analysis. For instance, the socio-economic level of people determines their living standards, their exposure to environmental risks, their capacity for reacting and recuperating from catastrophic events, and their access to superior quality of food, water, healthcare, etc. These factors determine that his statement is but a simplification of a more complicated reality. However, that being said, it provides a very fertile bed for thought experiments. The resulting discussion of which could help in decision making for policy and planning.

The other sociologist who developed the concept of a ‘risk society’ was British sociologist Anthony Giddens. This grand theory of society argues that society is transitioning to an era distinguished by technological hazards due to the modern industrial character of our present society. Both Ulrich and Giddens approach this concept from the perspective of modernity, their differences lie in that -Giddens sees risk society generating from a preoccupation with the future and of safety (Giddens & Pierson, 1998, p. 209), whereas Ulrich Beck saw risk as “a systematic way of dealing with hazards and insecurities induced and introduced by modernisation itself” (Beck, 1992, p. 260). Therefore, a ‘risk society’ can be comprehensively be defined by ‘technological hazards’; its distribution of goods (wealth) as well as its ‘bads’ (the by-products of production) (Baxter, 2020, p. 305).

Burgeoning antibiotic resistance from anthropogenic pressures too constitute as a technological hazard, a failure of infrastructure – the expected outcome of which has been calculated in monetary terms, loss of work-days due to illness, disability and loss of lives. Therefore, while the risk from antibiotic resistance is democratic, the complexity of risks associated with it make some people more vulnerable than others. It is a combination of environmental, socioeconomic, and behavioural risks, the combination of which this thesis argues, is importunate for those with limited material wealth. Especially without the presence of effectual infrastructural institutions. These conceptualisations of risk are important in order to extricate appropriate risk responses, especially when we consider them in the light of factors such as a global ageing population, reduction of investments in preventative health, increased human-animal contact, swelling human conflict, etc.

Furthermore, considering the fact that antibiotic resistant genes have been isolated from the air (Li et al., 2018), water (Hatosy & Martiny, 2015), soil (Martínez, 2008; McCann et al., 2019; Riesenfeld et al., 2004) in the Namib desert (Naidoo et al., 2020), and the Antarctic (Marcoleta et al., 2022) it is certain that infectious diseases will endure. Hence, newer antibiotics will be required irrespectively, however, the potency of our existing antibiotic arsenal must be ensured as well. One of the most sustainable ways to achieve this would be to invest in prevention and reduce transmission. Studies conducted by UCLA researchers on the death toll from bacterial antimicrobial resistance (AMR) worldwide estimated that in 2019

4.95 million deaths could be associated to resistant bacteria, another 1.27 million deaths attributable to ABR bacteria (Murray et al., 2022a). In comparison, WHO puts the official death toll of Covid-19 in 2020 to be 1.8 million and another 1.2 million more attributable deaths, to make a total of 3 million deaths. Compared to the past the dread associated with bacterial infections (plague, tuberculosis, cholera, typhus, leprosy, syphilis) has become replace with complacency. Bacterial diseases, and other infectious diseases, have lost its potency due to the antibiotic era, increasing immunizations, and improved public health measures - which have led to the fact that "we now live longer and tend to die later of chronic diseases" (Relman et al., 2009. p. 196). Additionally, we are also eating more than we ever have in history and to a large extent it is due to antibiotics, the question as to whether we are living healthier is another issue.

Hence, the pool for people at risk of contracting bacterial infections vary according to different dimension in ecology, economy, age, etc. However, the risks are growing even graver as other factors such as environmental change and changing global demographics (infection rates increase with increased temperature/temperature is linked to bacterial processes). These same pressures are responsible for food insecurity, as climate become unpredictable tonnes of crops are lost either due to unexpected rains, or spells of drought like conditions.

The issue with antibiotic resistance is that even though there are a lot of morbidity and mortality associated with it – awareness continues to be a problem. The issue being the deep embeddedness of antibiotics to modern living, the invisibility of infrastructure. However, patient stories have become a powerful tool to convey the extent of the risk and the gravity of the problem. For instance, the harrows of a resistant infection are perfectly captured in Steffanie Strathdee's book '*The Perfect predator*', she (a distinguished infectious disease epidemiologist) writes a horrific account of her effort to save her husband's life after contracting an antibiotic-resistant bacteria (*A. baumannii*) during their holiday in Egypt. She writes, "If we had any chance of outsmarting this superbug, we'd have to adapt ourselves and our medical arsenal, strategy, and tactics for this new fight" (Strathdee & Patterson, 2019). In her narrative she acknowledges the position of privilege she and her husband shared, as eminent professionals working in a medical university with friends in positions of influence in some of the best hospital in the world. The Infectious Disease Society of America (IDSA) too has a page in their website dedicated to patient stories of their battle with antibiotic resistant infections. However, the most common associated we have with bacteria is through the food we eat. Food poisoning is very common but most cases are not severe enough to consider hospitalisation. That being said, WHO's global estimates show that almost one third (30%) of all deaths from foodborne diseases are in children under the age of 5 years, despite the fact that they make up only 9% of the global population (WHO, 2015). While this report accounts for allergies, chemicals and toxins, parasites and viruses, bacterial hazards are globally distributed at higher levels responsible for foodborne illnesses.

Hence, from the above extrapolation it is clear that in this rapidly changing, complex, and progressively more interconnected world new risks are being created. And inherent in this new dynamic is the changing interface between people, animals, and the environment: an interface that is accelerating and becoming increasingly more consequential (see: SARS Cov2, Zika, Ebola), and antibiotics have only added to this complexity.

5.2 The Complexity of ABR and its Challenges: A Wicked Problem

The One health paradigm of antibiotic resistance gives us a sense of the complexity of the problem. It also informs the response required to mitigate it, i.e., a collaborative approach, was necessary as antibiotic use spans multiple actors, departments, institutions, and stakeholders. Furthermore, ABR presents us with multi-layered problems; for one, the more it is used the more resistance develop, however, if used sub-optimally the same. Also, antibiotics work in a spectrum, so the cross utilisation of the same medicine between humans and animals are possible. The presence of bacterial infection is also more ambiguous and less dreaded due to a century of an effective cure. Finally, they come in convenient packaging, at time mislabelled as supplements, and are considerably more accessible. These reasons compound to make bacterial infections and diseases different from viruses.

David Walter-Toews wrote of such an entanglement when he expounded that "wicked problems arise in situations that can be defined from a variety of apparently incompatible perspectives… solving one part of the problem may exacerbate other parts". (Walter-Toews, 2017, p. 3). 'Wicked problems' by definition are problems that fulfil ten important characteristics:

1) They do not have a definitive formulation.

2) They do not have a “stopping rule.” In other words, these problems lack an inherent logic that signals when they are solved.

3) Their solutions are not true or false, only good or bad.

4) There is no way to test the solution to a wicked problem.

5) They cannot be studied through trial and error. Their solutions are irreversible.

6) There is no end to the number of solutions or approaches to a wicked problem.

7) All wicked problems are essentially unique.

8) Wicked problems can always be described as the symptom of other problems.

9) The way a wicked problem is described determines its possible solutions.

10) Planners, that is those who present solutions to these problems, have no right to be wrong. This is because planners are liable for the consequences of the solutions they generate; the effects can matter a great deal to the people who are touched by those actions. (H. W. Rittel, 1973)

While it is a planning and policy terminology to suggest the difficulty of solving a problem due the incomplete, sometimes contradictory, but definitely changing environments. The concept, wicked problems, has been used to understand other by-products of complex systems, such as climate change, poverty, food insecurity and other issues characterised by increasing complexity unsolvable through the application of standard known methods. However, different approaches can be undertaken to address the issue, through – i. authoritative strategies, ii. Competitive strategies, or collaborative strategies (Roberts N. C., 2001). As the names suggests – an authoritative strategy involves a situation wherein a authority decides or imposes a solution, competitive strategies involve competing stakeholder in order to deliver a solution, and collaborative strategy is one where the various stakeholders work together to develop and implement solutions. However, these are merely coping strategies, another approach to addressing complex problems was proposed by Funtowicz and Ravetz (Silvio O. Funtowicz, 1993) in their article ‘Science for the post-normal world’. The post normal world of science, according to them, is one that is in contrast to the traditional problem-solving strategies which are now proven ineffective. Hence, they too point to the strategy of “an ‘extended peer community’, consisting of all those with a stake in the dialogue on the issue” (Silvio O. Funtowicz, 1993, p. 739).

Antibiotic and its association with healthcare, food production, a highly adaptable living organism, a dependant consumer base, and the added complexities of each of them (bacteria) makes the implementation of effective policies a challenge. The One Health strategy of involving stakeholders locally, nationally, and internationally has to deal with establishing a successful collaboration and coordination across different policy areas, with differing agendas, and impetuses. The terminology of 'wickedness' is merely a descriptive terminology that allows us to comprehend and compare with other similar 'wicked' problems. A solution for which is often fraught as they are highly impervious to resolution because of its flexibility, instability, and social complexity. Behaviour modulation, which is often cited as a solution by 'experts', relegates the responsibility on the individual and neglects to consider the behaviour of the numerous levels of society, most importantly – of governments and multi-national corporations. This also raises ethical challenges to the problem of ABR, one of which is the conundrum of asking people to behave a certain way when the incentive structure leads them the other way. The issue that is presented to us is devoid of a two-dimensional solution which can be solved by the traditional mechanism of policy making.

This concept of ABR as a 'wicked problem' has been further expanded by Jasper Littmann *et al*. through their argument that it now presents itself as a 'super wicked problem' (Littmann, Viens, & Silva, 2020, p. 426). They expound that this term includes four additional complications which are not included in the former. These complications include-

(i) Time for finding a solution to a policy challenge is running out;
(ii) Those seeking to solve the problem are part of the cause;
(iii) Central authorities to address the problem are either weak or non-existent; and
(iv) Policy responses discount the future irrationally (*ibid.*)

These criteria have been borrowed from the climate change discourse, but fit seamlessly in this context as well. Additionally, Littman *et al* propose that the term is not merely descriptive, as has been proposed above, but also offers a framework for "assessing the expected impact of policy making" (p. 433). According to them, this framework exposes the shortcomings of current policy efforts which are devoid of planning for reducing future dependence on antibiotics and discussion on ethical considerations. They go on to explain that such a framework could also cause a shift in path dependence. That is, the tendency of institutions to become committed to developing in certain ways as a result of their structural properties, their beliefs, or values.

In many ways this is a critique of the present methods advocated for in tackling antibiotic resistance, one in particular is behaviour change. Behaviour intervention research, it is believed, are lacking for LMICs, which are perceptibly the countries having the greatest burden of drug resistant infections. Other proposals for increasing research in new drug development also falters in the long run as the authors believe they benefit high income countries disproportionately. Hence, ethical considerations in policy making must be taken into account, and therefore, the authors call for a shift in path dependence. The current path dependence is founded on a reductionist ideology. While this path has been beneficial for science and medicine and will always be necessary in identifying causation – and finding effective treatments, health cannot be based on a single agent-single outcome model.

One of the most cited examples of path dependence is the development of a town around a factory; to shift the factory would be the most ideal for the health of the community but it would be far too costly, hence, the factory remains where it is. Similarly, fossil fuel persists due to the extensive dependence of the economy on it, it follows, therefore, that antibiotic use persists because of these same reasons. The problem with shifting path dependence is that it is expensive, extensive, and extremely contested. However, such is the requirement of the day as the current trajectory of antibiotic use compels to project a bleak future; for which our systems have proven not robust enough.

The recent SARS Cov-19 was an overwhelming display of this vulnerability and outlined the deficiencies of our current healthcare institutions. This, despite a flu pandemic being predicted by experts for a long time, this same system is straining silently to deal with bacterial infections in its wards. In fact, there are other similarities between the two which is worth exploring.

5.3 Covid19 pandemic parallels with the silent ABR pandemic

In December of 2019 news reports signalled to rising cases of respiratory illness of unknown origin ravaging the people of Wuhan city, Hubei province, China. Description of the illness included mysterious pneumonia characterized by fever, dry cough, fatigue, and occasional gastrointestinal symptoms. Soon after an epidemiologic alert was sounded by the local health authorities after which the market from where it was suspected to have originated was shut down by Chinese authorities on the 1st of January 2020, as 66% of the market staff were found infected. followed by the declaration by the WHO of a global health emergency on the

30th of January 2020. The disease was officially named as Coronavirus Disease-2019 (COVID-19, by WHO on February 11, 2020) an illness caused by a novel coronavirus called severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2; formerly called 2019-nCoV).

The propensity for transmissibility of the aetiological agent assisted in its rapid spread to neighbouring provinces and soon crossed borders into Thailand, then to South Korea, Japan, the US, rapidly altering into a global pandemic. Till the 14th of April of 2022 there have been 505 million confirmed cases resulting in the deaths of 6.2 million people worldwide (WHO, WHO Coronavirus (COVID-19) Dashboard, 2022).

The parallels to be drawn for antibiotic resistance is the fact that almost every influenza expert had been warning of such a situation for a long time before 2019. Ever since the Spanish flu of 1918, there were predictions made of the possibility of an influenza type pandemic. The flu virus's ability to mutate and evade our immune system and the limited efforts towards its prevention and treatment informed experts of the epidemiological probability of the spread of another global infection. The only consolation this time around was that the fallout caused by the Corona virus was limited by improved modern medicine, well-established international health agencies, global collaboration and quick vaccine development. The influenza virus (H1N1) that caused the 1918 Spanish Flu ravaged the globe causing upwards of 50 million deaths. In a similar fashion, antibiotic resistance is often referred to as the 'silent pandemic', mostly because due-attention to this growing problem is still lacking. Considering the fact that caution on antibiotic use had been advised by the discoverer of the first antibiotic himself, Sir Alexander Fleming. In his Nobel lecture (11th December, 1945) he had warned of a time when penicillin could be "bought by anyone in the shops" and resistance would develop because of 'the ignorant man' (Fleming, 2022).

The concern that experts had for the probability of a flu pandemic in the near-future, is being realised for ABR and its potential for unleashing havoc on public health and socioeconomic sectors. Other than a narrative parallel, SARS Cov-2 has also been fuelling increasing misuse of antibiotics. In the days following the beginning of the pandemic a flourish of literature on this fact have been published; publications expressing concern and anxiety from the expanding interdisciplinary cohort of ABR researchers and doctors (Abelenda-Alonso et al., 2020; Arshad et al., 2020; Comber et al., 2020; Getahun et al., 2020; Zeshan et al., 2021).

The SARS-CoV-2 pandemic also caused the disruption of many public health efforts. The return of Measles in the US in 2013, due to the revival of an ‘Anti-vaccine’ movement led by celebrity ‘anti-vaxxers’, also sprouted similar sentiments in other countries. In 2018, four European countries (Albania, Czechia, Greece, and the United Kingdom) lost their measles elimination status and the circumstances has been made worse by the numerous lockdowns and the deviation of health resources due to the Corona Pandemic.

Inadvertently, it also slowed the momentum that was building up in addressing antibiotic resistance. In recognition of the substantial political weight of the United Nations General Assembly (UNGA), UN General Assembly special session (UNGASS) and high-level meetings (HLMs) have been pursued for health-related topics. In 2016 a high-level meeting was called to discuss AMR, HIV/AIDS (2001) and non-communicable diseases (2011) were the only two other health issue taken up in this platform at that point. High-level meetings on Tuberculosis (2018) and Universal Health coverage (2019) were subsequently conducted. However, the priority and loudness of the Covid-19 pandemic, it is considered, resulted in reducing the traction that had been gaining for AMR issues (Marc Mendelson, 2022).

The statement, however, may not be completely valid as a search for MeSH terms, within a specified time, on the NIH database show that 1334 dedicated articles were published on ‘antibiotic resistance’ between January 2020 to March 2022. Also, in September this year (2022) the World AMR Congress is set to take place in Maryland, USA, which was conducted virtually during the WFH protocols set in place from 2020 onwards. What is concerning is the lack of public awareness and inadequate awareness within medical professionals despite awareness campaigns launched by WHO (World Antimicrobial Awareness Week, began in 2015) and national governments (e.g. India – Red Line campaign).

The other significant parallel is the links of antibiotic resistance and Covid-19 to animal-human interaction. The suspected Wuhan market, which is considered the epicentre for the transmission of SARS-CoV-2, is said to have had wet markets selling exotic animals, specifically bats suspected to have been the potential intermediate host for SARS-CoV-2 (Jie Zhao, 2020). Anthropogenic factors responsible for the intensification of cross specie interaction and transmission have led to emerging zoonotic diseases. Correspondingly increasing intensification of rearing domestic animals have led to the anthropogenic escalation of antibiotic resistance.

Chapter VI

Farming and its impact on Antibiotic resistance

a. Antibiotics and Food Security
b. The factory farm and the organisation of Disease transmission
c. A Stubborn Profit-Driven industrialisation
d. Growth driven agricultural development
e. Urbanisation, Sustainable farming and food traceability
f. Does antibiotic use in Animals affect human health?

Intensive agriculture, which is a system of cultivation and rearing that capitalizes on labour and investments to extract the most from a relatively small plot of land, requires various inputs in the form of fertilizers, efficient-machinery, biocides, modified seeds, growth promoters, hormone treatments, etc. As a consequence, more can be extracted from a smaller unit of land.

In plant agriculture antibiotics have been used to prevent certain bacterial diseases, especially in high-value plant products (fruits, vegetables, and ornamental plants). But overall, it accounts for a very small percentage of antibiotic use in agriculture. Streptomycin and oxytetracycline are the most commonly used antibiotics to tackle fire blight and bacterial spotting (McManus et al., 2003; Stockwell & Duffy, 2012). Such management of plant diseases are important for ensuring food security, however selective pressures on targeted and non-targeted species results in unintended consequences. In the US alone pesticide resistance have resulted in crop losses of approximately 1.5 billion USD per year alone (Pimentel, 2005). In India, indiscriminate use of crucial antibiotics in vegetable farming have led to possible traces of antibiotics in edible vegetables, hindering human health and disrupting soil ecosystem and increasing environmental pollution (Khullar et al., 2019). Incidences of streptocycline (an antibiotic mixture of streptomycin and tetracycline) use in the form of sprays for 'healthy and green harvest'(*ibid.*), from the banks of the Yamuna demonstrate that such practices are not an isolated event. Considering the fact that streptomycin and tetracycline are critically important for human medicine exacerbates an already concerning development of antibiotic resistance in the national capital.

