Review Article

Seeds of Change: Exploring Plant-based Livelihood Diversification for the Poultry Sector in India

ABSTRACT

Poultry farming is a cornerstone of India's agricultural sector, providing livelihoods for millions. However, the industry faces disease outbreaks, birds' and humans' health welfare concerns, and environmental challenges. To formulate a sustainable resolution, this review explores livelihood diversification within the Indian poultry farming sector. It examines current practices, opportunities, and obstacles, providing insights into sustainable agricultural practices and rural development strategies. By studying socio-economic factors, emerging trends in agricultural entrepreneurship, and the impact of diversification on rural livelihoods, the paper offers comprehensive recommendations for policymakers, stakeholders, and practitioners. This review also employs a multidimensional approach, utilizing qualitative and quantitative research case studies to present a holistic understanding of diversification in the Indian poultry sector. It aims to foster resilience among poultry farmers through practical recommendations and policy implications, promoting sustainable development and diversified livelihoods.

Keywords: Agriculture, Poultry, Plant-based, Diversification, Livelihood

1. INTRODUCTION

Poultry farming is a significant global Agro-allied industry, with India's chicken business emerging as the fastest-growing sector within agriculture [1]. Breeding farms, hatcheries, layer farms, and broiler farms collectively constitute the domain of poultry farming, which entails rearing domesticated birds primarily for their meat or eggs. Within this realm, layers are specifically bred for egg production, while broilers are raised for meat. Although less prevalent than chickens, ducks and geese also fall under the umbrella of domesticated poultry species. These birds are predominantly kept by small and marginal farmers, particularly in rural districts such as Andhra Pradesh, Karnataka, Tamil Nadu, Telangana, Maharashtra, West Bengal, Kerala, and Assam. India ranks among the top producers globally, being the fifth-largest producer of broiler chickens and the fourth-largest producer of eggs [2]. This industry encompasses egg and meat production and is integral to India's broader livestock and animal husbandry landscape, offering stable employment opportunities year-round. Poultry farming is experiencing rapid expansion, a trend expected to persist. According to the 20th Livestock Census report, India's poultry population is projected to reach 851.8 million. Notably, a substantial portion of India's poultry comprises "backyard fowl," totaling around 250 million birds [3].

The Indian economy mainly depends on agriculture, which provides significant employment to its population and contributes substantially to its GDP. Livelihood diversification refers to integrating multiple sources of income within agricultural practices. This approach enables farmers to mitigate risks associated with dependence on a single crop or activity [4]. In India, the rural population mainly depends on agriculture for their livelihood. Diversification offers resilience against various shocks and uncertainties [5]. One crucial aspect of livelihood diversification is crop diversification. Instead of relying solely on traditional crops, farmers are encouraged to explore alternative crops better suited to local agro-climatic conditions or have higher market demand [6]. Diversifying crops reduces farmers' vulnerability to crop failures and enhances soil health and biodiversity. Government policies and interventions are pivotal in promoting livelihood diversification in agriculture. The National Mission on Sustainable Agriculture (NMSA), Rashtriya Krishi Vikas Yojana (RKVY), and National Rural Livelihood Mission (NRLM) aim to support farmers in adopting diversified and sustainable agricultural practices [7]. Furthermore, investments in rural infrastructure, access to markets, technology dissemination, and skill development are essential for enabling farmers to explore diverse livelihood options. Livelihood diversification is imperative for the sustainable development of agriculture in India. By embracing diverse income-generating activities, farmers can enhance their resilience, improve livelihood security, and contribute to rural communities' overall growth and prosperity [8].

Exploring alternative livelihood options in the poultry sector in India holds immense significance, both economically and socially. Poultry farming has traditionally been a source of income for millions of rural households across India [9]. However, the sector faces various challenges, including disease outbreaks, environmental concerns, etc. Diversifying livelihood options within the poultry sector can mitigate these challenges while offering numerous benefits. Firstly, alternative livelihood options can enhance the resilience of rural communities dependent on poultry farming. By diversifying income streams, households can better withstand economic shocks affecting traditional poultry farming [10]. Exploring alternative livelihood options fosters innovation and entrepreneurship in the poultry sector. It encourages farmers to explore new ideas, technologies, and business models, leading to novel solutions to existing challenges. Moreover, diversifying livelihood options in the poultry sector promotes sustainable development and environmental conservation. Traditional poultry farming practices often raise concerns regarding waste management, resource depletion, and pollution. By exploring alternatives such as agroecological approaches or integrating poultry with other agricultural activities like agroforestry, farmers can adopt more sustainable practices that minimize environmental impact while ensuring long-term viability [11]. Furthermore, creating additional income opportunities and promoting entrepreneurship help lift rural households out of poverty and enhance their overall well-being. Moreover, initiatives focused on skill development, capacity building, and market linkages empower farmers to maximize their potential and participate more actively in economic activities. This review paper explores the potential alternative livelihood diversification options within the poultry farming sector in India. Focusing on the prospects and challenges associated with such diversification, the paper aims to provide insights into the various opportunities available for farmers to enhance their income and mitigate risks. By examining the current state of poultry farming in India and evaluating alternative avenues for diversification, this review paper will contribute to sustainable agricultural practices and rural development strategies. Through comprehensive research synthesis and critical analysis, the paper offers recommendations for policymakers, stakeholders, and practitioners to foster the adoption of diversified livelihood options in the poultry farming sector.

2. CURRENT STATE OF POULTRY FARMING IN INDIA

The poultry industry in India is valued at Rs. 80,000 crores, with a significant portion belonging to the unorganized sector, which aids disadvantaged families in supplementing their income and nutritional needs [12]. Small and medium farmers are extensively involved in contract farming, while approximately 30 million farmers engage in backyard poultry rearing. Distinct differences exist between the demands and operations of the organized and unorganized sectors. The organized sector dominates meat and egg production, while the unorganized sector operates on a smaller scale and is more scattered. Recent Livestock Census data indicates a substantial increase in India's poultry population, reaching 851.81 million, including 317.07 million backyard poultry. Egg production has grown consistently, with per capita availability rising to 90 eggs in 2020-21 [13]. Furthermore, chicken meat consumption in India has steadily increased, reaching an estimated 3.9 million metric tons in 2020. The average individual poultry consumption in India is currently around 3 kg per year, with projections suggesting this figure could escalate to 9 kg by 2030 [14]. This anticipated growth in poultry consumption has significant consequences. The intensification of poultry farming in India has precipitated profound structural changes within the sector, resulting in a cascade of adverse effects on birds, humans, and the environment.

The poultry industry significantly contributes to India's GDP, amounting to Rs. 7,500 crores, while employing over 2.5 million rural individuals [15]. Over time, India's chicken industry has evolved from small-scale backyard operations to a substantial agro-industrial enterprise, ranking as the world's third-largest producer of eggs and broilers [16]. Essential egg and broiler production hubs in India include Andhra Pradesh, Maharashtra, Punjab, and Tamil Nadu, collectively contributing to over half of the nation's output. Similarly, Tamil Nadu, Andhra Pradesh, Karnataka, Kerala, and western Maharashtra account for more than 60% of broiler production [17]. While most broiler farms in India are integrated into the market, the layer industry needs to be more organized. Backyard chicken farming is prevalent among rural and landless communities, offering a low-cost, high-return endeavor easily managed by women, children, and the elderly. This backyard poultry farming often involves scavenging, natural chick hatching, and minimal healthcare measures. The Indian poultry industry, comprising various key players and stakeholders, is vital to the country's agricultural landscape. At the forefront are the poultry farmers, who range from small-scale backyard operations to large commercial enterprises. These farmers are responsible for raising poultry birds, such as chickens and ducks, for meat and egg production. Their expertise, investment in infrastructure, and adoption of modern farming practices significantly influence the industry's growth and productivity. Another crucial stakeholder in the Indian poultry sector is the feed industry [18]. Feed manufacturers produce nutritious and balanced feed formulations essential for the health and growth of poultry birds. These companies continually innovate to develop cost-effective and sustainable feed solutions, leveraging nutrition science and technology advancements.

The veterinary and healthcare sector also plays a pivotal role in supporting the Indian poultry industry. Veterinarians, researchers, and healthcare professionals work to prevent and control diseases, ensure the welfare of poultry birds, and enhance productivity through vaccination programs, disease surveillance, and treatment protocols. Their efforts contribute to maintaining poultry farms' overall health and biosecurity, safeguarding the industry's sustainability. Additionally, the Indian government and regulatory bodies are significant stakeholders in the poultry industry. They formulate policies, regulations, and guidelines governing various aspects such as biosecurity measures, food safety standards, and trade practices [19]. Government support through subsidies, incentives, and infrastructure development initiatives further influences the growth and competitiveness of the poultry sector. Furthermore, stakeholders in the Indian poultry industry also include input suppliers,

transportation and logistics providers, processing companies, wholesalers, retailers, and consumers [20]. Each entity contributes to the value chain, from supplying inputs and transporting products to processing and distributing poultry products to end consumers. Collaboration and coordination are required to ensure the industry's efficiency, sustainability, and profitability among stakeholders.