6.1 Antibiotics and Food Security

The waters of the Yamuna River are already one of the most polluted in the world, laden with heavy metals, chemicals from leaching fertilisers and pesticides, factory effluents, and dumping of untreated sewage. The bacterial load of the river shows significant levels of antibiotic resistant bacteria as well as antibiotic resistant genes, including bacteria on the WHO list of pathogens in urgent need of new antibiotics (Lamba et al., 2020). Furthermore, a study of soil sediments of the river revealed a total of 139 antibiotic resistant genes (ARGs) from 39 microbial species, the genes of which were resistant to aminoglycoside, beta-lactam, macrolide, and tetracycline. Considering the fact that there are more than 2500 small-scale farms in the Delhi portion of the Yamuna plains growing a variety of vegetables (bottle and bitter gourd, egg-plant, okra, corn, pumpkins, cucumber, chilies, black-eyed peas, spinach and other leafy vegetables, cauliflower, mustard seed, wheat, rice, tomatoes, cauliflower melons, watermelon, carrots, radishes, guava and jamun fruit) it is certain that these products are sold and consumed locally (Cook et al., 2015). While most farms use groundwater in the Capital region, studies of groundwater in Delhi show permissible levels of physico-chemical and microbial parameters (A. Kumar et al., 2016), its proximity to concentrated urban settlements, nevertheless, make them susceptible to pollutants. Especially exposure to antibiotic resistant genes in the air, as one global survey revealed that different urban cities are challenged with varying health risks associated with airborne ARGs (Li et al., 2018).

With concerns to the NCR, in November of 2016, the National Green Tribunal (NGT), a specialised judicial body constituted for the purpose of adjudicating environmental cases in India, refused to permit a farmer from cultivating along the river banks, citing major issues with water and soil pollution. However, farming still continues despite the concerns of toxic vegetables being sold in the marketplace. In September 2019, the NGT directed the Delhi Development Authority to stop the farming of fruits and vegetables on the Yamuna floodplains, and presently there are plans to convert the areas into biodiversity parks. However, farming still continues along the river and there are also no controls in place for discerning place of origin for most vegetables, fruits, and livestock. Such checks are necessary for food safety, in order to expedite with certainty particular items found to be causing food borne illnesses.

A study led by Dr Philip Taylor in 2020 revealed that antibiotic use on crop production is more common than previously thought. The research used the *Plantwise Online Management System* (POMS, is an online platform established to assist smallholder farmers in LMICs with agronomic advice) as an information source to look into antibiotic recommendations made my agricultural advisors on the platform. It analysed more than 436,000 records from Plantwise plant clinics in 32 countries between 2012-2018, which revealed that antibiotics, some of which are considered critically important for human medicine, are being recommended for use on over 100 crops and in some cases in copious quantities and as prophylactic treatments(CABI Agric Biosci et al., 2020). Furthermore, the study revealed that most of the antibiotics were used in spraying rice crops in South East Asia, of which, 63 tonnes of streptomycin and 7 tonnes of tetracycline are used annually in the region.

Other than rice fields, sprays are used in commercial orchards to manage bacterial diseases. While relatively few, plant bacterial diseases can cause dire economic losses, and despite calls for 'One Health' there is very little attention given to antibiotics used in plant crops in comparison to veterinary use. In fact, a joint study by the WHO, FAO, and the OIE revealed that the number of countries monitoring antibiotic use in plant crops is few compared to monitoring for animal and human health.

i. The use of pesticides

The use of fungicides, bactericides, and other pest killing chemicals are an important tool in ensuring food security. The economic losses to farmers, while an important consideration, also means reduced supply to markets resulting in inflation, an important aspect considering affordability. To ensure a continuous stable supply of food crops to the market are important pillars of food security and one of the tools to ensure that are the use of pesticides. While there have been alternative movements (organic) against the use of chemicals in food production they only contribute a fraction compared to the industrial method.

Pesticides have become an established risk-management tool popular in the industry as a quick fix, and as monoculture intensive farming continues the chances of total crop failure due to pests are greater.

According to FAO estimates each year global crop production losses due to plant diseases amount to 220 billion USD, that is, 20 to 40 per cent loss of global crop (FAO, 2019), while crop loss due to invasive insects stood at 70 billion USD.

ii. Food Security

The pillars of food security include availability, access, utilisation, and stability; hence, it involves production just as much as it does distribution. The most contemporary example of food supply disruption has been the Ukraine crisis, leading to shortage and therefore increasing price of wheat and cooking sunflower globally, among other things. Another instance of food supply disruption, but due to disease, was the African-swine flu epidemic in 2019 which led to the culling of millions of pigs in China. In the first half of 2019 the country's herd population dropped by half and in neighbouring Vietnam 18 per cent of pigs died by February that year.

The SARS-CoV-2 pandemic starting early 2019 also led to a disruption of food production as farm lands went untended and unharvested due to the stringent lockdowns. Shortage of labour also added to this problem as farm workers were in short supply; bulk-sale markets, super markets, and other food distribution mechanisms (transport being one of the most crucial- lorries, ships, and trains) came to a halt adding to the fears of a food chain supply collapse.

Antibiotics is a part of this equation since its role as a pesticide, a growth-promoter, and a disease prevention medium adds to the securitisation of food supply. Considering the fact that monoculture agriculture (in animals and in plants) increases the chance of a colony collapse due to a single pathogen, antibiotics have been used preventatively to halt bacterial diseases. Studies show that monoculture combined with continuous cropping leads to a depletion of soil quality as well as reduced microbial biomass, making them more susceptible to disease (Maravillas et al., 2019; Shipton, 1977). Nevertheless, resistance to antibiotics is largely discussed in relation to health security, there is very little literature on food security (other than literature on food-safety, on which there are plenty). The limited literature often clubs food safety and security together without defining the different issues pertaining to the differ aspects and the scope of each topic. Food security pertaining to animal health is an issue of concern, especially considering small rural animal farmers and, or pastoralists; their precarious economic situation and their health (FAO, 2016). Hence, while availability of effective and cost-efficient antibiotics is critical for food security, the consequence of antimicrobial resistance include reduced food production, reduced food security, greater food safety concerns, higher economic losses to farm households, and contamination of the environment.

This is generally a common double-edged sword problem with technology; in the case of antibiotics (as with most other technologies) it suffers from unequal distribution among socioeconomic groups, and at the same time its unregulated availability has created a public health crisis. One of the reasons for the swift adoption of antibiotics and other farming technologies in India could be found in the dominating logic of the 1960s and the 70s. That is, a logic pursued by the need of the times, which was the need to produce more. Wars in early 1962 and 1965 followed by droughts in the mid-60s (1966 and 1967), brought in by a failure of the monsoon rains, heightened India's dependence on Western imports of grain[31]. War (increased defence expenditure), drought, a devaluation of the Indian currency, immense grain imports, increasing poverty, and a three-year plan holiday (1966-1969) later the need for food self-sufficiency was being realised with the launching of the Green Revolution.

The Green Revolution necessitated the swift adoption of new technologies which may have impacted traditional agricultural practices, introduced chemicals into the environment through pesticides, led to a depletion of soil quality, and therefore made farmers dependant on artificial fertilisers, weedicides, pesticides, and other tools of modern agriculture. The pay-off was that India solved its food shortage problems.

India has had other food revolutions in oil, fruit, jute, potato, milk production, including an egg and poultry revolution popularly known as a 'Silver Revolution'. Starting in 1969, egg production began to modernise with the inputs of medical science and improved protein-rich feeds; this movement aimed to increase demand of poultry product by ensuring a steady supply, also it compelled larger companies to adhere to bio-security protocols to avoid disease among the flock, it also forced adoption of innovation and biosafety protocols. While the programme had great success, whereby presently India is the third largest producer of eggs (after the US and China), India is also the fourth largest chicken producer (after China, US, and Brazil), the export market chickens today receive very different treatment compared to chicken for local consumption. India's aim for self-sufficiency and food security has come a long way, but since food safety and standards in India are not as stringently adhered to and reinforced there is a trade-off; price vs quality and cost of animal welfare.

Considering India's economic rise and its population explosion demand for protein-rich foods have also been on the rise (Rampal, 2018). But the increase has not been significant hence promoting appropriate levels of production and consumption of high-quality foods rich in protein has been a goal for the government. Furthermore, food security concerns seem to be

[31] The popular adage in Indian history – 'ship-to-mouth existence', came from this era's struggle with food insufficiency.

exacerbated by ‘progress’; global declines in poverty followed by an increasing demand in food, especially in the developing nations. Upsets in production due to crop failure or animal disease hinder this effort, hence antibiotics becomes critically important in food production. The issue is where medically important antibiotics which are used to treat human diseases and infection is used extensively in the production of food.

Therefore, with concerns to chicken, biosecurity, vaccination, animal welfare, etc. are being proposed for reducing antibiotic use in farms. The whole food chain must adhere to these principles of hygiene to prevent animal stress and illness, thereby, preventing infections passing on to consumers as well. However, examples from India and other developing nations show very poor management and concern for negative spill-over effects.

For instance, one of the biggest livestock wholesale markets in Asia as well as the largest chicken slaughter hub is located in Delhi, next to the city’s biggest dumping ground. The Ghazipur landfill, which is located adjacent to the Ghazipur Mandi (market), is the oldest landfill site of Delhi, it is also the biggest and tallest, it is also one of the deadliest. With incidences of huge fires choking residents and literal garbage collapses killing people, the area is also home to a vegetable wholesale market in addition to the livestock market. On October 2021, a Supreme Court appointed panel noted that major violations of safety were ignored at the market, which could pose serious public health concerns (Paras Singh, 2021). Details concerning source of consignment were not recorded and there were no veterinarians employed at the market. Additionally, waste from the slaughter were drained directly without any treatment bringing up concerns of environmental pollution. The market which is said to trade more than four million birds was found to have no checks in place to ensure the health of the birds, no separation of sale between live chickens versus carcass, and housed mostly in unsanitary conditions.

6.2 The factory farm and the Organisation of disease transmission

Henry Ford got his inspiration for the assembly line from the meat processing industry. The meat-processing industry in Cincinnati, Ohio, and Chicago, had overhead trolleys that conveyed carcasses from one worker to another, who disassembled a carcass by minimising unnecessary steps and therefore maximising productivity. It must also be noted, that Ford was among a dozen other car producers at that time, Ford however used the assembly chain to streamline production like the meat industry and thereby increase profits.

The poultry industry became one of the most comprehensive examples of this streamlining and profit maximising. Scientific advancements and technological fixes for growing, slaughtering, and packaging reduced the price per kilo of chicken making it one of the most affordable animal proteins. However, unlike Ford's Model-T cars, animals are prone to disease and infections, hence, this necessitated the need for organised disease management through prophylaxis and meta-phylaxis to protect investment. The system also created disasters like the loss of independent family farms, environmental hazards, loss of animal welfare, and increased food safety risks. As Michael Greger, veterinarian, food scientist and author, put it bluntly in his book, *'How to Survive a Pandemic'* (2020): "If you actually want to create global pandemics, then build factory farms."

Factory farms or CAFOs have the dubious reputation of being considered literal 'hell on earth' for animals. Considered to be an industry replete with animal abuse and unimaginable cruelty and filth. In the poultry factory farms, layer chickens are caged in battery cages at 16 weeks where they spend their entire lives confined to a space the size of a sheet of paper. Restricted from normal behaviour, they are made to lay eggs by regular feedings of artificial hormones while male chicks are killed at birth. Broiler farms confine chickens to giant sheds where they are bred and raised in crowded conditions designed to maximize the amount of meat they can provide whilst minimising the costs to the farmers (Dreyfuss et al., 2012).

These conditions give rise to serious ethical concerns, most notably of animal rights and welfare. But we are also presented with a manufactured ethical dilemma for society to choose between the continuation of the existing structure that produces cheap food or the reform of the industry which may make animal protein unaffordable for the masses. These systems of animal farming, we are made to believe, are necessary for the efficient production of cheap food and the efficient allocation of resources. However, as we now know, these systems are wholly inefficient and create serious environmental and public health problems. These "highly efficient systems" also result in very high levels of pollution and the uncontrolled spread of disease. Therefore, the role of antibiotics in this system has become significant and indispensable, without antibiotics producing commercially viable chicken would not be possible, that is if they survive the factory farm system at all.

Diseases incubated from this system also uses the "efficient" distribution networks of this system to disperse themselves globally, at times making them almost impossible to eradicate (Benedict & Hennessy, 2013). To illustrate this point; chicken waste is resold as fertiliser to various farms, the chickens themselves are transported many kilometres before they find a market or are processed in an abattoir. At each point shedding bacteria and viruses that can be picked up and carried further by other vectors to infect other animals, people or even crops.

The industrialization of food production therefore, has a fundamental flaw, it has created a system that has reduced the overall cost of food but at the expense of the environment, animal welfare and human health. More importantly, the ultimate goal of these enterprises is not to feed people or even provide a viable livelihood for the people in the communities surrounding these factories but to maximise profits for the owners of the businesses involved. Just as it is with the healthcare industry; the mixing of market forces with the production of food is counter-indicative of an ethical approach to both sectors as they represent the private interests of the few over the wellbeing of the many. The commercialization of food production has led to a situation where the cost of food has been artificially driven down while the associated environmental and social costs have been ignored.

The conversion of farmers into 'growers' is another aspect of this process that has negatively impacted on the food supply chain. A grower receives most of the inputs from integrators such as seeds, chicks, feeds, fertilisers, veterinary supplies etc. Growers must also sell their produce to these integrators at a price dictated by the latter. In turn the grower takes care of the most tedious part of the production process i.e., day-to-day care of the chickens, crop, etc. While this change has undoubtedly helped reduce the overall cost of production it has resulted in the depletion of traditional skills amongst farmers and also reduced their control over the production process. Hence, over time we have lost both the local knowledge and skills required to produce high-quality food products at the local level while concentrating disease burden and environmental degradation at the global level.

6.3 A stubborn Profit-driven industrialisation

The use of antibiotics is hugely profitable to producers, and the sale of antibiotics is highly profitable to the pharma industry. For factory farms or industrial farms, the use of antibiotics means 1.) an increase in feed conversion rations lowering costs of feed, 2.) it reduces veterinarian costs, 3.) require less investment in sanitation and hygiene operations, 4.) allows for crowding of animals. Alternatively, antibiotics as a pharma product is inherently not very profitable in terms of sale for human health purposes. Moreover, from a business perspective there are several things to consider – there are more animals than humans, their physiology and weight are greater (cows, pigs, horses), and there is constant demand. Hence, global sales of antibiotics are greater for animal health rather than for human health (about 70% are fed to livestock and poultry). This is poised to grow even more as global demands for animal proteins increases.

The animal health industry which sells antimicrobial treatments to the animal agriculture sector is currently worth upwards of $45 billion (Feeding Resistance (FAIRR Report), July, 2021). This constitutes only a small section of the larger agrochemical and animal health market which had developed in to profitable ventures through the industrialisation of agricultural processes.

For instance, were we to look into the history of these organic and inorganic chemicals, used in modern farming, there is a clear separation of a pre and post usage era divided by the Second World War. Where the technological advancements made during the War transitioned into marketable goods for public use, as mentioned in chapter 3. Other than antibiotics and farm and kitchen machinery - chemicals commonly used in agriculture, presently, was used during the war for preventing insect borne diseases (Malaria, typhus, etc.) on the various fronts, specifically in the Pacific Islands. Herbicides were also developed by the American war machine during the 1940s to "defoliate jungle forests and destroy food crops as a strategy to win battles and wars" (Olson et al., 2022). Furthermore, as mentioned earlier, antibiotics too were mass produced for the first time for the war effort, to heal broken soldiers. These organic and inorganic chemicals found new battle fields in the farms across America after the war, especially in the Southern agriculturally dense states of America. The successes observed there were marketed and exported to developing countries which became dependent on synthetic fertilisers, pesticides, weedicides and on antibiotics.

These chemicals were similarly considered as 'silver bullet' responses at every incarnation – during the war as disease prevention chemicals, post-war use as farming products, and later as home pest killing products.

Food and agriculture post Second World War is, therefore, characterised by a complete transformation of how food comes to be grown. Other than herbicides and pesticides, Ammonium nitrate use for making explosives during the war, were recommissioned for civilian use as fertilisers. This solved a huge biological hurdle, that of nitrogen-fixation, and paved the way for industrial levels of output and therefore allowed for the induction of industrial principles into food. This excess of synthetic fertilisers, however, disturbed the carbon-to-nitrogen ratio in plants, resulting in weak plant structure and providing access to pests, therefore, leading to an increasing demand for pesticides. Similarly, antibiotics transformed livestock farming, allowing for farmers to increase the size of their stock as well as their numbers. Similarly allowing for industrial principles to become feasible for profit-maximisation.

This was also a time where the ideologies of the West were competing with that of the USSR, where the technological race between the two nations extended to the farmlands. The obvious winner, the American industrialised model, was the visual representation of abundance, efficiency, and choice. However, this "capitalist supermarket model" while under the guise of free enterprise was a result of massive state investment (Hamilton, 2018). It was based upon an infrastructure that depended on public spending, government management, and research and development by public institutions. This top-down approach has been symptomatic of the Indian context as well, and in many ways, it has contributed to where India is now a surplus exporting nation. These changes to India's agricultural policy were made under the 'Treaty of Rome' (*Foreign Relations of the United States, 1964–1968, Volume XXV, South Asia - Office of the Historian*, 1965) at the behest of the American Government under the presidentship of Lyndon B. Johnson. It was a reform – for – grains deal, pushing India to 'modernise' its grain production. however, it failed to reform traditional structural problems within the system.

As Prof. Utsa Patnaik observed, Indian agriculture was based on the pre-capitalist family-labour based peasant holdings rather than the wage-based capitalist agriculture that developed in the West (Patnaik, 1972). Hence, mere injection of money and exchange into Indian agriculture failed to overcome the limits of -i. rigidity of the land markets, ii. Shortage of workers, and iii. development of usury (Sau, 1976). Therefore, what developed in India was a 'Junker-style landlord capitalism' (Patnaik, 1986. p. 782) despite decades of agrarian reforms and planned expenditures by the government the same problems persist. Nevertheless, food security and self-sufficiency has remained a dominant theme for agricultural reforms in India due to the country's history with severe devastating famines and dependence on foreign food aid. But these developments have been made along the lines drawn by the United States of America.

For instance, the 'Treaty of Rome' came about due to a failed monsoon in the summer of 1965, although the Indian government did not accept it at that time, the threat of famine was looming over the subcontinent. The Americans leveraged their aid for reforms – a. review of price policy, b. new irrigation techniques, c. credit to farmers against advances to their crops, d. private investment in the manufacture and distribution of fertilizer, e. import of new high yielding seeds (Foreign Relations of the United States, 1964–1968, Volume XXV, South Asia - Office of the Historian, 1965). Hence, such events internationally were also used by the US to speed up the "evolutionary movement of U.S. farm policy" (ed. Gavin & Lawrence, 2014, p. 126).

Thereafter, India began to rely heavily on American aid and the event came to be advertised as a new model for internationalised economic development (*ibid.* p. 132-133). Thereafter, the *Green Revolution* came about based up on – Soviet aid established seed farms, Rockefeller's Mexican dwarf wheat (Sonora 64) to establish new yields, Philippines high yielding rice strains, and American fertiliser and pesticides to grow and protect them. But whereas America domestically shifted attention to "community development, rural industrialisation, improved education and regional development policies" once commodity prices could not provide satisfactory incomes (Amstutz, 1984, p. 729) and gave way to private international trade, India began to open up only in the 1990s.

By then ecological fatigue (land degradation, yield plateau) and economic fatigue (stagnating farm growth) had taken over (Shetty et al., 2014). The poultry sector also changed from a backyard activity to a vertically integrated industrial model based on contract farming, where farmers work under contracts from large agribusiness corporations by the early 2000s. This 'tyson-isation'[32] of the poultry sector came to integrate a majority of the total Indian poultry industry. However, only about 5% of the total poultry meat sold in India is processed, this is due to the market preference for live birds. As a result, Indian poultry markets are regional, rather than national, in and there is a limited potential for low-cost producers to market their product in higher cost regions.

Poultry was encouraged in India with the objective to provide farmers with supplementary income and subsidiary employment. It took on a more formal arrangement as development programmes became a matter of plans, targets, budgets, technology, material aid, experts and organizations to govern them. Thereafter, growth driven motives preceded ecological concerns resulting in the situation we find ourselves in presently.

6.4 Growth driven Agriculture Development

This above model of agricultural development has been historically motivated by an unchecked and unsustainable global pursuit of economic growth which has had a lot of impact on the environment (Livingston, 2019). Its engine has been fuelled by an overdependence on technology to overcome natural barriers while creating other ecological problems, as is evident by the subject of this thesis. Poultry farming, as an income generating

[32] Tyson Foods USA was the first to set up the model of vertical integration in the poultry sector in the USA. It bought up feed plants, hatcheries, contracted producers, and built processing plants.

activity, may have developed in the 1970s as an activity to aid smaller farmers who did not benefit as much from adopting the relatively new agricultural technologies of the period.

Therefore, given the conditions under which India adopted a ‘modernisation’ of it agricultural sector credit lines were extended to farmers, and government expenditure on agriculture was increased to accommodate for these new changes. Thus, was establish the driver of agricultural change in India, what Prof. Rajeswari S. Raina calls the “Supply syndrome of the State” (Raina, Beyond Supply Driven Science, Feb 2014). Wherein, the subsidised supply and dissemination of agricultural technologies became the mainstay of agricultural development (Raina et al., 2022). Poultry, as noted earlier, developed in India due to government support, the Government of India, State Governments, and other nationalised banks provide subsidies and loans in order to encourage poultry business. This allowed for phenomenal growth within a very short period of time. Therefore, India has become self-reliant within five decades with the establishment of specialised institutes, feed processing plants, technology development, targets, and other aids provided by the Government.

Auxiliary industries that produce feeds for the poultry industry also receives benefits from the government, with up to 50% capital subsidy under the National Livestock Mission Scheme. These operations increasingly depend on the supply of maize and soy. In fact, feed costs account for about 70 percent of the variable cost in rearing poultry which too depend on subsidies. Over 20 million maize farmers and 500,000 soybean farmers are directly dependent on the poultry sector, as more than 80% of the maize and a very substantial share of soybean meal produced in the country are used by the poultry industry. These grain and oilseed farmers also benefit from government subsidies for seed, electricity, water, as well as for fertilisers.

Hence, the poultry industry has far more dependencies that also act to impact the price of chicken in the market. For instance, during, the SARS Cov-2 pandemic poultry prices in North India rose up due to supply chain problems, this was followed quickly by a crash in prices due to an avian flu scare. Hence, the volatility and the enormous economic machinery required by modern industrial poultry farming has brought in to question concerns of sustainability. Sustainability of the enterprise as well as a livelihood option for farmers who are generally at the fag-end of the pecking order.

Volatility in the price has also led to informal consolidation of smaller growers by larger farms, as sustaining through market shocks require considerable capital. Hence, smaller farms are converted into contractual farming operations of bigger businesses which is continually taking over the industry (Bera, 2022). The scale of contract farming is still in its infancy compared to the American model. However, it is worth mentioning that India has some of the biggest vertically integrated poultry companies in the world and with more than 6 million small to medium poultry farms nation-wide the scope for consolidation is immense. This, from the perspective of growth economics is a veritable opportunity for creating market value along existing economic logic. The alternative could be to use this potential to shorten food chains along sustainable lines – one that takes into consideration of the environmental, economic, health and social consequences of different agricultural production processes.

6.5 Urbanisation, Sustainable Farming and food traceability

One of the solutions presented to deal with antibiotic use in farms is the suggestion to instead increase 'biosecurity protocols.' These protocols have been highlighted by The Department of Animal husbandry, Dairying and Fisheries, Government of India, and provides a guideline that structures vigil and maintenance in poultry farms under the following heads:

1. Farm Location and Design
2. Restricted Access and movement of Birds, farm workers and visitors
3. Isolation and quarantine of new birds
4. Cleaning and Sanitation
5. Personnel hygiene
6. Hygienic disposal of poultry manure
7. Disposal of dead birds and other bio/ biomedical wastes
8. Feed safety
9. Medication/ vaccination of birds
10. Flock profiling for high risk/ Alarming situation
11. Documentation and Record keeping
12. General considerations for collection of infective/ suspected material for laboratory testing (Dept. of Animal Husbandry, Dairying & Fisheries (GOI), 2015)

In a sense, it suggests for structural changes to be made within farms by improving the living conditions of birds as well as increasing sanitation and hygiene. The irony of which is the fact that the same logic is not extended to human health considerations, which instead calls for reductionist behaviour change efforts.

If we were to juxtapose the way we farm animals with the industrial urban human settlements we reside in, there are surely some parallels. In 2009, the International Institute of Population Sciences studied the NFHS-3 to come up with a report on the 'health and Living Conditions in Eight Indian Cities'. Their report examined, among other things – the living environment, living arrangement of children, utilization of health services, and other aspects of urban life. Their findings showed that poverty and slum dwelling population in India has been increasing, indicating worsening living conditions and increasing poverty. According to the latest report (World Social Protection Report 2020-22: Regional companion report for Asia and the Pacific) on social protection by the International Labour Organisation (ILO), only 24.4% of Indians are under any sort of social protection benefit. Furthermore, considering changing climate conditions, poor sanitation, acute water shortages, poor living conditions in the city, and high air, water, and land pollution Delhi is one of the most expensive cities in terms of healthcare expenses. According to a 2019 report by research organization Praja, the average household expenditure on health in Delhi was 1.16 lakhs per annum (Praja, 2019) with the highest incidence of disease being from bacterial infections.

A history of human civilization has shown us that infectious diseases thrive in poor and overcrowded environments, and are related closely to poor sanitation, unhealthy housing, and improper waste management. If the period during the Victorian Era in England was any indication of the importance for investing in public health sanitation and engineering, especially in mega settlements, then the importance of reducing contagion through provision and improvement of public health infrastructure becomes starkly significant. London in the 1800s reached a population of about 1.4 million, made up of a majority of working-class labourers and their families who worked and lived in unsanitary conditions. Fredrick Engels wrote of this in his manuscript "Condition of the Working Class in England (1845)" describing the conditions that lead to starvation, disease and deaths. He wrote this of the slums, "… poverty often dwells in hidden alleys close to the palaces of the rich…".

Delhi by comparison has a population of 32 million (2021), in many instances living in similar conditions to those described in Engel's England. The provision of modern amenities aside, city planning and public engineering of developing LMIC urban settlements are usually struggling to keep-up with expanding city boundaries as well as populations (migration). Solutions are required for housing, waste management, pressures on existing infrastructure, pollution, hygiene and sanitation. Such burgeoning problems, to a great extent, have been buffered by the use of antibiotics and other medico-chemical innovations. Like poultry in factory farms, concentrated human settlements in developing nations rely on antibiotics for disease management and provision of food. Therefore, the concept of behaviour modulation to correct antibiotic use, while important, is reductionist at best. Behaviour, if defined as a response to internal and external stimuli, can be argued to be a composite of influences that are independent from contextual interferences. Such inferences retain constructions of the Biomedical model of illness that fails to incorporate understandings of the social determinants of health (Baum & Fisher, 2014). Furthermore, considering the complexity of the matter at hand the current push to correct antibiotic use based on a combination of cognitive and health belief models, while logically appealing, do not translate to macro level changes. Hence, instead of locating interventions in individual knowledge and attitudes to antibiotics there is a need to view the issue in terms of the relationship we share with these medicines (Denyer Willis & Chandler, 2019).

Borrowing from environmental discourse, through the merging of poverty and environment agendas, many reports claim that poverty itself contributes to environmental degradation in rural areas (Brundtland Commission, 1987) (UNEP, 1999). This is, according to the reports, due to the lack of resources and education which contributes to the overuse of locally available resources. While consequently the pressures on the environment resulting in a lack of natural resources affects the poor the most. Their choices are limited by their incapacity to afford better technologies, participate in decision making, access basic needs and other socio-economic services. In lieu of which there is an increased dependence on available resources. Similarly, antibiotics provide a ‘quick fix’ for the larger entrenched systemic problems leading to overuse. Antibiotics are locally available resources to mitigate the larger problems of hygiene, production of food, healthcare in setting with minimised resources (Denyer Willis & Chandler, 2019).

Furthermore, use of behavioural theory does not increase intervention effectiveness (Prestwich et al., 2014) (Baum & Fisher, 2014) (Hagger & Weed, 2019), while history has illustrated the inverse, i.e., environment’s impact on behaviour. Urban planning (built-environment) has had the greatest impact on disease dynamics, and has also shaped the architecture of the post-miasmatic era, which concentrated on reducing over-crowding and improving sanitation (Pinter-Wollman et al., 2018). However, while improvements are being made to urban settlements the pressures from urban centres have had other unintended consequences, symptomatic of a complex system.

Delhi is a megapolis by any standard of the definition, the second-most populous city in the world after Tokyo. These concentrations of people are a kaleidoscope of production activities, save for land intensive activities – the most essential of which is for the production of food. Such considerations are what led to Thomas Malthus's concerns with population and production on fixed resource in the late 18th century. While progress in science and technology and historic data proved his theory to be inaccurate the questions he raised still persists. The resurgence of Neo-Malthusian ideas in the 1960s is one such instance. That having been said, the global population reached its first billion around the time of Malthus (1804), comparatively the planet presently sustains, to varying degrees of subsistence, a population of more than 7 billion. The majority of whom live in urban settlements (according to the World Bank – 56 percent of the world's population currently live in cities) and are dependent on long value chains of industrialised food production and distribution which alienate the consumer from the source of food. At the same time these processes limit the choices of food, reduce nutrients in the food and increase dependence on chemicals which are ecological unsustainability.

I

Industrial farming is based on a high entropy principle of labour saving – capital using system of food production. The proponents of this model depend on human ingenuity to solve natural problems through the use of science and technology. While in fact this has created other problems that again require solving – the use of carbon fuels, antibiotics, pesticides and fertilisers have created other complications. So far, the thesis in most part dealt with the question of 'how did we get here?' A situation, wherein, public health considerations are passed over for cost saving considerations, corporate interests and considerations of economic growth. A process which has created a system of production anchored on the labour of antibiotics. A fulcrum up on which to observe the absurdity of this production paradigm is Julie Livingston's parables as a stance to reimagine planetary politics. But instead of beef (as Julie Livingston dis), we observed at how a bird from the jungles of South-East Asia came to conquer the world?

The question thereafter follows – 'how do we get out of it?'

The Indian food supply chain remains very opaque, separated by multiple intermediaries at different levels, which is complicated further by the globalisation of the food supply chain.

From a public health perspective this proves to be a maze, raising concerns about food safety and quality. Traceability, therefore, provides an equitable option similar to that of removing the 'the Broad Street pump', but in the food chain to halt food related threats. However, food traceability is about more than just streamlining recalls. From a consumer's perspective, being able to ascertain the origin of products, ingredients and their attributes, from the farm through food processing to retail, foodservice is important for informed choice making. Sustainability on the other hand looks into alternative modes of farming to supply poultry in to urban population dense settlements. Sustainability here is defined as environmental, ethical, and economical. Presently, poultry from factory farms are mass produced, fast growing, located close to urban settlements, and government subsidised, the paradox is that organic requires stringent parameters that cannot compete with cheap meat. However, the same State sponsored development that created the industrial poultry industry could be replicated to help chicken farmers increase efficiency, productivity and environmental sustainability.

Additionally, epidemiological frameworks used in the past to hold corporations responsible for the health of populations could be replicated in this situation as well. The framework of 'Corporations as vectors of disease' (Big tobacco, Nestle, Coca-Cola, Monsanto, Dupont) readily fits into the classical public health triad of – host, agent, and environment (Jahiel, 2008). Corporate vectors, like biological vectors, interact with different environments during the production, transport, and transmission of the agents. However, corporations have more agency over their influence on the environment, and hence, can be asked to take responsibility. But should also acknowledge the essential conflicts of interest involved when corporations engage in activities aimed towards reducing the harmful behaviours on which their profitability depends (Gilmore et al., 2011).

6.6 Does antibiotic use in Animals affect Human Health?

In the United Kingdom, a 'Joint Committee on the use of Antibiotics in Animal Husbandry and Veterinary Medicine', chaired by Professor M. M. Swann, was appointed jointly by Health and Agriculture Ministers in July 1968. The report concluded that "the administration of antibiotics to farm livestock, particularly at sub-therapeutic levels, poses certain hazards to human and animal health" (Wise, 2007). Particularly, it had led to resistance in enteric bacteria of animal origin. This resistance was transmissible to other bacteria[33], and enteric bacteria are transferable from animals to humans. Additionally, the ability to transfer resistant gene from one to another horizontally indicate that bacteria can form resistance to antibiotics which it has never been introduced to before (Boto, 2009) (Burmeister, 2015). This is significant in considering the prospects for the emergence and re-emergence of infectious diseases (Morens & Fauci, 2013) (Mukherjee, 2017). As the increasing cases of multidrug resistant tuberculosis cases indicate, these persistent infections complicate recovery.

The above question on whether antibiotics used for livestock causes resistant infections in humans, or the question in a similar form, was asked by a reader of the journal 'Science' in 2015 ("Antibiotic Resistance: A Question or Two," 2015). The debate that followed in the comment section discussing the matter sided along three basic refrains, that:

i. There are insufficient studies to correlate the two, and what is required is a study similar to what Doll & Hill accomplished for mortality in relation to smoking, but for antibiotics in animal farming.
ii. There are studies available that connects infections in farming families and farming communities to resistant strains found in their livestock, and hence, antibiotic use does effect human health. But are they more virulent than the non-resistant strains?
iii. The planet is teeming with resistant plasmids, hence, to correlate resistance to antibiotic use is naïve.

The above equation has not changed much in the seven years that have since past its initial publication. Therefore, the answer to the above question still remains not as straightforward as that which the question requests. For one, a Doll & Hill type of study for antibiotics would be dreadfully expensive and complicated considering the number of bacteria and the numerous resistant plasmids and interaction complexities. Such a study must also confound for other exposure routes other than solely agriculture; food handling and storage for instance. Secondly, the available correlation studies test for very few bacteria and its resistance to a limited class of antibiotics. And finally, the natural evolution of resistance in bacteria can be difficult to distinguish from resistance due to anthropogenic selective pressures (Dcosta et al., 2011).

[33]Since then, much more has been understood about how multi-resistance can be transferred from one bacterium to another through horizontal transfer of genes (R plasmids) (M. Rozwandowicz, 2018).

Furthermore, biological barriers prevent a simplistic straightforward explanation as exposure of humans to resistant organisms from agriculture must also clear the species barrier to transmit more efficiently within humans. These physical, biological, financial, knowledge barriers and the corresponding uncertainty has been used by the industry to continue prevalent practices of using antibiotics. A review study published in 2004 asked the same question as well, in a paper titled '***Does the use of antibiotics in food animals pose a risk to human health?***' the authors concluded that "the clinical consequences of resistance may be small" and that the application of the "'precautionary principle' is a non-scientific approach…" (Phillips et al., 2004). As a side note, it may interest the reader to note that the paper was funded by the Animal Health Institute (AHI) which is a research body that represents companies that develop and produce animal medicines in the US. Nevertheless, given the different levels of regulation and enforcement of food safety principles across the world there is not one yardstick that can be used to ascertain the impact of antibiotic use in animal farming to causing antibiotic resistance. For instance, the common arguments made in favour of continued use of antibiotics for animals farming are that -

i. There are different antibiotics that are used for animals and for humans.
ii. Medically important antibiotics are not used in feed for growth promotion.
iii. Meat producers that utilize antimicrobials for treatment follow strict withdrawal periods.
iv. It is easy to blame the agricultural industry, but human antibiotic use is the true concern.

But evidence show that antibiotic cross-over use of antibiotics is common (see table below) (Mutua et al., 2020; Myers et al., 2022; Nayiga et al., 2020; Van et al., 2020), and withdrawal periods (a time between the last dose of antibiotic given to food animals and consumption of food animals) are not always honoured. Moreover, in one of the most comprehensive assessment of the problem to date, an expert group comprised of the World Health Organization (WHO), the Food and Agriculture Organization (FAO), and the World Animal Health Organization (OIE) in 2003 concluded that there was a "*clear evidence of adverse human consequences due to resistant organisms resulting from non-human usage of antimicrobials… Evidence shows that the amount and pattern of non-human usage of antimicrobials impact on the occurrence of resistant bacteria in animals and on food commodities and thereby human exposure to these resistant bacteria*." (WHO F. O., Joint FAO/OIE/WHO Expert Workshop on Non-Human Antimicrobial Usage and Antimicrobial Resistance: Scientific assessment, 2004, p. 1). But noted that more research was required to establish virulence factors of resistant organisms and there was a need to expand research to human health consequence for a wider range of bacteria (*ibid.* pp 28 -29).