3. SECTORAL CONCERNS RELATED TO BIRDS, HUMANS, AND ENVIRONMENTAL HEALTH

In India, the poultry industry frequently grapples with infectious disease outbreaks that significantly impact productivity and profitability. Notable diseases include Newcastle, avian influenza, infectious bronchitis, and fowl cholera. These diseases often cause high mortality rates within flocks, sometimes wiping out entire farms [21]. The economic consequences for farmers are severe, as these outbreaks result in the loss of birds, reduced egg production, and increased costs for disease management and control measures. Moreover, the situation is exacerbated by limited access to veterinary services and vaccines, particularly in rural areas. Many small-scale farmers need more financial resources to afford regular veterinary care, leading to inadequate disease prevention and control. This, in turn, contributes to the rapid spread of diseases, creating a vicious cycle of recurring outbreaks and financial losses. The environmental repercussions are alarming. The rapid expansion of intensive poultry farms has led to increased pollution levels, with high concentrations of ammonia, methane, and other harmful gases released into the atmosphere [22]. These emissions contribute to air quality deterioration and exacerbate climate change. Additionally, the improper disposal of poultry waste and the excessive use of antibiotics and pesticides have contaminated water bodies and soil, leading to severe ecological imbalances and posing a threat to local biodiversity [23]. The intensification of poultry farming also disrupts local ecosystems, leading to significant biodiversity loss. Natural habitats are being destroyed to make way for large-scale poultry operations, endangering various species of flora and fauna. This biodiversity loss diminishes the region's natural beauty and ecological balance and disrupts the food chain and ecosystem services vital for human well-being.

For humans, the health implications are concerning. Workers in these intensive poultry farms are exposed to numerous occupational health and safety risks, including respiratory problems, zoonotic diseases, and injuries from handling equipment and animals [24]. The use of antibiotics in poultry farming to promote growth and prevent disease has also led to antibiotic-resistant bacteria [25]. Furthermore, the social and economic impacts must be noticed. Large commercial operations often displaced or marginalized small-scale farmers, exacerbating rural poverty and social inequities. The concentration of poultry farming in certain areas can also lead to community conflicts over resources such as water and land. These resistant strains transmit to humans through direct contact with poultry, consumption of contaminated poultry products, or environmental pathways such as water and soil. The spread of AMR poses a severe threat to public health, as infections caused by resistant bacteria can lead to higher mortality rates [26]. This issue is compounded by farmers' need for more awareness and education regarding the judicious use of antibiotics and insufficient regulatory oversight to monitor and control antibiotic usage in the poultry industry.

The traditional poultry sector faces these significant challenges that impact poultry farmers' livelihoods and pose broader public health and environmental risks. Addressing these challenges is critical for ensuring the sector's sustainability and protecting the well-being of communities involved in poultry farming. One viable solution to mitigate these challenges is diversifying plant-based options [27]. Promoting plant-based alternatives can reduce the reliance on poultry farming, thereby minimizing the risks associated with disease outbreaks and AMR. Plant-based options can also alleviate environmental pressures by reducing

waste and pollution associated with intensive poultry farming practices. Moreover, plant-based alternatives can provide farmers with new livelihoods and reduce their vulnerability to market fluctuations and disease-related losses [28]. Developing infrastructure and market access for plant-based products can further enhance their viability and acceptance among consumers. Additionally, rising costs of feed and water, coupled with climate-related challenges such as droughts and floods, make it challenging for farmers to sustain their operations profitably. Considering these challenges, there is a pressing need for targeted interventions and support mechanisms to empower traditional poultry farmers in India. Access to affordable technology, improved veterinary services, and training programs on modern farming practices are crucial for enhancing the country's resilience and productivity of traditional poultry farming.

4. CONCEPT OF LIVELIHOOD DIVERSIFICATION

Plant-based livelihood diversification refers to expanding income sources and economic activities by utilizing plants and plant-derived resources. This approach includes activities such as agriculture, horticulture, forestry, agroforestry, and the production of plant-based products. The goal is to enhance economic resilience, food security, and sustainable development by leveraging the diverse potentials of plant resources. This concept is often discussed in the context of sustainable development, rural livelihoods, and agricultural economics [29]. This approach involves utilizing various plant resources, such as crops, fruits, vegetables, and herbs, to create sustainable livelihoods for communities. It encompasses various activities, including farming, gardening, agroforestry, and herbal medicine production. Plant-based livelihood diversification enhances resilience against economic shocks and environmental changes while promoting sustainable practices [30]. By diversifying income streams, communities can reduce their dependence on a single source of income, thereby mitigating risks associated with fluctuations in market prices or crop yields. Moreover, plant-based diversification often aligns with environmental conservation principles and promotes the sustainable use of natural resources. This approach provides economic benefits and contributes to food security, biodiversity conservation, and community well-being. It empowers individuals and communities to harness the potential of plants in innovative ways, fostering entrepreneurship, skills development, and knowledge sharing. Plant-based livelihood diversification is crucial in building more resilient and sustainable livelihoods in rural and urban areas [31]. Diversification is a pivotal strategy for fostering sustainable rural development in India, a nation deeply rooted in agrarian traditions. The country's rural landscape, with a significant portion of the population depending on agriculture, faces inherent risks from climate change, fluctuating market prices, and limited resource access. Embracing diversification mitigates these vulnerabilities, ensuring sustainability by reducing dependency on a single income source. It fosters innovation and knowledge transfer, driving sustainable development through the exchange of ideas and practices. By embracing a diversified approach, rural communities can achieve prosperity while safeguarding livelihoods and preserving cultural heritage for future generations.

5. PROSPECTS AND OPPORTUNITIES

Poultry farming has long been a traditional livelihood option for many rural communities in India. However, in recent years, people have been discussing the environmental degradation and ethical concerns associated with poultry farming, mainly deforestation, climate change, water usage, and animal welfare. As a result, many poultry farmers are now exploring alternative plant-based livelihood options as sustainable and profitable alternatives. One significant benefit of transitioning to plant-based livelihood options is the potential for diversification and resilience. By cultivating crops such as fruits, vegetables, grains, or pulses, farmers can reduce their reliance on a single income stream and mitigate the risks

associated with fluctuating market prices or environmental factors that may affect poultry production (Figure 1).

Figure.1: A close-up image of various fruits, grains, and pulses

Additionally, plant-based agriculture often requires fewer resources, such as water and land, than animal farming, making it a more sustainable choice in the long term. Another benefit is the potential to produce higher value-added products and achieve market differentiation. As demand for organic and locally sourced produce rises, farmers shifting to plant-based agriculture can tap into niche markets and secure premium prices for their products. This shift can enhance profitability and economic stability for farming communities while promoting environmental conservation and biodiversity. Furthermore, transitioning to plant-based livelihood options can positively affect public health. Farmers can improve access to fresh and healthy food in their communities by cultivating nutritious crops and addressing malnutrition and food insecurity. Additionally, Plant-based diets are linked to reduced rates of chronic illnesses, including heart disease, diabetes, and certain cancers. This dietary shift can lower healthcare costs and enhance well-being [32]. The shift towards alternative plant-based livelihood options presents numerous benefits for poultry farmers, ranging from economic diversification and market opportunities to environmental sustainability and public health improvements. By adopting these alternatives, farmers can adjust to evolving consumer preferences and market trends while helping to create more sustainable and equitable food systems for the future.

In recent years, India has witnessed a significant surge in the demand for plant-based products driven by various factors, including health consciousness, environmental concerns, and ethical considerations. The market demand for plant-based products in India is

experiencing a steady rise as consumers increasingly opt for alternatives to traditional animal-derived products [33]. This trend is especially noticeable in metropolitan areas, where many people adopt partially or entirely plant-based diets. A key driver of this demand is the continuously growing concern for the health benefits associated with plant-based diets. With rising instances of lifestyle diseases such as diabetes, obesity, and heart ailments, consumers are turning to plant-based products as a healthier alternative. Additionally, plant-based diets are often perceived as more sustainable and environmentally friendly, aligning with the growing environmental consciousness among consumers [34]. Moreover, India's abundant cultural heritage and culinary variety create an ideal environment for innovating and developing diverse plant-based products suited to local tastes and preferences. From traditional Indian dishes made with plant-based ingredients to modern vegan alternatives, the market offers many options to cater to diverse consumer preferences. With its robust agricultural foundation and abundant plant-based resources, India is well-equipped to capitalize on the rising global demand for plant-derived products. With increasing globalization and the expansion of international trade networks, Indian companies can tap into overseas markets by exporting various plant-based products ranging from spices, pulses, and grains to processed plant-based meat alternatives, dairy substitutes, and packaged snacks [35].