Field/Area	**Antibiotic used**
Agriculture	Oxytetracycline, streptomycin, penicillin, oxolinic acid, gentamycin
Swine Production	Benzylpenicillins and tetracycline (most commonly used), sulfadimidine, sulfathiazole and trimethoprim, bacitracin, lincosamides, macrolides, floroquinolones, 3rd generation cephalosporins, colistin
Chicken Production	Bacitracin, chlortetracycline, decoquinate, diclazuril, naracin, nicarbazin, monensin, penicillin, rebenedine hydrochloride, virginiamycin, colistin, tylosin, doxycycline, tiamulin, roxithromycin, amikacin
Cattle Production	Penicillin, tetracycline, ceftiofur, florfenicol, tilmicosin, enrofloxacin, and tulathromycin, phenicol, lincosamide, pleuromutilin, macrolide, polypeptide, streptogramin, carbadox, bambermycin

Table 4Antibiotics commonly used in agriculture and animal husbandry (Mann et al., 2021)

Hence, in situations like this we can look to comparative studies – **pre-post studies** that evaluate the outcomes of an intervention. Considering that antibiotic use in livestock has been a concern for quite some time now, there have been a few instances where nations have banned or limited the use of antibiotic in livestock. These instances provided ideal conditions for natural experiments to be conducted which tests for resistance levels before an intervention and after an intervention.

For instance, ever since the 1990s countries have been banning or controlling for the use of antibiotics and hormones in their livestock due to trade considerations or as a public health measure. Interestingly, one of the first countries to adopt this policy was Namibia, who in 1991 introduced a law that banned the use of antibiotics for growth promotion in their beef industry. It was the first African nation to do so, however, ever since then due to policy inconsistencies across sectors broad-spectrum antibiotics are still being used in animals (Kaupitwa et al., 2022).

Year	Country	Description
1986	Sweden	Sweden was the first country to ban AGPs in food animal production. In 1986, it instituted a national ban on AGPs and prohibited the use of antimicrobials absent a veterinary prescription.
1991	Namibia	Banned the use of hormones and antibiotics for growth promotion in their beef industry.
1995	Denmark	Banned avoparcin. In 1998, the Danish poultry industry voluntarily stopped using growth promoters. In 2000, it instituted a comprehensive national ban on AGP use, and made veterinary prescriptions mandatory.
1996	Germany	Banned avoparcin. Veterinary prescriptions were made mandatory.
1997	European Union	Placed limitation on the use of avoparcin for growth promotion. In 1999, limitations were extended on the use of tylosin, spiramycin, bacitracin, virginiamycin, carbadox, and olaquindox for growth promotion, and by 2006 the remaining antibiotics were banned.
1997	Netherlands	Antimicrobials - olaquindox and carbadox, were banned due to its suspected carcinogenicity. In 1999 they began surveillance of antimicrobial resistance which led to a decline in the total sales of antibiotic.
2005	Taiwan	Taiwan amended its Veterinary Drugs Control Act to ban AGPs and require veterinary prescriptions to use antimicrobials in food animals.

Table 5 Country-wise ban of Antibiotics use as growth promoter

i. Eco-epidemiological and Pre - post studies

While there is an absence of a definitive study that takes every pathogenic bacterium and follows it farm to disease causation, historically, the approval of therapeutic use of antibiotics in food producing animals have been observed to be followed by increasing cases of resistance. For instance, in the Netherlands, Spain, and the US – the approval of fluroquinolones in the 1960 and 1970s, to treat chickens for bacterial infections, saw an increase of resistant isolates of *Campylobacter* from treated animal and humans (Centre for Veterinary Medicine, FDA, 2001). The starkest demonstration linking farm use to population effect has come from **Denmark**. Denmark limited how much veterinarians could profit from antibiotics in 1995 and banned all use of antibiotics for growth promotion in 1999, this led to a decline of resistant bacteria in farm animals, in retail meat, poultry, as well as within the general population (Aarestrup et al., 2001; S. Levy, 2014). The year before, in 1998, the Danish poultry industry voluntarily stopped all use of antibiotics for growth, and the pork industry followed the following year.

The ban of antibiotics in Denmark also presented the settings for natural experiments to be conducted. Factors such as, cost to farmers, the ban's effect on the livestock, and the sale of therapeutic drugs could be determined. Hence, studies conducted thereafter found that the impact on farmer profits was greatest in the first year after the ban, by year two the impact was borne by the customers – increased retail prices. The size of the animal (Denmark is one of the largest producers of pork) became leaner and health concerns of animals increased; antibiotic use in feed decreased but therapeutic antibiotic increased (S. Levy, 2014). The fact is that the continuous use of antibiotics in animal feed makes them more prone to infections once removed from it. This may result in flock losses and increased veterinary costs dissuading producers from adopting such a step in the short run. However, in poultry production, there were no negative effects observed on either the total kilograms of chickens produced per square metre (Emborg et al., 2001). In pigs as well, reducing antibiotics had no negative effects on productivity, number of pigs produced per sow, average daily weight gain or the amount of feed needed to produce a kilogram of meat (Aarestrup et al., 2010). In fact, pork production has increased steadily in Denmark and presently stands as one of the largest pork exporters in the world.

The lack of serious long-term effects of the Danish experiment shows that there are other considerations other than animal health that push the usage of antibiotics in livestock agriculture. Could the banning of veterinarians profiting off antibiotic sales have anything to do with the exacerbation of the problem? That is uncertain, and a comparatively miniscule proportion of the larger problem, significant nonetheless. However, economic incentives do feature as a resounding motif in most discussion concerning antibiotic resistance. For example, antibiotic debate on the supply end of the antibiotic chain has been populated with profit considerations. The fact that the antibiotic chain drying up is due to the unprofitability of antibiotic R&D and the solution is sought in advance purchase contracts, not-for-profit research, and tax incentives (Nathan & Goldberg, 2005) suggests the overwhelming economic consideration that precede public health concerns.

Alternatively, colonisation of resistant strains is also found in other areas with heavy antibiotic use and discard, such as – hospitals, hospices, waterbodies with pharmaceutical effluents, and in sewage treatment plants[34]. However, farm studies conducted as far back as 1975 demonstrated the effects of antibiotics, wherein low dose growth promoters used in a chicken farm resulted in the acquisition of resistant strains in the gut flora of not only the birds but of the farm family as well as some of their neighbours (S. B. Levy et al., 1976, 2009). Exposure studies done on industrial poultry workers in the US show that they were 32 times more likely to carry gentamicin-resistant bacteria (Price et al., 2007). Risk assessment and modelling exercises have also shown that agricultural use of antibiotics have hastened the appearance of resistant bacteria in humans (Smith et al., 2002). Prospective study on *E. Coli* strains from factory farm poultry samples further suggests that some strains have become established in poultry populations around the world and that meat may serve as a vehicle for human exposure and infection to multidrug resistant uropathogens[35] (Liu et al., 2018).

There are ecological studies as well that show how resistant germs can travel from the farm to your fork. Tests conducted in and around farms have observed antibiotic-resistant bacteria of animal-origin in the environment. For instance, the Centre for Science and Environment, India, published a report in 2017 alluding to the pollutive nature of antibiotics used in farming (CSE, 2017). The report was based on a study conducted during 2016 – 2017, wherein samples from 12 poultry farms, distributed within 4 different states namely, Haryana, Uttar Pradesh, Rajasthan and Punjab were collected to understand the extent of ABR in the poultry environment and then establish if the resistant bacteria is moving out of poultry farms into the environment. The report concluded that their findings show that the misuse of antibiotics in poultry farms are leading to multi-drug resistant *E. coli*, and other bacteria, which is spreading into the environment through unsafe disposal of poultry litter and waste in agricultural fields, with the potential to infect human beings (CSE, 2017, p. 24). Similar findings have shown similar findings from across the world:

[34] Most antibiotics are not fully metabolised by humans or animals. They are also not fully degraded in waste water treatment plants or sewage treatment plants, and natural degradation varies greatly between drugs.
[35] Uropathogens are microorganisms that have mechanisms that allow them to colonise and infect the urinary tract.

Study, Author, Year	Study Description	Findings
(Graham et al., 2009) USA	Antibiotic susceptibility analysis of bacteria isolated from poultry litter and flies near poultry farms.	Enterococci and staphylococci were often recovered from flies captured near poultry farms. Isolates from flies carried resistant traits similar to those observed in isolates from poultry litter.
(He et al., 2016) China	Measured the content of antibiotic resistance genes (ARGs) in the pig manure of three commercial pig farms in southern China.	22 kinds of ARGs studied were detected in almost all samples, and the abundance was high.
(Ji et al., 2012) Shanghai, China	Study of the content of antibiotics in farm-land soil near pig, cattle, and chicken farms in Shanghai	Concentrations of tetracycline and oxytetracycline in the soil were 1.87–4.24 mg/kg dry matter (DM), while the concentrations of sulfadiazine, sulfamethoxazole, and sulfamethoxazole were 1.29–2.45 mg/kg.
(Berendsen et al., 2015) Netherlands	Presentation of a multi-class method for the analysis of over 20 antibiotics in faeces.	Study reported antibiotics in 55% of the swine faeces from 80% of the swine farms and 75% of the calf faeces from 95% of the cattle farms
(Braykov et al., 2016) Ecuador	Study on the effects of animal agriculture (small-scale poultry farming) on the spread of antibiotic resistance.	Results suggest that AR associated with small-scale poultry farming is present in the immediate production environment but likely originates from sources outside the study area.
(Dandeniya et al., 2022) Sri Lanka	Investigation of antibiotic resistance colonisation in crop root microbiome due to use of broiler chicken litter as manure.	Results confirmed that broiler chicken litter (BCL) acts as a carrier of antibiotic resistant bacteria (ARB), and continuous application of BCL to soil increased the prevalence of ARB among epiphytic and endophytic bacteria in carrot.
(Veloo et al., 2020)	Assess the prevalence of multiple antibiotic	More than half (58.2%) of the 511 total bacteria had MAR, and a number of bacteria

Malaysia	resistance (MAR) among the environmental bacteria in poultry farms and to determine the risk contamination category of poultry	were resistant to cefazolin (86.8%), fusidic acid (84.6%), ampicillin (79.3%), clindamycin (65.5%) and erythromycin (63.7%)

Table 6 Evidence of Human health impact of antibiotic use in livestock

These and other findings correlate the interconnected domain ideology of shared ecosystems and environments that entails the One Health paradigm. Such considerations point to food animal rearing as a major source for the dissemination of ARGs. Evidence from history has shown that the initial use of antibiotics in animal farming was followed by resistance, but the same can be said about antibiotic use in human health as well. The main difference is the scale of use, animal health uses more than 70% of all antibiotics (Tiseo et al., 2020), of which more than 57% are essential for human medicine according to the WHO. Considering that 30 to 90% of antibiotics are excreted unmetabolized from the body, depending on the animal (chicken, pig, cattle) (Cheng et al., 2019), the fallout therefore presents a considerably more urgent cause of concern. In soil, accumulated antibiotics has been observed to affect soil fertility, crop chlorophyll synthesis, enzyme secretion, and root growth. Antibiotic in the water has been shown to cause developmental issue in fish embryos (Bielen et al., 2017).

However, what is in question, as mentioned earlier, still remains - whether there could be any possible harm from antibiotic use in animal farming? If so, whether such incidences can be traced back solely to food animal farming? Meat producers rally behind this technicality to profit off the cost saving use of antibiotics. The other point of contention is the fact that there is a dearth of research on industrial farms. This lack of data, which in many ways is restricted by the industry, has allowed the industry to persist despite regulations (Moyer, 2016). After all, Big Agri and Big Pharma are great beneficiaries of the inputs to and outputs from such enterprises, hence, the subversion of public health concerns for profits seems reminiscent of Big-tobacco in the last century. In India, similar problem exists, especially information from big growers have been difficult to come by complicated further by the disorderly structure of the Indian agricultural markets which presents as another barrier to understanding the true extent of the antibiotic problem.

Soil environments can become contaminated due to antibiotics used as pesticides. Meat and poultry can be contaminated by other common unsafe handling processes by the time it reaches the kitchen. Finally, water pollution with antibiotics can be released as effluents from pharmaceutical companies or as untreated human sewage. The existing body of knowledge, is therefore, available but imperfect and not all-encompassing; it depends on confirming several complex processes that must confirm bacteria evolution, spread, and disease causation (Smith et al., 2005) from farm to fork. Antibiotic resistance is bound to occur regardless as it is a natural process. However, given the weight of evidence, some of which have been cited above, it is safe to note that the animal farming industry is a major driver of resistance.

From disrupting the larger environmental microbiology, antibiotics also disrupt the microbial ecology of the body. Dr Theodor Rosebury in 1969 (pre-eminent bacteriologist and author, considered the father of Modern Oral Microbiology) found parallels with his work on bacteria and that of Rachel Carson's work on pesticides. He opined that:

"…one of the things, one of the troubles, one of the problems we get into in our own bodies is that when we disturb these normal things that live on us, we are likely to do harm, just as w e, man, does harm to the earth by disturbing the ecology of life that lives on it." (Rosebury, Dr. Theodor Rosebury discusses his book "Life on Man", 1969).

Dr Rosebury was also very wary of the profitability that the fear associated with germs and dirt could generate, we shall discuss this in another section. Nevertheless, he maintained that to disrupt this symbiotic relation we shared with bacteria could cause more problems that solve them. His work and others like him set up the foundations for a new understanding of human health, that of the 'microbiome'.

The human gut contains an abundant and diverse community of microorganisms (> 100 trillion), considered to be one of the most densely populated microbial habitats known on earth (Ley et al., 2006). Research into this ecology implicates it the pathophysiology of a range of physiological and psychological disorders ((Ley et al., 2006); Butler et al., 2019; O'Hara & Shanahan, 2006; Scalese & Severi, 2021; Wang et al., 2017). Therefore, disruptions to this ecosystem through the use of antibiotics could lead to colonization by antibiotic-resistant bacteria through selection. Studies conducted by the ICMR also found that antibiotic resistant organisms were commonly found among healthy Indians (139 of 207 individuals) suggesting stubborn infections in the future, high prevalence of resistant bacteria in the environment, and also high shedding potential. Therefore, in this way the internal ecosystem of the human and animal 'microbiome' directly correlates to the larger balance of the external environment, leading to a cyclical transfer and increased propagation of antibiotic resistant bacteria.

The current understanding of the human microbiome links chronic illnesses such as obesity, inflammatory dowel disease, arthritis, asthma, cardiovascular disease, mental health disorders, etc. to disruptions of the gut bacteria (Vijay & Valdes, 2021). The loss of bacterial diversity impacts the functioning of the gut microbiota, which is responsible for mainly three functions – **metabolic, defensive, and trophic** (Guarner & Malagelada, 2003). The first function is the basic absorption, synthesis, and breakdown functions that we generally associate with the gut. The other two are more complex, by competing for attachment sites and nutrients with indigenous fungi or bacteria with potentially pathogenic organisms, the resident microorganisms inhibit the growth of competing bacteria (McFarland, 2008). Of the different trophic functions, the induction and regulation of the adaptive immune system is one of the major functions of the gut microbiota (Ramirez et al., 2020). Hence, we can infer how disruptive antibiotics can be. However, microbiome studies on humans remain scarce, conflicting, and remain largely region specific to the US and Europe. However, disruptions to it and its implications on human health are abundantly clear already from the plethora of studies documenting its evolutionary and ecological consequences. Microbiome research is shedding light on the intricate relationship between humans and microbes. In the context of sustainable systems where contemporary life depends on this fragile ecosystem, questions around the impact of antibiotic overuse and misuse are inevitable.

However, the more immediate concern with the use of antibiotics in food animals is not so much the development chronic illness in humans but still remains the inability to control infections – in the hospitals and in the community. Hospitals for instance, house some of the most dangerous resistant bacteria – Methicillin-Resistant *Staph. Aureus*, *C. Diff*, Vancomycin-Resistant Enterococci, CR (Carbapenem-Resistant) *Enterobacteriaceae*, CR *Kleb. Pneumonia*, Necrotising fasciitis. That having been said, as mentioned earlier, there are presently a dearth of studies that directly correlate antibiotic use in animals to infections in humans. In such cases the alternative may present a far more formidable argument, i.e., antibiotics use by people and resistant genes and bacteria in human settlements offers a more direct mode to transfer and spread antibiotic resistance.

In conclusion, the implications of antibiotic use in animal and plant agriculture remains a driving factor, a threat, a potential risk to human health. The farm – environment – individual mode of antibiotic resistance distillation is the most cited form in studies of transmission. The other being farm – to – individual through residue antibiotic. Resistome[36] studies from China

[36] A collection of resistant genes in both pathogenic and non-pathogenic communities.

suggests that animal and human interfaces in live animal trade is a significant disseminator of antibiotic resistant genes (Y. Wang et al., 2021). The risks of exposure to airborne resistant genes show that farm hands and local residents are at risk up to 10 kms from the animal houses(Bai et al., 2022). Livestock associated bacterial resistance from a small study in the US also demonstrated the presence of *MRSA* and multi-drug resistant *S. aureus* in the nasal cavities of farm workers in a hog-farm (Nadimpalli et al., 2015).

Hence, it is also a zoonotic health threat, given that almost 60% of infectious disease in humans are caused by zoonotic pathogens which have the potential to mutate due to selective pressures. Bovine tuberculosis, plague, anthrax, brucellosis, Lyme disease, Camphylobacteriosis, Leptospirosis, are some well documented zoonotic bacterial diseases, a potential risk considering the overlap of antibiotic classes used in human and veterinary medicine. A 2015 academic literature review chaired by British macroeconomist Jim O'Neill, observed that of 107 academic papers reviewed only 7 papers were against limiting the use of antibiotics in agriculture (O'Neill, 2016). Besides, the implications to human health, as can be surmised from the discussion above – can **directly;** by transferring antibiotic resistant genes to human pathogens, or **indirectly;** by polluting the environment, disrupting gut microbiome, and compromising food safety, be a health impediment. The repercussions of which could potentially cause chronic illness, extend hospitalisation of patients, which would mean higher medical costs, increase risks of lifesaving interventions, and or increased mortality.