Furthermore, India's competitive advantage lies in its ability to offer high-quality plant-based products at competitive prices, leveraging its abundant agricultural resources and relatively low production costs. Indian exporters can increase their competitiveness and secure a robust position in the global market for plant-based products by prioritizing product innovation, quality assurance, and compliance with international standards. Overall, India's growing market demand and export potential for plant-based products present lucrative opportunities for businesses to capitalize on the shifting consumer preferences toward healthier, sustainable, and ethical food choices [36]. With a vast and multifaceted landscape, India has long recognized the necessity of diversification to mitigate risks and foster sustainable growth. Government interventions are pivotal in incentivizing and facilitating diversification across various sectors. Government policies in agriculture and rural development sectors aim to diversify income sources for farmers and rural communities. Programs like the Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) focus on water resource management and irrigation, enabling farmers to cultivate various crops and reduce dependency on monsoon rains [37].

6. POTENTIAL ROADBLOCKS IN THE WAY OF PLANT-BASED LIVELIHOOD DIVERSIFICATION

Understanding the obstacles that hinder the adoption of alternative plant-based livelihood options in India is essential for promoting sustainable development and addressing various socio-economic challenges. Given India's expansive agricultural terrain and rich biodiversity, there is significant potential to encourage plant-based livelihood alternatives instead of traditional methods. Nonetheless, numerous barriers currently obstruct the widespread acceptance of these alternatives. [38]. One significant barrier is rural communities' need for more awareness and knowledge regarding the benefits and feasibility of alternative plant-based livelihood options. Many individuals in remote regions must know the potential income streams and environmental advantages of cultivating alternative crops or engaging in agroforestry or herbal medicine production [39]. Addressing this barrier requires comprehensive educational initiatives and outreach programs to disseminate information and build capacity at the grassroots level. Transitioning from poultry farming to plant-based diversification in India presents many technical, financial, and institutional challenges. On a technical front, adapting to plant-based agriculture requires a shift in farming practices, knowledge, and infrastructure. India's agricultural landscape is primarily dominated by

traditional methods optimized for livestock rearing, particularly poultry. Introducing plant-based cultivation demands education and training for farmers on crop selection, cultivation techniques, and pest management tailored to local conditions [40]. Additionally, the need for updated infrastructure, such as irrigation systems and storage facilities, poses technical hurdles, especially in regions with limited resources.

Another critical barrier is more infrastructure and support mechanisms to promote alternative plant-based livelihood options. Access to markets, transportation facilities, storage facilities, and financial resources is necessary for the scalability and sustainability of such ventures [41]. Establishing robust infrastructure networks, including market linkages, cold storage facilities, and credit mechanisms, empowers farmers and entrepreneurs to transition towards alternative plant-based livelihoods. Policy and regulatory barriers also pose significant challenges to adopting alternative plant-based livelihood options in India. Complex regulatory frameworks, ambiguous land tenure systems, and bureaucratic hurdles often deter individuals from exploring new avenues or investing in sustainable practices. Simplifying regulatory procedures, offering incentives to promote eco-friendly practices, and guaranteeing land tenure security are crucial in establishing a supportive framework for adopting alternative livelihood options. Moreover, socio-cultural factors and traditional practices can hinder change, particularly in conservative rural communities. Deep-rooted beliefs, social norms, and cultural practices may inhibit individuals from deviating from traditional livelihood patterns or embracing innovative approaches [42]. Addressing these sociocultural barriers requires tailored interventions that respect local customs and traditions while promoting sustainable practices through participatory approaches and community engagement. Identifying and addressing barriers to adopting alternative plant-based livelihood options in India is critical for promoting sustainable development, enhancing resilience to climate change, and improving livelihoods in rural areas. By addressing issues related to awareness, infrastructure, policy, and socio-cultural dynamics, India can unlock the full potential of its natural resources and empower communities to thrive in a rapidly changing world.