Despite these considerations, and more than 50 years of research, the inherent complexity of the problem asks policy makers, doctors, veterinarians, farmers, and corporate farming industries to err on the side of precaution as demands for certainty may be intrinsically impractical (Smith et al., 2005). Therefore, in the absence of absolute scientific evidence a call has been made for these production stakeholders to switch to other methods of feed conversion and nutrition optimisation, and primarily self-limiting biosecurity measures to improve hygiene and sanitation within farms.

Unfortunately, these measures can be expensive and can cost the farmer a considerable portion of their time, capital and labour. Keeping in mind the difference between the size of operation and their capacity for undertaking such measures. Therefore, unless there are financial incentives for small farm owners, biosecurity will remain a suggestive pressure, and unless there are regulatory pressures big corporate agrobusiness will continue to reject causal links and depend on chemicals such as antibiotics to cut input costs (labour, vet-care, feed) and increase flock density. Finally, customer awareness about the effects of antibiotics in meat is also important in order to change industry practices and increase demands for antibiotic-free animal protein. Hence, until then the cost of cheap meat continues to be hinged on antibiotic use as replacement for labour, quality feed, sanitation and infection control.

Nevertheless, since antibiotic use in farms have become a huge point of dissention there have been companies that advertise antibiotic free products in India and elsewhere. The assumption among scientists has been that if farmers stopped using antibiotics, the bacteria would lower their defences to save energy, and eventually remove the DNA that codes for antibiotic resistance. This is because resistant genes are generally not stored as primary DNA but as plasmids. However, a 2012 study from Canada found that despite weaning out antibiotics from a swine farm for two-and-a-half years – gut bacteria from the pigs were still highly resistant to chlortetracycline and tylosin (Pakpour et al., 2012). Another study from the US found contamination in 9 of 95 samples with *MRSA* in retail meats labelled 'antibiotic-free' (O'Brien et al., 2012). Hence, using animal wastes from farms and other improper disposal methods could have considerable downstream impacts through the spread of resistant pathogenic bacteria even from antibiotic-free operations.

Moreover, as poultry farming in India becomes further consolidated and expands to adopt industrial model of food production the profits accrued would certainly become larger and private, and production more efficient while the risks would remain collective. Furthermore, as more people shift to urban settlements and farming becomes further pushed away to the fringes, the peri-urban, the hinterlands, to the rural areas the disengagement with our food only hopes to increase, far more than just geographically but cognitively as well.

Chapter VII

The Big City Chicken

One of the most striking things about eating in the modern world is that we do so much of it without a sensory connection. In fact, we have relinquished many of the functions of our own senses to the modern food industry – which suit it well as it allows it to control what we consume and how we consume it. Even in small towns across the country increasing disengagement with agriculture and food production have resulted in a consumption pattern that is almost entirely devoid of sensory awareness. This alienation is experienced most acutely in industrialized nations where large numbers of people work in urban areas and spend the majority of their time interacting with consumer products rather than growing or preparing food for themselves. This industrial process has contributed to a "generational amnesia" in which modern humans have lost the ability to experience the natural world in any meaningful way. As a result, we are increasingly dependent on corporate processes like industrial farming, food processing and packaging to deliver our food to us.

Industrialized food production represents a unique intersection of economic interests and individual psychology. On the one hand the food industry relies on sophisticated technological and scientific innovations and manufacturing processes to maximize its profits while at the same time promoting a myth of authenticity and heritage that appeals to our most basic psychological needs. Meanwhile, the anxiety that many people feel about their role in modern society has generated a fascination with nostalgic visions of simpler times and the mythology of the traditional family farm which has allowed the industry to exploit this nostalgia to drive consumer behaviour.

The conflict of interest that exists between the interests of corporations and the interests of consumers has led to a system of industrial food production that is highly unsustainable and destructive to human health and the environment. It has also been devastating to small-scale farmers around the world who have struggled to compete in the face of heavily subsidized agribusiness operations that have monopolized the market and driven small farms out of business. This has led to a worldwide decline in agricultural biodiversity that has been disastrous for ecosystems and local communities all over the world.

This alienation goes both ways, as consumers are estranged from the production of food, and the producers are estranged from the consumption of it. Modern consumers have relegated themselves to a subordinate role in the food chain and have become increasingly removed from the source of their nourishment. Meanwhile, producers have been marginalized by the system of industrial agriculture that has forced them to engage in practices that are often harmful to the environment and the health of their animals.

However, the solution to these problems is not to abandon modern agriculture and return to the pre-industrial era, but rather to find a way to use technology to create a more equitable and sustainable food system. While conducting preliminary exploratory fieldwork for my thesis, I had the opportunity to meet with several small local poultry farmers as well as technicians who work with the Government's agricultural and animal husbandry department. From these conversations I was able to learn about the difficulties these farmers face as they attempt to make a living in an industry that is dominated by large multinational corporations that are pursuing short-term profits at the expense of long-term sustainability. As well as the governmental agencies which are tasked with regulating this industry but are hamstrung by inadequate funding and weak enforcement mechanisms. The motive for conducting this exploratory research was to gain a better understanding of the poultry industry at the grassroots level in order to design fieldwork strategies for more in-depth ethnographic research later in my program of study. The results of my investigation were as follows:

7.1 Preliminary exploratory study:

On August 2018, preliminary field-work began in the neighbouring towns Khatkhati and Bokajan of Assam. They form the periphery of Dimapur district, the commercial hub of the State of Nagaland, India. The idea was to investigate the farms that supply poultry products to Dimapur, a town with a high animal consuming population of about 400,000. Dimapur town ends abruptly at the border with the State of Assam, hence, the neighbouring district of Karbianglong, in the State of Assam, figures as the major producer and supplier of food such as vegetables and livestock produce. About fifteen kilometres north from the town limits is the rural outskirts of Bokajan where there has been a boom in poultry farming due to huge demand. They supply live broilers to vendors mostly in Dimapur, Nagaland. These farms are located a few meters away from the highway and are generally a cost cutting operation where the most important investment is made on the birds themselves.

A few farms were visited with Dr. Achi, a veterinarian by training and now a senior officer of the Nagaland Agri- department. The motive of this process was to gain a preliminary understanding of the poultry industry with expert eyes before moving on the mega farms in the Near Capital region of India. Hence, visitations to the area were made once a week for a month and a half before compiling my observations and recording my discussions with the farmers. The task was made formidable due to the summer monsoons, which are particularly heavy in the North Eastern region of India, and which turned winter dust roads, that I needed to traverse, into a quagmire of mud and water. Nevertheless, my continuous sojourn to these sites in Bokajan, Assam was a mixed bag - I could only meet the farm-hands but never a manager nor the owner. This was significant as most of the workers, majorly Bangladeshi migrants, commented that they only acted upon the instructions of the owner. Hence, the construction of the coops, the choice for the type of feed, the antibiotics/vitamins/minerals used, were all beyond their realm of 'control' and in most cases – 'understanding' as well.

The design of the coops was similar in all the sites, mostly using local materials to cut cost. The coops were rectangular half brick bottomed structures, with criss-crossed bamboo latticing, topped with either a tin roof or a thatched roof. The birds were bred in the coops in the tens, usually overcrowded. The structures had open ground in the centre on which there was a thin layer of hay, and hanging from the centre frame were three feed and water bowls along with incandescent lights that burnt through the night.

The chicks, some farm hands explained, were shipped to them from Punjab, and were kept in crowded batches. The logic of such a setting, I was told, was to limit the movement of the birds and to keep them awake and induce them to feed through the night. Hence, day-old chicks are ready for the market hardly able to carry their own weight in a few weeks. They are then transported in open caged trucks to the whole sale markets in order to be further distributed. This is also what makes chickens popular for agri-business, the short growth time, the low investment required, and the perpetual demand.

Chicken feed:

According to the Central pollution Control Board of India, Assam has an industry of 46.712 million poultry birds in 2021, and Nagaland a paltry 2.8 million, these numbers include chickens, ducks, goose and other domesticated birds. The extent of these farms is mostly small in scale, and highly influenced by fluctuations in the price of the feed, the market for which is highly unregulated. A scoping research of poultry feed resulted in the discovery of a variety of medicated and unmedicated pellets that are made available in grocery stores, grain stores, and even in neighbourhood 'paan-shops' (a generic term for small multipurpose shops that sell everything from FMCGs, food grains, chewable tobacco products, and more recently animal feeds). These medicated feeds commonly have coccidiostats and/or antibiotics that costs 80 to 100 INR per kilo and are preferred by farms as it aids and promotes faster growth by limiting disease outbreaks.

There are mainly three stages of broiler feed, that is, a 'Starter' (triphase 1: day 1 to 12), 'grower' (triphase 2: Day 13 to 24), and finally a 'finisher' (triphase 3: Day 25 to 35). In all phases coccidiostats, enzymes, and antifungal (mycotoxins) are added to the feed, while supplemented by antibiotics, calcium, zinc and other minerals which are added to the water. In some feeds antibiotics such as Penicillin, Bacitracin, Chlortetracycline, and Oxytetracycline are directly mixed to the feeds.

Hence, when an inquiry was made into the contents of the feeds, most farmhands were unaware of the contents of the big plastic bags, usually stored improperly. They revealed that every month a pick-up truck would show up with bags of feed and their only concern was that they feed the birds and load up the chickens for sale in another truck. The involvement of the owners seems to be very limited, "they mostly come to count the number of birds for sale, and the pay us our salary". Which was revealed to be either pegged upon the number of surviving birds or a limited monthly emolument.

Sanitation and Waste Management:

While the sanitation of the bird houses were questionable, the living conditions of the farm workers were less than ideal. With no access to running water in three of the four farms and the lack of proper toilets for the workers in all four. The air reeked of ammonia and the dust stirred up from flapping wings made it difficult to breath, which was corroborated by statements made by the farmhands about the impact to their health. While most farmhands stayed in the village nearby a few lived in-situ in order to prevent theft.

The coops were visually unassuming and the waste from the chicken coops were piled on to the one side of the farm. They were generally sold to farmers as manure, but the mounds of refuse and hay that remained leeched into the environment. Many of the chickens showed signs of stress and were moulting abnormally.

In the market place (New Market, Dimapur) chickens were mostly sold live; there is a difference in prices between live chicken (live weight) and de-feathered, gutted chicken. Vendors inhabit a dingy area with drains running down the middle of the alleyway and share one or two de-feathering machines, which is a stainless-steel drum with finger-like rubber protrusions on the insides. After a chicken is halalled, the carcass is soaked in piping hot water and dumped into the drum which spins to pluck the feathers. Considering that multiple chickens are soaked in the same water, often having droppings and dirt on them, and used in the same de-feathering drum, these machines are genuinely a health hazard. Several studies have demonstrated the spread of bacteria through this means, with some studies showing a multiple-fold increase in the proportion of salmonella positive carcasses (Ed. G.C Mead, 2004). All the waste from butchering operation in the market either went into landfills or were thrown in to the drains.

Governmental intervention:

At the local level the state departments and ministries such as the Ministry of Food and Agriculture and the Ministry of Livestock Development have played a critical role in the development of rural and agricultural infrastructure in the region. From providing training and educational support to establishing markets for locally produced goods, and distributing hi-stock chicks to farmers these agencies have made a significant contribution to strengthening local economies and improving food security. However, the informal local practices within the State dictate a division of labour along indigenous and non-indigenous lines, wherein the latter are more inclined to broiler farming. Furthermore, as land ownership laws disallow non-locals from owning land in Nagaland the neighbouring districts of Assam have become the preferred locations for large farms.

Other livestock produce such as pork, beef, quail and backyard chicken are more commonly produced by indigenous peoples of the State. This division has resulted in an underdeveloped poultry sector within the State of Nagaland, this technicality has hindered the development of regulatory mechanisms to check antibiotic use. Additionally, unregulated sale of antibiotics in Nagaland has led to its widespread abuse among farmers and producers; as pharmacies and other retail outlets often sell over-the-counter antibiotics without the required prescriptions from qualified medical personnel.

Antibiotic use:

Medicated feeds were widely available and were a popular purchase for commercial farms as well as by backyard farmers. While the term ‘antibiotics’ was not used, the local way to distinguish feeds was to ask the vendor – “*itu dawai walla toh asey?”* (Is this the medicated one?) It was widely considered locally that medicated feed meant the inclusion of vitamins and minerals as well as other chemicals, but not antibiotics. As such these feeds were sold widely and were unregulated. Furthermore, access to veterinary antibiotics was fairly easy and informal sale of these antibiotics was also common. It is fair to conclude that the use of medication usages were fairly high and there is widespread use of medicated feed by most of the livestock farmers in the state. The number of veterinarians available is also very low and the services are not very widely available to farmers at affordable costs and conveniences. Furthermore, most farmers as well as consumers are not aware of the risks and dangers of misusing antibiotics for human health and certainly not aware of the importance of the correct usage of antibiotics in the animal husbandry industry.

Discussion:

Based on my research, it appears that the use of antibiotic growth is are quite widespread. The initial fieldwork also helped establish the prevalent patterns of antibiotic use on the local level and revealed the chains through which poultry products are grown, reared purchased and distributed from the periphery to the urban centres. This part of the study also helped me to understand the mechanisms involved in production, distribution and consumption of antibiotics and related chemical inputs at the local level. It also revealed that there is considerable potential for unintentional use of antibiotics in agriculture as most farmers are not aware that improper and excessive use of these drugs in animal feed can lead to emergence of serious public health problems.

Furthermore, the broad availability of medicated feeds in the market is concerning but also point to soft markets where companies find little difficulty in selling the products despite regulations to the contrary. Additionally, the main concerns of department in-charge of livestock welfare continue to be in economically significant livestock diseases of which antibiotic resistance is not a priority. Hence, there is an emphasis mostly on control of helminths and viral infections through improved husbandry practices and vaccination programs rather than on control of disease caused by bacteria. Finally, since livestock farming continues to be a source of livelihood and a supplementary source of food for the majority of the population in the semi-urban areas there is a higher chance of zoonotic transmission of resistant bacterial strains.

Image 3 Condition of Broiler Chickens in Farm 1

Image 4 Storage of Finisher feed pellets Farm 1

Image 5 Rows of 'kaccha' poultry coops Farm 2

Image 6 Condition of Broiler Chickens in Farm 2

Image 7 Storage of Feeds Farm 3

Image 8 Storage of Poultry Feeds Farm 3

7.2 Scoping field study of Poultry market in Delhi.

Three market areas were visited from October 2018 to January of 2019 – South West Delhi (Dabri Mor Market, Dwarka sector 3 market), South Delhi (Safdarjung, Munirka, and RK Puram – Malai Mandir Market), and South East Delhi (Lajpat Nagar 4). The purpose of this exercise was to understand the supply chain links within the city, albeit to a limited capacity as most vendors visited were in the South of Delhi. Nevertheless, this exercise helped identify Ghazipur Mandi (East Delhi) as the loci of poultry distribution in the city. It also facilitated for observations to be made with concerns to the conditions under which poultry were handled and sold in the various places, throughout the south of the capital region.

Dabri Mor and Malai mandir markets had a dedicated section for the sale of chickens along with fish and/or mutton, while interspersed with vegetable, fruit, and dry good vendors (grain, pulse, spices, etc.). Both these markets were also located close to major city drains.

Other areas had dedicated butcher shops that sold chicken and mutton, and/or fish as well. There were live chickens present in cages in most establishments except in the butcher shops in Lajpat Nagar, Munirka, and Safdarjung. In all these establishments (permanent or otherwise) live chickens were sold, usually kept in cages or housed in small enclosures below the butcher's platform.

The municipal departments are responsible for providing licence to meat shops and thereby responsible for enforcing regulations with regard to safety and hygiene in these establishments. Furthermore, wholesale markets also come under the purview of the municipal corporation from where individual vendors buy stocks in bulk to be further distributed to customers.

Discussion:

The supply chains for poultry products are vast and intricate, spanning from the farms where poultry is raised to the stores where they are sold. They are similar to the chains in place for other agri-produce. However, differences arise between the various products as different parts of the supply chain experience different levels of risk and are subject to different regulations. Through the years that I have been working on this topic, there have been a number of changes made that have had a significant impact on the sale of chicken meat to consumers in the NCR. The establishment of waste-to-power plants in places such as Ghaziabad Murga mandi has reduced waste volumes in the area. In addition, the Delhi High court banned the slaughtering of birds in Ghazipur in 2018 following reports by the Delhi Pollution Control Committee (DPCC) about numerous health and waste disposal violations at the market. However, such practices still continue in Ghazipur as well as other markets across Delhi.

The Department of Veterinary Services of the Municipal Corporation of Delhi (MCD) has also put in place several guidelines that ban the sale of live birds in open markets and restrict the transportation and sale of birds. However, due to a lack of poultry slaughterhouses in Delhi, culling of live birds in the shops is still allowed. Such practices are unsafe for the public as they are likely to cause infections to both human handlers and the animals themselves. However, there are other MCD approved butcher shops that source birds from the abattoir. It must be noted that Delhi has only one abattoir at present which faces multiple closures in a year which reduces its operationality and is also insufficient to meet the high demand for chicken meat.

On the production side of the poultry industry, the Government of India through the Ministry of Agriculture and Farmer's Welfare published the draft rules on antibiotics in poultry on the 29th of April, 2019. The rules outline aspects relating to licensing of farms, permitting farm inspection, banning of growth promoters, however, since it only covers egg production activities it is limited in scope and does not address the major issues faced by farmers with broiler breeding operations. This is instead covered by the Food Safety and Standards Authority of India (FSSAI). The Food Safety and Standards (Contaminants, toxins and Residues) Regulations, 2011 which sets limits for residues of antibiotics in food stuffs and also sets withdrawal periods along with inspection guidelines. These regulations have been amended several times and the current version of the regulations was published in 2019. However, there are limitations to manpower and financial resources to implement the regulations and their effectiveness is doubtful as many instances of violations have been uncovered through recent studies.