Financial challenges loom large over the transition to plant-based diversification. While poultry farming often entails relatively low initial investment and rapid returns, venturing into plant-based agriculture necessitates capital for land acquisition, equipment procurement, and operational costs [43]. Moreover, the extended gestation period for plant-based crops to yield profits compared to poultry farming can strain the financial stability of farmers, requiring access to affordable credit and support mechanisms to weather the transition period. Institutional barriers further complicate the shift towards plant-based diversification in India. Government policies and subsidies historically favor livestock farming, reflecting entrenched interests and a lack of emphasis on sustainable agriculture [44]. Regulatory frameworks must be restructured to incentivize plant-based initiatives, including subsidies for organic farming practices, research and development in plant-based protein alternatives, and market incentives to stimulate demand. Additionally, extension services and agricultural institutions must be reoriented to provide guidance and support tailored to the needs of farmers transitioning away from poultry farming, fostering a conducive ecosystem for plant-based diversification. Addressing these multifaceted challenges demands a holistic approach encompassing technical innovation, financial support mechanisms, and institutional reforms[45]. Collaborative efforts involving government, industry stakeholders, agricultural experts, and grassroots organizations are essential to facilitate a smooth transition towards sustainable plant-based agriculture in India. By overcoming these hurdles, India can unlock the potential of plant-based diversification to promote food security, environmental sustainability, and economic resilience in the agricultural sector.

Economic considerations significantly influence dietary preferences [46]. In nations with widespread economic hardships, plant-based diets frequently emerge as a more cost-effective and readily available alternative to meat-heavy diets. Plant-based proteins such as lentils, beans, and legumes are generally more cost-effective sources of nutrition, making them particularly appealing to lower-income households. Additionally, the agricultural landscape of India heavily favors the production of plant-based foods, further incentivizing their consumption [47]. Growing awareness about the health benefits of having plant-based diets lowers the risk of chronic diseases, a significant factor motivating Indians to diversify their food choices towards more plant-based options. This trend is further reinforced by a growing interest in wellness and holistic health practices, with consumers actively seeking nutritious plant-based options for a balanced lifestyle. The socio-cultural factors influencing plant-based diversification decisions in India are multifaceted and deeply ingrained in the fabric of society. From Indian traditions and culinary heritage to economic considerations and health consciousness, these factors collectively contribute to the widespread adoption and acceptance of plant-based diets nationwide. As India continues to undergo rapid social and economic changes, understanding and addressing these factors will be essential for promoting sustainable dietary habits and improving public health outcomes.

The discussion about shifting from poultry farming to diversifying into plant-based alternatives is closely linked to issues of the environment and sustainability. Although poultry farming meets the rising need for animal protein, it brings notable environmental challenges. These include considerable emissions of greenhouse gases, mainly methane and nitrous oxide, stemming from activities such as feed production, animal digestion, and manure management [48]. These emissions exacerbate climate change, leading to unpredictable weather patterns and environmental degradation. Furthermore, poultry farming requires vast land, water, and feed resources, which is particularly challenging in India due to limited land availability and persistent water scarcity in many regions [49]. Large-scale poultry operations often lead to deforestation and habitat loss due to the extensive land needed for feed crop cultivation—the intensive use of water in poultry farming further strains already stressed water sources, compromising agricultural sustainability[50]. In contrast, transitioning to plant-based diversification presents a compelling alternative that addresses many of these environmental concerns. Plant-based agriculture generally requires less land, water, and resources than animal farming. India can reduce its environmental footprint by shifting towards plant-based protein sources such as legumes, pulses, and grains. These crops typically have lower water requirements and can be cultivated on smaller land areas than feed crops for poultry. Additionally, plant-based agriculture offers opportunities for crop rotation and soil conservation, enhancing the long-term sustainability of agricultural practices [51]. Promoting plant-based diversification aligns with India's commitment to sustainable development and environmental stewardship, reducing the ecological burden associated with animal agriculture and addressing public health concerns like heart disease, obesity, and diabetes. By encouraging the consumption of locally sourced, plant-based foods, policymakers can support environmental sustainability and public health objectives, fostering a more resilient and equitable food system for future generations.