Finally, many poultry sellers within the NCR lack cold storage facilities, posing a threat to food safety as the quality of these products is often compromised due to improper handling. However, the development of app-based e-commerce solutions for the poultry trade presents an opportunity for new players to enter the market and provide safe, high-quality food to consumers. Chicken, fish, mutton, and other animal protein products are now available to Delhi residents on delivery apps such as Swiggy, Zomato and Licious. Such services have become popular following lock-down restrictions during the COVID-19 pandemic and provide another mechanism for controlling quality, safety, and traceability in the meat sector for the NCR consumers

7.3 Expert interviews:

Respondent number	Role/ Affiliation	Mode
1	Senior Department of Animal Husbandry and Dairying	Personal
2	Veterinarian/Member of Empowered Committee for Animal Health ECAH/ Consultant to the Poultry Association of India	Personal
3	Senior Professor/Medical anthropologist,	email

4	Health systems and Health Policy expert/AMR research expert	Telephonic
5	Veterinarian/Livestock policy advocate/Founder, Livestock resource centre	Telephonic
6	Programme Dir. Public interest research and advocacy organisation/ Food Safety & Sustainable Food Systems Expert	Personal
7	Dept. Microbiologist	Personal, Telephonic
8	Public health specialist, Animal husbandry and Veterinary services	Telephonic
9	Principal Scientist/Agricultural Policy/Science and technology expert	Personal
10	Oncology Pharmacist/Co-founder pharmacy education online resource/Asst. Professor of Pharmacology	email

7.4 Healthy Chickens sick Humans

Experts agree that antibiotic resistance is a growing problem, and one which will have serious consequences for human health. One of the most serious consequences is that antibiotic-resistant bacteria can spread from animals to humans, leading to more serious infections which can sometimes be fatal. The consequences of this will not be seen immediately but could take decades to fully develop. However, there are a number of things that can be done to slow or halt the spread of antibiotic resistance, including ensuring proper use of antibiotics in animals and improving sanitation in the agricultural industry. As urbanisation increases the interaction humans have with animals and the environment, so will the incidences of zoonotic diseases increase, which put human health at risk.

“Antibiotic resistance is a problem that can affect anyone, regardless of class, age, gender, lifestyle or location” (Expert 1), and in recent times such incidents have been increasing in both number and severity. These range from the more common diarrhoeal illnesses to more serious conditions like pneumonia and blood poisoning.

Core theme 1: Awareness and approach (Antibiotic use and knowledge)

"...the biggest role in combating AMR in the poultry sector is the farmers, for which there needs to be education and awareness programmes. They need to be made aware that they are producing food for human consumption and that the way they raise and treat their animals can have an impact on the health of consumers." (Expert No 2)

Farmers and veterinarians have expressed a need for antibiotics to keep their chickens healthy. However, many veterinary antibiotics are disguised as vitamins and mineral supplements in feed and water and are therefore not regulated like they are for humans. The lack of awareness about the detrimental impacts of antibiotic use among farmers as well as the general public has allowed for the proliferation and apathy of these ‘invisible’ antibiotics in the chicken supply chain. Hence,

a comprehensive communication strategy, which takes into account the various drivers of AMR and provides support to all stakeholders along the chicken value chain, is needed to help reduce the rampant and indiscriminate use of antimicrobials in poultry farming and promote responsible antibiotic use. As for consumers, while there is a growing demand for antibiotic free, and or hormone free animal produce such products are often more expensive and not easily available in local shops or supermarkets. This poses a significant barrier to consumers who want to reduce the use of antimicrobials in their diets but face challenges in accessing these products. A joint effort between industry, government and civil society is needed to provide education about the risks of overuse of antibiotics and promote the sale of more prudent and sustainable poultry products to consumers.

"Even among law makers the awareness is not where it should be. So, until we have awareness and through those communication channels that are designed in a fashion that reaches everybody, you can't hope to make significant progress. Even in terms of prioritization this is still somewhat late. It is something that we need to consider today though we are actually thinking about tomorrow." (Expert 1)

The issue of awareness, education and communication is complex, multifaceted and requires different strategies for different stakeholders at different stages of the food system. In order to effectively address the problem of AMR it is necessary to develop a multi-pronged strategy. This is particularly relevant in developing countries where the burden of AMR is high and access to healthcare is limited. therefore, health programmes should target farmers and veterinarians by providing them with information about responsible antibiotic use and encourage the development of local alternatives or resort to traditional remedies and treatments that are not reliant on antimicrobials. The success of these strategies will ultimately depend on their widescale implementation and sustainability. Moreover, it is important to ensure that the right information gets to the right people at the right time and place and that the messages resonate with the target audience.

"While steps towards this end have been undertaken in India, it is still early days and there is a long way to go before the problem can be fully addressed. There are some success stories where people have worked together and have emerged with good solutions...but that's on a very small scale." (Expert 6)

Therefore, in order to improve awareness, there is a need to adopt new technologies such as e-learning and mobile technology to reach more people and increase access to information about AMR. In addition, policymakers should support the development of local capacity for training in order to empower local communities to implement localised strategies to deal with AMR. In the long term, capacity building should include providing formal education to people living in rural areas so that they acquire the skills they need to better manage their livestock and resist the spread of disease. Education in schools is also an important step and should be expanded to ensure children learn about responsible antibiotic use and the consequences of misuse from an early age. Dissemination of such information through media campaigns should also play an important role in raising awareness of the dangers of antibiotic resistance and the importance of using antibiotics responsibly. These are among the most important actions required to achieve the goal of curbing the spread of AMR.

Core theme 2: Surveillance, Regulations and resource shortfalls

The scale of the problem

The antibiotic problem in India while significant is not supported by comprehensive data nor evidence because there is a lack of a coordinated approach to monitoring the spread of antibiotic resistance. There are localised studies in some areas that have attempted to gauge the extent of the problem but this data has not been gathered nationally nor sub-nationally. This lack of data means that we cannot be confident that we are dealing with the full magnitude of the problem. There is also a lack information on how people are accessing antibiotics and their usage patterns without which implementation of appropriate control measures to address the problem becomes difficult. There is also limited information on the availability and effectiveness of existing regulatory measures in addressing this problem. Hence, we have a situation wherein the scale and scope of the problem is not fully known and therefore there is uncertainty over how to effectively respond to it. Antibiotic use in agriculture is surely a significant contributor to the problem of antibiotic resistance but there are other factors such as poor hygienic practices in the hospital setting that must also be addressed if we are to successfully combat the problem. Therefore, one of the key challenges is to develop a comprehensive strategy that can target both the problem itself as well as the underlying causes.

This is common in most LMICs where data are minimal and the research community are not funded sufficiently to build capacity and expertise in this area. There is thus an urgent need for developing and instituting a national surveillance system to monitor antibiotic use patterns and monitor the emergence of resistance in different pathogens in the country. India is a signatory to several international conventions on antimicrobial resistance and has the potential to develop a strong national surveillance system that can help identify hot spots and implement control measures to address the problem. However, the necessary resources to achieve this goal are not available within the current regulatory framework and resources are also being diverted to other more urgent priorities such as polio eradication or the health budget reduction measure etc. It is vital that the government dedicate adequate resources to establish an effective surveillance programme and develop the necessary legal framework to effectively implement policies to address drug resistance at the national level. Furthermore, information regarding the same needs to be made publicly available to all stakeholders through regular reporting mechanisms to ensure accountability and transparency in the policy-making process as well as to provide researchers and doctors with relevant information to formulate effective prevention and control strategies.

Antibiotic use in low-resource settings compounded by lack of resources among regulatory bodies and limited capacity for laboratory diagnosis means that it is difficult to formulate and implement appropriate policies and regulations to address the growing problem of antibiotic resistance. Among the resources required are trained manpower and technical infrastructure to detect the presence of resistant bacteria and institute the appropriate control measures to eliminate them from circulation and prevent further spread of the resistant strains. Such capabilities would also support local healthcare personnel in providing proper guidance regarding prescription of antibiotics and other treatment measures for a variety of diseases. Hence, in these ways antibiotic resistance uncovers the systemic problems that lie at the heart of the existing public health infrastructure and its implementation at local level across rural India.

Banning of antibiotics in animal husbandry has been a central plank of India's response to the problem of antibiotic resistance. While this has resulted in a marginal reduction in consumption of antibiotics other problems arise as a result of inappropriate substitutes that are commonly used in their place. Use of substitute agents could also pose serious health risks to the animals as well as to human beings as most do not have proven efficacy against bacterial infections and are potentially toxic when administered orally or parenterally (as in the case of some anti-parasite agents). In addition, it has also resulted in a negative impact on livelihoods of small farmers in the country as it has increased production costs and led to a decline in the quality of animal products.

The literature also suggests that apart from excessive antibiotic use in India for human health there is also the lack of access to quality antibiotics which contribute to the emergence of resistant bacteria. As for veterinary pharmaceuticals there is even fewer regulations and quality controls in place. This especially is the case of veterinary medicines used for poultry and fish farming which are prepared and sold without the approval of the Drug Controller General of India in many parts of the country. There is also a lack of adequate diagnostic facilities in many rural communities across the country which contributes to higher mortality rates among patients and further spread of resistance.

As for regulations, India does have laws in place to control the sale of antibiotics such as Schedule H of Drugs and Cosmetics Act 1940 which states that all drugs have to be registered with the Central Government and the Central Drugs Standard Control Organization before being sold in the market. Furthermore, newer regulations have been put in place through the Food Safety and Standards Act 2006 which require labelling of foods with information on the presence of antibiotics, however these are still lacking in practice. In addition to these there have been numerous policy initiatives over the past few years aimed at reducing the demand for and use of antimicrobials in livestock which have seen mixed results so far due to a number of underlying factors including limited implementation capacity and difficulties in implementing change at the local level. Hence, newer policy strategies have been proposed that take in to account stakeholder participation to ensure their buy-in and commitment towards the adoption of interventions. SMART interventions have also been suggested, which take into consideration a series of regulatory design principles in order to achieve high compliance rates and success. This model moves away from the conventional 'command and control' approach to incorporate a form of “regulatory pluralism” that embraces “flexible, imaginative and innovative forms of social control”. Proposed by Neil Gunningham, Peter Grabosky and Darren Sinclair in the 1990s this approach was proposed in order to overcome the inefficiencies of traditional regulation.

"...the current mechanisms in place for the oversight and governance of antimicrobials require a fresh and more holistic approach if we are to achieve meaningful and sustainable change. SMART regulations are a new and innovative approach to achieving this goal, one that adopts a participatory and inclusive approach to designing regulations and tools aimed at engaging and empowering different stakeholders." (Expert 4)

The Smart approach represents a shift from traditional regulation and incorporates design principles such as i. the Incorporation of a broad range of policy instruments and actors; ii. adoption of least interventionist viable measures to achieve the desired outcome; iii. progressively serious penalties for non-compliance with regulatory measures; and iv. hopes to empower a broad range of parties to act as surrogate regulators. Therein, increase the number of eyes and ears on the ground to tackle the problem at the source, each section responsible for regulating their peers/stakeholders as part of the enforcement and monitoring process. To date there have only been a small number of studies that have adopted this approach with mixed results. Nevertheless, working on a subject that is as complex as antimicrobial resistance requires a comprehensive and strategic approach that accommodates the complexity of the issue and therefore is open to novel solutions and strategies. One of the requirements set out for regulation is that they need to be cost effective as well considering the nature and distribution of resources that are available for implementation. It is argued however that the costs are often underestimated in the case of antibiotic resistance because the focus is on individual cases and not on the full impact of antimicrobial resistance on society as a whole.

Currently, interventions are based on behaviour -change approaches that emphasize the need for training and education about health and hygiene at an individual level. However, most of these programmes result in only minor behavioural changes and fail to make a significant impact on overall prevalence of multidrug resistant bacteria. This highlights the importance of a broader approach that includes community-wide interventions aimed at modifying the social, economic and cultural environment to promote healthy behaviours and increase compliance with the existing regulations. Community-based initiatives are less likely to be rejected by individuals as they appear less intrusive and more socially acceptable than government-led initiatives. However, the success of such programmes is often limited by the difficulties encountered in getting them implemented at a large scale and sustaining their effects in the long term. There is also a strong role for public health authorities as well as policy makers in initiating and driving changes to policy and practice on a wider scale.

Core theme 3: **One Health, Food Safety and Security**

There was also consensus that the problem was not limited to a single sector, such as human health or livestock production, but would affect all sectors involved in the food production chain including aquaculture, public health, agriculture and environment. An integrated approach was therefore seen as the most effective way to tackle the issue. Hence, One health has become the motto for the global effort to address cross-sectoral issues of human and animal health. While the concept of "One Health" has had much success in raising awareness about the relationship between human, animal and environmental health within a number of countries, many countries have failed to establish a coherent strategy to achieve their vision. Such problems are multiplied when it comes to India, as the country is simultaneously undergoing a period of rapid economic transformation while at the same time striving to address the complex challenges that arise from rapid urbanisation and the transition to an industrial farming system. Additional complexities are further compounded by different departments having different agendas at different levels of governance which make it difficult for coordinated action to be achieved and sustained.

"...when there was an outbreak of Nipah in Kerala we asked the state veterinary department for samples to test for the virus. They were not willing to collaborate as they declared that they already processed the samples..." (Expert 1/ 2).

"Why do you suppose they refused to cooperate?"

"Well, there is a lot of politics involved."

"...so, what of the considerations of the One Health surveillance network?"

"You see, it all looks very good on paper but the reality is very different because in practice everyone has their own interests at stake. In meetings no one really wants to hear what anyone else has to say because everyone has their own agenda and no one wants to compromise." (Expert No 1)

One Health is by no means a new concept, however, in its modern avatar it has been re-conceptualisation to constitute an idea of health management in response to the accelerating environmental changes of the past century, changes that saw an exponential growth of population and industry, and their consequent impact on ecosystems, and therefore its interaction with human and animal health. The ideology that it stands for is embracing the idea that the health of humans is inextricably linked with that of animals and the environment. However, the systems we have in place do not allow for this kind of holistic thinking to take place and as a result there is a great deal of disconnect between the different stakeholders that are involved in the process. While the AMR campaign is based on this notion of interwoven relationships and the interconnectedness of our health and that of our environment, in reality these linkages are not reflected in the way we organise our health system and the way our communities think about the problem.

However, this does not spell as a failure for the AMR campaign but rather as a challenge that needs to be addressed. The problem is not that we lack the scientific knowledge and technology to address the problem but that we need to address the underlying structural issues that prevent us from taking a holistic approach to the issue. Our institutions are set up in such a way that we are unable to break down the barriers between different stakeholders so that we can create a unified response to the AMR. In many parts, due to an informal hierarchical positioning of the different stakeholders there are psychological barriers that prevent partnerships and the sharing of information between them. This creates a vicious cycle that prevents a collaborative environment that is necessary for tackling complex problems such as AMR.

“What then is the future of the One Health approach?”

"...well...It is difficult to say, at the moment it is still an ongoing process of hammering out the details and figuring out what works and what doesn't. Clearly there is a need to inculcate the ethos of it, but it is proving difficult." (Expert 1). Similar sentiments were share across the board, while as a concept it has been widely accepted, the operationality of it professes to provide barriers to its implementation.

A. Food Security and Safety

Some experts questioned the narrow definition of 'food security' often used by the development agencies in India. Which focuses primarily on guaranteeing access to adequate quantities of food rather than promoting its quality. When coupled with a lack of regulatory mechanisms to ensure high standards of food safety, this leads to an increased risk of food-borne illnesses and undernutrition among the poor and the marginalised sections of society. India reports food poisoning cases at the rate of approximately 60-70 per million people per year, and weak legislation and enforcement, and a lackadaisical attitude on the part of the consumers have contributed to this alarming figure.

Food security and safety is also a major economic issue as it leads to significant losses in terms of productivity, trade and more recurringly social disruptions. It also places an additional burden on governments as they are forced to spend more on health care and other social programs. Furthermore, antibiotics or antibiotic resistant bacteria in the food chain could also have financial consequences in a country's export trade. Experts and scientists have already collected evidence of AMR bacteria or genes in crops, animals, fisheries, fertilisers, seafood, other agricultural outputs, soil, water, and in the air as well from studies conducted across India. Such findings have a grave implication on reaffirming an image of hygiene and safety in the international market as well as undermining the country's ability to claim a clean and healthy environment to attract tourists and investments to the country.

Such images deliver significant projections to the world. As the controversy with the naming of the New Delhi metallo Beta Lactamase-I (NDM-1) "super-bug" gene manifested, there are fears of stigmatisation associated to entire population groups and communities. On one hand, the concerns voiced with the naming of NDM-1 was economic as health experts feared that it could impact India's burgeoning medical tourism significantly, it was also seen as an unjust scapegoating of India for the rapid spread of antibiotic resistance globally. This is not unique to India, as the recent controversy with calling the SARS Cov-19 virus as the 'China virus' clearly demonstrates similarly. However, that having been said, and as discussed through various research works on the situation of antibiotic resistance in India, there is a significant amount of work that needs to be done to improve the current situation in the country in order to combat the problem effectively as well as cognitively.

Hence, the immediate course of action should be to work from the bottom up, i.e. through the implementation of the various policies targeted at improving farm-level practices, improving awareness and providing education, and also placing stringent food safety and quality measures. There has already been considerable work done in this aspect and trends suggest an increasing awareness, however, antibiotics and bacteria being a very scientific concept sometimes suffer from being lost in translation. Hence, messaging also needs to be curated to the targeted population groups so that accurate information can be delivered to them in an engaging manner. In particular, campaigns aimed at women need to be crafted more delicately as they are the key decision-makers in the family when it comes to consumption patterns in the household. Another important aspect to focus on is adoption of alternative farming systems that do not use antibiotics regularly.

B. "...but why are you researching poultry? It has already been quite extensively researched. The real problem now is the fishing industry, which is vastly overlooked in terms of research...." (Expert 6).

"Oh! could you elaborate a little bit more?"

" Well... fishing has really taken off in places like Bihar and UP (Uttar Pradesh) where large ponds have been constructed to farm fresh water fishes and shrimps as well. These are ponds with thousands of fish that have no water filtering system so they are a huge source of pathogens. So, antibiotics are poured into these water bodies to control disease. Other than antibiotics even disinfectants are being used, and this practice is going unchecked. Imagine whole ponds with antibiotic-resistant bacteria!" (Expert 6).

Poultry farming is a popular antibiotic topic because it is a widely practiced industry and there is a large amount of data available on the use of antimicrobials in poultry production systems. Fisheries and aquaculture in India, on the other hand, have not received as much attention and remain an area of concern. The types of research being conducted in fisheries and aquaculture have focused primarily on infectious diseases and toxins rather than on the use of antibiotics. Having said that, fisheries in India have not integrated as much into the factory model as the poultry industry has. As such, we have a better understanding of poultry farming processes and the associated risks associated with the use of antimicrobials than we have of fisheries practices.

" These areas (Bihar, Bengal, UP) are prone to flooding as well, the chances of resistant bacteria proliferating and polluting and surrounding environments as well as seeping into the ground water etc are enormous." (Expert 2).

These are avenues for future research that require further enquiry. Fish farming is a major area of agricultural production in the subcontinent and India as a whole play a pivotal role in this arena as it is the second largest producer of fish in the world after China. Furthermore, the nature of fish farming differs considerably from other livestock animals as they are exposed to different environmental parameters which could impact ground water quality leading to a greater fall-out of antibiotic resistant strains in the ecosystem. As India experience higher demands for all animal proteins, it is likely that fish farms will also continue to expand to meet growing demands. Hence, it is important that we understand the extent of antibiotic use in this sector as well.

Core Theme 4: Sustainability

As evident from the above the subject of 'sustainability' is intrinsically linked to the problem of antibiotic resistance and recurs throughout the different themes and subthemes discussed in this paper. Whilst there is no single definition of sustainability or a specific framework that can be used to determine its applicability to a particular context, there remains an agreement that it is inversely relatedly to the concept of 'growth'. Here growth is defined as an increase in the number of goods and services produced which often results in an increase in resource use and environmental degradation and depletion of non-renewable resources. In modern industrial societies 'growth' is often viewed as positive, particularly in terms of increasing national wealth and improving standards of living, bringing people out of poverty. This view is also prevalent in the agriculture sector where increased yields and increased production of commodities are seen as a machine for economic growth. However, this view is based on an implicit assumption that natural systems are inexhaustible and therefore that the economy can grow without limit.

If we were to use the definition of sustainable food production as "a method of production using processes and systems that are non-polluting, conserve non-renewable energy and natural resources, are economically efficient, are safe for workers, communities and consumers, and do not compromise the needs of future generations" (Foresight. 2011), then clearly there are serious concerns about the continued use of current farming systems and their impacts on the environment (other than ABR) such as air pollution, eutrophication and loss of biodiversity. However, the predominant industrial model of farming persists because the current economic models in which the economy is subordinated to the greater needs of the market and supported by state subsidies and trade protection measures make it virtually impossible to make significant changes. As corporations come to control more of our food production and distribution systems the pressure will increase to focus on profitability and productivity rather than social and ecological factors.

Antibiotics in many ways is the perfect tool for manifesting this "commercial imperative" with the potential to produce more food using fewer resources, producing cheap and highly profitable products. While one may argue that this inadvertently makes food more affordable which is understandable and necessary; the mechanisms that allow for this is detrimental to local food diversity, their agricultural communities and their traditional practices. If we were to look into the political economy of food then it becomes quite evident that food prices are not solely an outcome of demand and supply alone as traditional economics suggests. Government policies, international trade agreements and private sector interests all have an impact on the price and availability of food. Furthermore, as the Covid-19 pandemic demonstrated, out food infrastructure is an overextended network of complex global supply chains which attempts to source cheaply over many distances making them vulnerable to disruption at any time. The Ukraine war with Russia (February, 2022) also demonstrated this vulnerability as wheat supplies from Ukraine were unable to exit into the world markets. We shall explore more on this in the discussion section as many of the respondents emphasized on the importance for local resilience and supply as well as the role of new practices and technologies in overcoming these challenges.

Therefore, in light of all this, there is an increasing call to strengthen local non-industrial production model of food production that would benefit the communities involved in the activity as well as the consumers through the increased availability of healthier and more nutritious and sustainable food, and finally the environment as well. Sustainability and antibiotic use in agriculture are issues of mutual concern where solutions for both problems could be pursued in parallel. There is no expectation of antibiotic use to completely banned, instead it is proposed that its use be judicious and restricted to prescription from qualified experts. The widespread prophylactic and metaphylactic use contributes to the unsustainability of the current production systems.

“In order to understand how we reached this point; it is important to research how it started. While my expertise is not in poultry per se, there are parallels to the development of the food ecosystem in India. What we find is an emphasis on Western models of development which has led to the abandon of our indigenous systems. And antibiotic use has been a part of this model” (Expert 9). That being said, when experts were asked what a sustainable poultry industry could look like, and whether they could compete or replace the current poultry models in terms of price and supply, there were no significant insights. Sustainability, therefore, needs to solve for cost-efficiency and yields before it can become widely accepted as standard practice.

Core Theme 6: Lack of solutions

Ultimately, the absence of effective solutions to combat antibiotic resistance and lack of information to inform decision making leads to even more complicated problems down the road. As with other complex problems the nature of this issue requires multiple experimentation and evaluation. The Stewardship approach is a promising buffer to impede the inevitable while experts around the world continue to identify and implement more effective solutions. This could prove to be a huge challenge especially in resource-poor settings, furthermore it is certain that there will not be a one-solution-fits-all approach. Hence, all efforts need to be directed towards solutions that are local, contextually appropriate and are flexible enough to adapt to the changing circumstances.

There is also a pressing need to increase the level of public awareness about the threats of antibiotic resistance and appropriate ways to mitigate its impacts. The current methods that sensationalise the issue and encourage fear are not sufficient as they will not improve understanding and will in fact aggravate the problem rather than mitigate it. Lasting impact are more likely to occur where the public understands the root causes of the problem and its connection to broader socioeconomic and environmental challenges; this is possible through incorporation of the issue into the educational curriculum and relevant public campaigns.

"...just like they did with that subject where they taught environmental issues in schools, I think there should be the same for antibiotics. What do children do after they learn in school? ...They tell their parents, nah! (*sic*). Similarly, even in medical schools it should be made mandatory. Only then people will change their behaviour, that is why we need people like you (social scientist), to inform how to change people's behaviour." (Expert 2)

Three of the stakeholder/experts interviewed agree that promoting behaviours that encourage rational antibiotic use is key to combatting the problem. This is in alignment with the WHO's approach that emphasizes the importance of behaviour modulation to reduce unnecessary antibiotic use in the community. However, other argue that hinging on behavioural solutions is akin to "gauging poverty through reductive scales such as calorie intake, or malnourishment through BMI." (Expert 5/9)

Such intervention could "surely help but that is not enough because there are many other factors beyond the control of the individual" (Expert 3/9). Hence, there is a need to change the way the problem itself is described; in order to sway the discussions towards framing the issue as one primarily driven by structural factors rather than individual decisions. This will require that new narratives and paradigms are developed around the issue.

However, there were other experts interviewed who believe that individuals have a significant role to play in dealing with the problem of antibiotic resistance. “I think it is as much about personal responsibility as it is about government responsibility. I do think people have a role to play... [But] it is important to acknowledge that there are things we can do as individuals to help address this problem.” (Expert 2/4/7)

"People buy too many antibiotics - they go to the pharmacy for every small problem.... even if they don't need it. And then they don't finish their course” (Expert 2).

“But what about the poultry famers? Is their use of antibiotics an individual choice as well?”

“I do not think antibiotic misuse is as much as it is reported to be. We have standards and guidelines, there is also a lot of exchange of information between the industry and vets (veterinarians) as well… there are always some who misuse but not much.” (Expert 2).

There is clearly a division in the expert community about the role of individual behaviour in driving antibiotic resistance. Some disagreement also remains over the extent to which individual actions contribute to the problem and whether those actions can be changed through policy interventions alone. Therefore, while both perspectives have some validity, there is also room for a deeper discussion in order to develop a more comprehensive understanding of these complex issues.

Discussion:

The major themes that were extracted from the expert interviews were in-line with the dominant discourse in the antibiotic resistance field, which is that there are multiple causes of antibiotic resistance and that each cause must therefore be addressed in an ecological framework that focuses on the organism and its environment (biological, economic, and cultural). The experts also emphasized that a multi-faceted approach is required for addressing the problem of antibiotic resistance. The experts stated that we must tackle the problem at the microbial level, but also have to tackle the human and social factors that contribute to the problem. Behavioural changes were emphasised as key for reducing antibiotic consumption and improving health outcomes, as these behaviours are largely driven by cultural pressures and socio-economic issues. Finally, the experts highlighted the need for further research that identifies effective interventions to reduce antibiotic use and improve health.

Within these themes were several sub-themes that emerged during the interviews. Some of the most prominent of these were the issue of regulation, surveillance of antibiotics and drug resistance, access to quality antibiotics, and the access to healthcare.

In terms of regulation, several of the experts stressed the importance of strong regulation, and in particular the need to regulate the use of veterinary antibiotics. While there has been some progress in this regard in recent years, it is clear that more needs to be done to ensure that all antibiotics are appropriately used. Others emphasised for different regulatory regimes other than strictly command-and-control strategies to be effective in reducing antibiotic use. For example, one expert argued that changing social norms regarding antibiotic use will be more effective in reducing antibiotic resistance than strict government regulations. This point was echoed by others, who noted that much of the human behaviour relating to antibiotic use is conditioned by cultural norms rather than regulations. Hence, making antibiotic use a part of school curricula or normalising it in the medical community would be much more effective at reducing antibiotic consumption than traditional regulatory approaches. However, as highlighted by the others, there also is a need for clear and effective regulations instead of the multiple and conflicting guidelines that exist in many countries today. Furthermore, self-regulation by the industry would greatly help to address the problem of antibiotic resistance as well.

Antibiotics are essential for most public health interventions, as they are the frontline treatment for many infectious diseases. They are also important for achieving globally established sustainable development goals (SDGs), and therefore, the issues identified above are particularly important beyond purely medical considerations.

There are also no signs that antibiotic use would decline in the near future, India and its continued economic growth will play a significant role in driving the demand for antibiotics. Increasing urbanisation and the presence of a large rural population with limited access to health care will make the problem even more challenging. Therefore, solutions must take into account economic factors while designing any intervention to control antibiotic usage. That having been said, solutions must also be tailored to the economic capacity of the country, as resistance to antibiotics in lower middle-income countries tends to be higher due to excessive use and poor infection prevention practices. Such concerns signify deep-rooted systemic issues with the existing healthcare system in the country.

There are examples of sustainable initiatives addressing this problem worldwide that can serve as a good starting point for developing strategies to address drug resistance in India. The Indian scenario is unique but not completely different from those in other countries facing similar challenges, suggesting that existing solutions could be adapted to the Indian context with minimal modification. Also, other than economic migration to urban areas, India has advanced health infrastructures which are concentrated to the same few urban centres which compel medical migrations as well. Such development also increases spread of antibiotic resistance to other States.

Availability and affordability of antibiotics have become a challenge too, India's poor regulation of generic medicines has led to the proliferation of substandard products in the market. This has led to an increase in the use of cheap antibiotics in both human and veterinary medicine. There is a greater need for anti-fungal medicines as well, which some experts feel are not getting the attention they deserve from policymakers and healthcare professionals alike. Hence, policy makers need to be made aware just as much as the public.

On the issue of food production system, some experts feel that further consolidation and concentration could allow for more oversight and monitoring of quality and compliance with standards by the large corporate farms instead of by individual farmers. While others argue that this would dilute consumer interest and make private producers unaccountable for their production practices. The argument put forward is that the entry of corporations into the agriculture sector threatens the rural economy and consequently erode public goods. Furthermore, large corporations also tend to have enormous lobbying power enabling them to influence regulatory decisions in their favour to the detriment of public health interests. Antibiotic use in agriculture has been sustained due to such interests in the past and concerns continue to be raised about the impact and sway it continues to have on current policy making. Also, since the One Health approach faces several challenges in practice in India antibiotic-use continue to remain high in the livestock sector as well as in the agricultural sector where the direct application of antimicrobials is widely used for crop protection.

The way forward in the face of these challenges is to strengthen the policy environment along with providing technical support at the farm level to promote prudent use of these life-saving drugs, and lastly to increase the number of trained personnel to supplement antibiotic stewardship programmes in both the human and animal sectors. However, without data any initiative in this direction would be purely speculative and not effective in achieving its objectives. Therefore, presently, the need for data is a primary pre-requisite for any evidence-based intervention in antibiotic use.

Lastly, the poultry sector in India is an important economic activity and industry, and current research indicates that some of the greatest offenses to antibiotic-use occur in this setting, and hence, the current efforts to curtail antibiotic-use in this sector are urgent and important. Biosecurity measures should be advocated and implemented in order to protect the producers as well as the consumers from the threat of emergence of resistant bacteria. However, the greatest difference can be made by increasing consumer awareness as demand directly influences production and supply. In conclusion, the cumulative problems associated with antibiotic resistance points to structural deficiencies which require a multi-pronged approach to address them. Hence, Regulation, surveillance, enhanced diagnostics and treatment, education and training, public awareness, sustainable use of resources and environmental conservation are all necessary to ensure long-term control of this problem, which all need to be implemented in unison in order to combat this problem effectively.

Chapter VIII

Conclusion: Antibiotic Resistance as a Cultural Syndrome

Current literature describes antibiotic resistance as heralding 'the end of modern medicine' and envisages calamitous renderings of the 'post-antibiotic era'. An era precipitated by modern industrial farming standing in as one of the four horsemen of the apocalypse, a multiheaded monster of which the poultry industry is the foulest of the lot. Such discussions, while captivating, are petered with what Nik Brown and Sarah Nettleton considers "notions of catastrophism… (and) trauma" (Brown & Nettleton, 2016). Such sensational-isation and fearmongering had been used and are being used in the climate change narrative as well, leading to stagnant conversations. When AMR is projected as an inevitability, it reinforces a sense that the problem is too big to solve and the solutions too costly to implement, thus creating a sense of resignation towards the problem. Some believe that such rhetoric is unrequired when "...the truth is scary enough!" (Cox & Worthington, 2017).

But what exactly is the truth? Other than the fact that mortality due to resistant infections are projected to increase and we require experts from all disciplines come together to solve this problem. This is not to imply that there is much matter under the rug, rather, it is an acknowledgement that the situation is messy and complex and requires a certain level of nuance if we are to move beyond the current stalemate. There are still many questions that are not being discussed or adequately addressed. An easy question to answer is - What can we say about this complex issue that is not couched in hysteria or fearmongering? The main dilemma is in answering questions as to where the root of this problem lies and what can be done about it. The answers to these questions could be a starting point in understanding why there has been little to no progress toward reducing antimicrobial resistance, in fact, reports suggest that the situation is likely to worsen.

That having been said, we need to begin with a deeper understanding of the forces driving antimicrobial resistance, how it is affecting different sectors of society and the economy, and how it is being managed at different levels of government around the world. Most importantly we need to understand how these various forces interact with each other and form a complex web of interconnected factors.

For the sake of brevity, we can conclude by stating that an overhaul, a systemic change is required to address the astonishing complexity of this ‘wicked problem’. Decades of neoliberal-capitalist economics have produced systemic ills that have been showing symptoms in different spheres of society, and AMR is another manifestation of a market logic that has led to widespread environmental destruction, growing inequality and social injustice, to name a few of the many problems we are facing today. The drying up of the antibiotic pipeline, the proliferation of antibiotic-use in farms, the over-prescription by doctors, the over-the-counter sale by pharmacists, and the misuse by individuals are augmented under the umbrella of neoliberal economics. One could ask if this is a fair assessment, but neoliberal forces since the last century have encouraged corporate deregulation, decreasing incomes, increased work hours as well as cost of living (artificial inflation to maximise corporate profits), increased pressures on families and individuals to take drastic steps for their ensuring their economic security, and reduced accessibility to healthcare and education. In Lesly-Marie Buer's book *"Rx Appalachia"*, where she explores the state-corporate nexus and the encounters of women with substance abuse, she very succinctly notes "For me, this persistent overdose catastrophe reflects the very definition of a neoliberal capitalist state that values the deregulation of corporations and overregulation of individuals." (Buer, 2020. para 14.6) So it is with antibiotic use, hence, the current discourse on AMR suffers from a 'fundamental error of attribution'.

However, resistance to systemic change and reform is deep-rooted in the fabric of how our society is currently structured and the vested interests that the current system serves; to be fair, such resistance is discernible in natural systems as well. The difference is in the agency in which we are conferred to act as opposed to nature's inherent limitations in affecting conscious change and advancement. Therefore, what we observe is a decomposition of the solution to the root cause into a series of sequential sub-components which have not been very successful as they are in contention with the implicit goal of an overarching system that is initiating insurmountable resistance. Albeit, transformational systemic changes are a horizontally time-intensive process and often take decades to manifest (e.g., the civil rights movement, women's suffrage movement) and the progress of antibiotic resistance do not allow for this luxury. Nevertheless, along with short-term interventions it is in our best interest to begin the process of implementing systemic changes to minimize disruptions and ensure long-term sustainability as antibiotic resistance is a continually evolving threat.

I

India in the following years needs to increase investments in healthcare and other social services, along with strengthening the surveillance arrays and One Health partnerships that have been already established. More specifically, diagnostic services must be to reduce unnecessary prescription while further research is needed to improve treatments as well as inform strategies. Vaccines should also be made available for common illnesses, such as pneumonia and diarrhoea. Such measures will help to ensure the sustainability of health care in the country. Furthermore, food safety and sanitation practices should also be improved with interventions aimed at strengthening public and community initiatives to popularise sustainable and alternative farming. These include growing vegetables, fruits, and herbs instead of relying on industrial agriculture methods and the use of chemical fertilisers and pesticides. Finally, holistic interventions such as the provision of housing, safe drinking water, solid waste management and education are especially important in poor communities where issues of sanitation and health may coexist.

Most importantly, instead of viewing interventions to antibiotic resistance as a cost to be incurred, it should be used as an opportunity to create new opportunities for economic growth and development. Just as the Clean India Mission (Swaatch Bharat Abhiyan) has led to the creation of jobs and other opportunities for greater investment in infrastructure and, a similar effort for antibiotics could have a significant impact on the quality of food, the environment and the quality of life in India. This could in turn lead to higher employment rates and reduced poverty levels. Moreover, it would also contribute to better health and greater longevity of the population as a whole. Such an approach would serve as a powerful model for combating antibiotic resistance in other low-income countries as well. It also would in the long run ensure better economic returns by improving the productivity of the economy and ultimately reducing inequalities within and between states. The current approaches towards tackling the problem of antibiotic resistance are not likely to yield the desired results as most of these do not directly address the issues of poverty and poor health that are the major drivers of the resistance problem.