7. CAUSE OF SHIFT: SOME EXAMPLES

Examining the successful diversification of plant-based products within the Indian poultry sector reveals a transformative journey marked by innovation, sustainability, and adaptability. India's poultry industry has shifted significantly in recent years, with a growing focus on plant-based alternatives driven by changing consumer preferences, environmental concerns, and health awareness. Arora (2020) explores consumer preferences for meat alternatives in India, revealing that consumers are willing to pay more for plant-based and cell-based meats than conventional meat, with a general preference for plant-based

options[52]. This finding underscores the market potential for plant-based poultry alternatives, further supporting the sector's shift towards innovation and consumer-centric approaches. One prominent initiative gaining momentum is the development of plant-based protein products as substitutes for traditional poultry items. By utilizing indigenous crops like pulses, soy, and millets, several companies have pioneered the production of plant-based meat substitutes that replicate conventional poultry products' taste, texture, and nutritional profile. These initiatives address the rising demand for vegetarian and flexitarian options and tackle food security, resource depletion, and animal welfare issues. Shraddha et al. (2024) highlight the role of neglected vegetables and under-utilized legumes in addressing nutritional deficiencies and health issues, promoting crop diversification to enhance food security and climate resilience [53]. This perspective supports using Indigenous crops in plant-based poultry alternatives, contributing to a sustainable and nutritious food system.

Additionally, successful plant-based diversification initiatives in the Indian poultry sector have been marked by strategic partnerships and collaborative efforts among various stakeholders. Collaborations between food tech startups, agricultural research institutions, government agencies, and grassroots organizations have facilitated knowledge exchange, technology transfer, and market access, creating a supportive ecosystem for innovation and growth. These partnerships have been instrumental in overcoming challenges related to supply chain logistics, quality assurance, and consumer acceptance, ensuring the scalability and sustainability of plant-based ventures. Shepon et al. (2018) introduce the concept of "opportunity food losses," highlighting the inefficiencies of consuming resource-intensive animal-based foods compared to plant-based alternatives. They find that replacing animal-based foods with plant-based options could significantly improve food security and availability [54]. This notion supports the shift towards plant-based products in the Indian poultry sector, emphasizing the potential benefits of dietary changes on a large scale. Jacobsen et al. (2015) emphasize the importance of maintaining a diverse gene pool to support future plant production and rural agriculture, showcasing how agrarian biodiversity can enhance the nutritional quality, reliability, culinary diversity, and sustainability of food production [55]. They argue that agrobiodiversity is often overlooked in current debates but is crucial for meeting the demands of a growing global population. This perspective aligns with the plant-based diversification in India's poultry sector, where leveraging indigenous crops enhances sustainability and food security.

The examination of successful plant-based diversification initiatives in the Indian poultry sector underscores the transformative potential of alternative protein solutions in addressing evolving consumer preferences, environmental imperatives, and socio-economic challenges. By embracing innovation, collaboration, and market-driven approaches, poultry industry stakeholders can capitalize on emerging opportunities and contribute to a more resilient, inclusive, and sustainable food system for future generations. Mendoza (2023) emphasizes the need to reduce global greenhouse gas emissions, advocating for a transition from a meat-based to a plant-based diet to achieve significant emission reductions [56]. This aligns with the environmental goals of the plant-based poultry sector in India, reinforcing the broader impact of dietary shifts on climate change mitigation. Patel et al. (2020) discuss the environmental and food production challenges, emphasizing traditional agricultural practices that can mitigate climate change effects and enhance sustainability [57]. Their insights into sustainable agricultural practices align with the plant-based initiatives in the poultry sector, highlighting the importance of integrating traditional knowledge with modern innovation.

8. DISCUSSION

The landscape of poultry farming in India presents a complex interplay of economic significance, environmental impact, and social dynamics. With its substantial contribution to

the GDP and employment, the poultry industry is critical to India's agro-industrial sector. Yet, as the industry grows, so do the challenges associated with its environmental footprint and socio-economic impacts. The current state and prospects of poultry farming and a growing trend towards plant-based diversification highlight the intricate balance between maintaining economic viability and promoting sustainable practices. The rapid expansion of intensive poultry farming in India has led to significant environmental concerns. The industry's reliance on large-scale operations results in high pollution levels, including emissions of harmful gases such as ammonia and methane. These emissions contribute to climate change and deteriorate air quality, posing severe ecological threats. Additionally, the improper disposal of poultry waste and overuse of antibiotics and pesticides have led to water and soil contamination, further exacerbating environmental degradation and posing health risks to humans. The health implications for workers in intensive poultry farms are equally troubling. The exposure to occupational hazards, including respiratory issues and zoonotic diseases, underscores the need for stringent health and safety regulations. Moreover, the pervasive use of antibiotics has contributed to the rise of antibiotic-resistant bacteria, presenting a significant public health challenge.