A comprehensive strategy that tackles these issues at its roots would go a long way in addressing this problem effectively. However, in order to ensure that such a mission is successful and sustainable in the long run, it is necessary to ensure that it is based on a clear understanding of the needs of the country, including its specific social and cultural characteristics. An appropriate policy framework must also be developed in order to overcome any existing barriers that could hamper the initiative's effectiveness. For one, policies and recommendations based on individual traits, while economically efficient, are not necessarily socially and environmentally sustainable in the long term. Antibiotic resistant is a case in point, it professes to be a cultural problem tied to an economic model that wishes to minimize cost and maximize output/profit without regard to any side effects in terms of health and the environment; in short – a model whose goal is to impose efficiency at all costs. This "cost" has been essentially extracted at the direct expense of social and environmental capital – that is health, nourishment and livelihood of communities.

II

In a short story called *'The Ones Who Walked Away from Omelas'*, writer Ursula Le Guin presents us with a *psychomyth* (a thought experiment) in the guise of a narrative. In the story she writes of about the fictional city of Omelas; a city that lacks for nothing and its citizens who bask listlessly in the wonder of this utopia. A fairy-tale-like city, with no rulers, no slaves, a bright city with beautiful parks and gardens, inhabited by joyous people. In the story we are introduced to Omelas on the day of their summer festival, a breezy sun-kissed day with colourful flags fluttering in the highs of the buildings, the people below dancing and singing as music flows among the crowds, and children scurrying through the maze of the crowd attempting to follow along with the festival procession.

But under one of their myriads of beautiful buildings lies the secret to what makes this utopian city function: a child no more than a few years old is kept in abject misery, living in its own filth, and given just enough food to keep the child alive. The abominable suffering of this maltreated child in that windowless cellar is what ensures the happiness of the rest of the city. There is no explanation given as to how this is so, but it is. So, the people of Omelas continue to torture one child for the benefit of the 'larger good'. Every few years when the children of Omelas are mature enough they are taken to view this abused child, and they are told that this is the reason why they live such happy lives. The children, who so far had lived in ignorance, are now presented with a dilemma - to remain in the city knowing what their contented life is based upon or to walk away. Both options, however, do nothing for the abused child.

Ursula Le Guin's use of the scapegoat trope can be argued to be a commentary and a criticism of a socioeconomic model that has provided prosperity to many at a hidden cost, often known but ignored. It can be argued to be a parallelism; a question thrown to the reader living in the real world – Would you stay or walk away? We could make a proposition that there is yet another choice to be made here - to remain and change. However, history shows us that the progress of humankind has always been hinged on the conquest and exploitation of others (human or otherwise), and continues to be so. The conveniences of our present modern life are based up on having, not just one but, a plethora of things under the basements of our most beautiful buildings, of which corporate farming claim a few.

The availability of cheap food is a celebration that comes at the cost of animal welfare, farm labour exploitation, the sustained impoverishment of farmers, environmental degradation and ecological health risks. Cheap food, which fuelled the golden era of capitalism and continues to do so for neoliberal globalisation. It has been made possible by subsidizing large corporate agri-sector at the cost of replacing smaller subsistence farmers.

Furthermore, the "habitual, mundane, regular and perhaps increasingly void or withdrawn" experience individuals have with food allows for greater exploitation and furthering the risk of unsafe food production and consumption ((Eds) Gray & Hinch, 2018. p. 11) . This and other such truths have been publicly known for decades by now, but we still remain in Omelas. The fact is, it is almost impossible to leave Omelas when it encompasses almost every real estate available on this allegorical plain. Food chains are becoming more consolidated limiting choices one can make, and in turn concentrating control, wealth and power away from the communities and in to the board rooms.

8.1 Expensive Cheap food

"…the incentive to overcrowd is great and antibiotics are cheap."

- Michael Carolan, *The Real Cost of Cheap Food,* p. 91.

Hence, within the existing foodscapes we need antibiotics, that is because "the conventional system has become almost completely dependent upon … external controls" (M. Carolan, 2018. p. 151). Externalities, that over time, became critical components of the system; a system designed for and crusaded for under the rationale of 'efficiency'. But in reality, are hiding operational costs and environmental costs which smaller sustainable farmers cannot contend with. In India, poultry farmers have been dealing with increasing feed prices over the years (which accounts for 70 per cent of production costs), opening of cheap imports from America, increasing price of day-old-chicks, daily demand fluctuations, and bulk supplies from big integrator companies. antibiotics are one of the technological tools that is responsible for the success of this value chain.

Realistically, the true cost of cheap food today are battery cages, medicated animals, factory farms, soil degradation, collapse of pollinator species (insect die-off due to pesticides), deforestation, environmental damage, and a direct impairment on human health. However, farming in India is not as industrialised as farming in the US or in Europe, therefore, traditional farming knowledge remains preserved in pockets throughout India which needs to be encouraged. This is important as food production using traditional knowledge is based on a long history of tweaking and perfecting, while modern farming is based on the neoclassical assumption of 'substitutability' (M. S. Carolan, 2014). An approach wherein the utility to consumers and not the cost of production constitutes the most important factor in determining the value of a product, it also assumes that human ingenuity would triumph over constraints of resource, and any other barriers.

Therefore, the dependence of modern agriculture on science and technology, and agricultural economies on fossil fuels and economies of scale has increased the 'trade-off' equation of food production's effect on the environment. The cost of a broiler chicken, for example, is an accumulation of the hidden expenses that goes in to convert a one-day-old chick to a marketable carcass at four to seven weeks[37]. The industrialised chicken has, therefore, become archetypal example of cheap, convenient and uniform food, which provided the model system on which other animal rearing operations came to emulate.

Fossil fuels in agricultural production and economics, among other things, are a particularly important input necessary for farming machinery, electricity, processing and transport. For an industry that is so dependent on predictable weather and climate patterns, the carbon footprint of the Agri-industry has been very large, reports from 2012 suggested that one-third of all greenhouse emissions (GHG) came from agriculture (Gilbert, 2012). If we add the contribution of the food supply chain to that equation then it would be even larger, for instance an FAO study in 2021 showed that 16.5 billion tonnes of GHG emissions from global total agri-food systems in 2019, of which 7.2 billion tonnes came from within the farm

[37] This measurement of ecological impact is also known 'life-cycle analysis' (LCA), a sustainability concept that looks at the impact on the ecology from planting or mining till final disposal at landfills, or consumption.

gate, 3.5 from land use change, and 5.8 billion from supply-chain processes (Tubiello et al., 2022). That accounts for 31 per cent of the total global greenhouse gas emissions which is a considerable amount even though between 1990-2019 it had been 40 per cent (*ibid.* p. 1799-1800).

The convenience and uniformity of food available in most capitalistic market economies presently, argues Mark Bittman, has come at the cost of social inequality, human health, and environmental disregard, the only ones who benefit from such an arrangement are large companies. Hence, cheapness can be seen to have very expensive consequences. the trade-off for cheap chicken, from a public health perspective, has been overwhelming, the consequences of which we have only begun to see. Furthermore, industrial farming and the narrative of 'efficiency' have come under increasing criticism considering the environmental, societal, and health costs (M. Carolan, 2018; M. S. Carolan, 2014; Negowetti, 2017; Pimentel, 2005). In the books of Michael Carolan, he explores this conundrum; the price of cheap things, he states, are only when costs and risks are socialised, that is, we all pay for cheapness, but not at the point of purchase (M. S. Carolan, 2014). Antibiotic resistance, among other things, can in this sense be considered as a charge on the future for the present conveniences.

Lastly, with climate change threatening agricultural production, the Covid-19 pandemic disrupting food-chains, and most recently the Ukraine-Russian war[38] hindering supply of food-grains -food insecurity threatens to increase considerably. Therefore, alternative systems of food production are advocated for, and necessary.

8.2 Alternative Food chains (Covid19 and the shrinking of food supply chains)

Modern-day food supply chains are a behemoth feat of industry, it allows nations to concentrate on mass production of a few food items and depend on import of other goods from other nations. The canals of the Suez and Panama were engineered for the purpose of this trade, while being an ancient activity – trade through seas and vast land routes led to the establishment of wealthy settlements, modern day trade is conducted in volumes that previously were unimaginable. Ships the length of several football fields today can transport grain and other goods in excess of 300,000 tonnes.

[38] Russian operations in Ukraine began on the 24th of February, 2022. Considering the fact that Russia and Ukraine put together supply 30 percent of the world's wheat and barley food inflation presents a threat to the security of many dependent countries.

This choreographed movement of goods from one place to another is what keeps afloat a fragile supply chain on which billions of people depend upon for their daily groceries. The recent pandemic showed just how fragile this system is, the undoing of the pandemic led to fears of supply chain collapse and, along with mass hysteria, led to hoarding tendencies. While toilet paper hoarding became an important news segment food stuffs were also disappearing from supermarket aisles. The subsequent debate that arose of this crisis was the need to 'shorten' food supply chains, thereby making them more resilient and robust.

Shortening of food chains has been advocated for some time now, especially by climate change advocates since the carbon emissions that are released in effort to import and export of food is immense. However, during the pandemic it was rediscovered under principles of sustainability. Shortening food supply chains is about buying local, a TIME's article revealed this same fact; the story of a farmers producing for larger markets losing out as middleman dependency made him unable them to sell his produce (Gunia, 2020). The title of the article, "*How Coronavirus Is Exposing the World's Fragile Food Supply Chain*", writes about closing bulk-markets, abattoirs shutdowns, nation's adopting protectionist food policies, and falling prices curiously followed by increasing unaffordability. While falling prices and unaffordability are juxtaposing statements, loss of work due to the pandemic, initial excess of foods unable to reach markets, followed by a fall in production and increase in demand, created for a very unstable economic situation. The above description is but a simplified version of the market volatility that followed the pandemic announcement; aspects of panic buying, market differences in LMICs compared to high-income countries, and local variances also makes for a complicated understanding of the subject.

Nevertheless, large sections of the food growing industry incurred large net losses, in India prices of poultry products were halved and sales went down a staggering 80 per cent (Biswal et al., 2020). Of the associated crises the non-availability of labour for farming operations in India, due to the lockdowns, had been a concerning development despite Government allowing for essential services to continue (*ibid.*). The pandemic also disrupted the supply of feed and other critical inputs such as veterinary services and medicines led to substantial economic losses as well.

The scientific community were also concerned with the increasing antibiotic use among people during this time (Abelenda-Alonso et al., 2020; Arshad et al., 2020; Getahun et al., 2020; Zeshan et al., 2021). Correspondingly, as stated in the earlier paragraph, dependence on medicated feeds and veterinary medicines, which became evident during the pandemic, indicate that antibiotics have become vital role for the production of food. In this way it is evident how antibiotics have become a part-and-parcel of systems of agriculture.

Moving on, restrictions during the pandemic made people rely on local productions of food, buying and eating local. In doing so, it promoted sustainable agriculture, increased awareness, and was a poster campaign for the ’farm-to-fork’ movement (Alsetoohy et al., 2021; Kapur, 2021). Another by-product of the pandemic was – increased cases and increased awareness of mental illnesses, but that is a subject for another day. However, an associated result was increasing number of people gardening and growing their own food as a coping mechanism (Corley et al., 1015; Fratello et al., 2022; Harding et al., 2022; Lal, 2020; Sia et al., 2022). Gardening as a stress relief activity had become a popular trend during the lockdowns, while research suggests that agricultural sales will revert back to pre-pandemic levels – this inclination towards self-sustenance and buying local has been a case study for sustainability and securitising food.

The Covid-19 pandemic has led to the parts of the food supply chain to drop-off leading to disruptions, especially in four sectors – Harvest, Logistics, Processing, and finally Sourcing. Hence, it has become more imperative to hasten the conversation for alternative, and more robust supply chains. The organic agricultural movement presently has become a segment of the market mainly for the rich, in urban centres. The premium costs of organic produce are not affordable or sustainable as a regular purchase for the middle to the lower classes who make up a bulk of all populations across the world. For instance, a kilogram of chicken in New Delhi alternates within ₹160 - ₹240 (May 2022), comparatively, the price of organic chicken in Delhi ranges between ₹800 - ₹1400 per kilogram

In an article in The Guardian newspaper titled – “Can we ditch intensive farming – and still feed the world” (Harvey, 2019), it states that by 2050 we have to grow fifty percent more than we currently do now in order to sustain the expected population in that decade. Hence, what is required is not only change in one aspect of the food-economy, while changes in farming methods are important, but the way we consume will also need to change. Hence, one of the most pressing questions regarding sustainable or alternate farming has been the supply side potentials.

Discussion

In the past year, more have been written on 'antibiotic resistance' than ever before, and these reports, papers, article point to the antibiotic era coming undone at the seams. As 'superbugs' become common and are increasingly responsible for more deaths every successive year. The threat, this pose, is not only to modern biomedicine but to the modern way of life as well. The popular narrative on antibiotics resistance suggests that we are currently experiencing a slow burn of events that continues to remain largely unnoticed. Ominously dubbing AMR as a 'silent pandemic'. However, studies show that this is not so silent anymore as this pandemic is already underway. Death toll estimates from West and Sub-Saharan Africa suggests that there were 98.9 deaths per 100,000 directly associated to antibiotic resistance; followed by South Asia with death associations of 76.8 per 100,000 in 2019 (Murray et al., 2022b). Neonatal deaths as well as hospital acquired infections in India is also increasing due to antibiotic resistance, which could be far more significant if we had good data at hand.

Therefore, in a way antibiotic resistance is symbolic, it reveals the limits of biomedicine and of technology driven industrialisation sans social development. This research similarly reveals that antibiotic resistance story is complex, far-reaching, and intertwining intermittently with the progress of modernity to become amalgamated into the structures that form our current society, and in many ways, sustaining the structures of modern society itself. From healthcare, food production, to sanitation and hygiene – antibiotics carry the burden of increasing disinvestment in public health infrastructure and increasing urban demand for food.

The current efforts designed to dispel this wave of antibiotic failures have been to ask:

i. researchers and pharmaceutical companies to concentrate on developing new antibiotics,
ii. medical doctors to be judicious with their prescription,
iii. agriculture to consider biosecurity measures, and for
iv. Social scientists to change people's behaviour.

Such a multi-pronged strategy, while important and clear-cut, is missing a huge body of knowledge that continue to be glide along the fringes. The problem with the above reasoning is incorporation of the logical fallacy that attempts to compete with nature without changing the structures that produced the problem in the first place. Hence, delaying the inevitable for a later time, i.e., until human ingenuity can come up with a solution. However, the nature of problems faced by our society are becoming more complex and our ability to implement solutions have not kept pace. Ultimately, keeping in mind the overarching political and economic inclinations, newer technological interventions will replace or supplement antibiotic use, investments into newer antibiotics will increase for a few more years, bacteriophage therapy could become more conventional, and lab-grown animal protein might become more widely available and popular. Nevertheless, such interventions do not provide a surety to hindering future outbreaks. As the COVID-19 pandemic showed, instead of well as a more sustainable food ecosystem.

In conclusion, we are presented with many intricacies and in-betweens that make resistance origin and transmission not as straightforward as it may suggest; a. over prescription, misuse, under-use in human health, b. use, misuse, overuse in animal rearing, and c. use of antibiotics important for human health in animal rearing certainly needs to be addressed. However, unless we understand what the root of the problem is any intervention will be short sighted. This research, through a political-economic approach shows that behaviour change can only come about if the conditions responsible for those behaviour are tackled.

With respect to the poultry industry, antibiotic use within India is a concern shared by many. And like other developing countries a growing population along with a weak healthcare infrastructure and a still expanding agricultural sector could produce further anxieties. This is in contrast to European, American, Japanese, or South Korean markets which are well established and have robust controls in place to address food safety issues. The poultry industry in many ways epitomises the complexities that exists within the antibiotic resistance conundrum, but in doing so it also brings clarity to the problem. India in the past few decades have undergone, and is undergoing, a formalisation of this sector. Which presently, has transformed from a backyard activity into a crucial Agri-industry worth billions of dollars.

The chicken, in India, is looked upon not only as a food source for establishing food and nutritional security for its citizens, but also as a source of economic security to millions of farmers. Which also has had a great contribution to the country’s economy. Hence, there are three different stories to be written here – one, of the commercial farmers, the growers, and the factory farms; secondly, of the small to medium scale entrepreneurs (contractual in many cases); and lastly, of the backyard farmers. But altogether the story of commercial chicken in India, as elsewhere the world over, is about uniformity, mass production, and industrial processes in the name of convenience, scale, (cheapness) and profit. It is an inferior product that typifies the priorities of the broader socio-economic culture under which we function – a culture driven largely by consumerism and the imperatives of growth at any cost.

Such is the logic of neoliberalism, which has also had a profound influence on the way individuals understand and experience health and illness. Suggesting that human beings are first and foremost economic beings, leaves little for valuing the physical and social aspects of life. It explains much of why over-the-counter sales have increased in recent years, why antibiotic use in livestock production is foreseeable and why time and money considerations have become more important in determining access to medical care. In exploring the social construction of health, Wendy Savage (2000) suggested that there is a relationship between the cultural and political climate of a particular society and the prevalence of certain diseases within that society. Thus, a society in which the dominant ideology emphasizes individual autonomy and the primacy of the market, would likely be more likely to blame individuals.

Hence, as John Locke wrote of the microscope in his *"Essay Concerning Human Understanding"* (1690):

"…if he could not see things he was to avoid, at a convenient distance; nor distinguish things he had to do with by those sensible 1qualities' others do. He that was sharp-sighted enough to see the configuration of the minute particles of the spring of a clock, and observe upon what peculiar structure and impulse its elastic motion depends, would no doubt discover something very admirable: but if eyes so framed could not view at once the hand, and the characters of the hour-plate, and thereby at a distance see what o'clock it was, their owner could not be much benefited by that acuteness; which, whilst it discovered the secret contrivance of the parts of the machine, made him lose its use." (Book 2, chapter 23, 12)

Thus, attempting to reason that to learn about disease by examining the body through a microscope was akin to trying to tell time by peering into the interior of a clock (Wootton, Bad Medicine. 2006). Perhaps the use of a machine as an analogy for society or the human body fails to recognise the organic complexity of such organism, and also prime it for reductionist disassembly. However, as the concept of wicked problems underscores, we are dealing with unknown complexities unlike a clock which catalogues every part and its function in its manual.

- END -

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