The economic dichotomy within the poultry sector—comprising highly organized commercial operations and a significant unorganized segment—illustrates the varied impact on rural communities. While the organized sector dominates production, the unorganized sector provides critical livelihood support for disadvantaged families. However, the concentration of large commercial operations often marginalizes small-scale farmers, exacerbating rural poverty and contributing to social inequities. Community conflicts over resources like water and land further highlight the socio-economic tensions arising from the industry's growth. Amid these challenges, the shift towards plant-based livelihood options presents promising opportunities for economic diversification and environmental sustainability. The benefits of transitioning to plant-based agriculture include reduced reliance on a single income stream, lower resource requirements, and the potential for higher value-added products. With growing consumer demand for organic and locally sourced produce, farmers can tap into niche markets, enhancing their profitability and economic stability. The health benefits of plant-based diets, including reduced rates of chronic diseases, align with public health objectives and contribute to improved community well-being. Additionally, plant-based agriculture promotes environmental conservation and biodiversity, addressing some critical ecological concerns associated with intensive poultry farming.

Government policies play a crucial role in facilitating the transition towards diversification. In the agricultural sector, programs like the Pradhan Mantri Krishi Sinchayee Yojana and the National Rural Livelihood Mission aim to diversify income sources for farmers, promoting sustainable practices and reducing dependency on monsoon rains. These government efforts are essential for creating an enabling environment that supports the shift towards sustainable and resilient agricultural practices. Despite the potential benefits, several barriers impede the widespread adoption of plant-based livelihood options. These include a need for more awareness and knowledge among rural communities, insufficient infrastructure and support mechanisms, and complex regulatory frameworks. Addressing these barriers requires comprehensive educational initiatives, robust infrastructure networks, and streamlined regulatory processes. Tailored interventions that respect socio-cultural dynamics and promote community engagement are crucial for overcoming resistance to change. Transitioning from poultry farming to plant-based diversification involves significant technical, financial, and institutional challenges. Farmers need education and training in new cultivation techniques on a technical front. At the same time, financial challenges include the need for capital investment and more extended gestation periods for plant-based crops. Institutional barriers, such as policies favoring livestock farming, must be restructured to incentivize sustainable practices.

9. CONCLUSION

The landscape of poultry farming in India reveals a nuanced interplay between its significant economic contributions and environmental and social ramifications. While the industry is vital to India's agro-industrial sector, providing substantial GDP contributions and employment opportunities, it also brings considerable environmental concerns and socio-economic challenges. The rapid growth of intensive poultry farming has exacerbated pollution, including harmful gas emissions, water and soil contamination, and health risks from antibiotics overuse. The sector's dichotomy, with organized commercial operations overshadowing small-scale farmers, underscores the socio-economic inequalities and rural poverty issues. Amid these challenges, the emerging trend toward plant-based agricultural diversification offers a promising pathway to achieving economic stability and environmental sustainability. Government policies play a crucial role in this transition, yet barriers such as lack of awareness, infrastructure deficiencies, and complex regulatory frameworks hinder widespread adoption. Addressing these obstacles is critical to promoting sustainable agricultural practices and improving community well-being. A multi-pronged approach is essential to address the multifaceted challenges of poultry farming in India and leverage the potential benefits of plant-based diversification. First, educational initiatives should be implemented to raise awareness among farmers about sustainable practices and the advantages of plant-based agriculture. Training programs focusing on new cultivation techniques and sustainable farming methods are vital. Second, robust infrastructure networks, including improved irrigation systems and market access, must be developed to support diversified agricultural practices. Third, regulatory frameworks should be streamlined to facilitate easier transitions for farmers, with policies and incentives favoring sustainable and resilient agricultural practices. Additionally, financial support mechanisms, such as grants and low-interest loans, can aid farmers in overcoming the initial investment barriers associated with transitioning to plant-based agriculture. Finally, fostering community engagement and respecting socio-cultural dynamics are crucial for ensuring the acceptance and success of these changes. By addressing these areas, India can create an enabling environment that supports sustainable agricultural diversification, mitigates environmental impact, and enhances socio-economic equity.

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