
REIMAGINING FOOD SAFETY IN INDIA: HUMAN RIGHTS, EMERGING TECHNOLOGIES, AND ETHICAL PUBLIC HEALTH GOVERNANCE

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ABSTRACT

“Food is our common ground, a universal experience” – James Beard

Food safety in India has largely been treated as a matter of regulatory compliance and welfare policy; however, its deep connection with human rights and public health calls for a stronger rights-based legal framework. The right to life under Article 21, read with Directive Principles such as Articles 39(a) and 47, implicitly recognizes access to safe and nutritious food as a fundamental entitlement. Despite the presence of statutory mechanisms like the Food Safety and Standards Act, 2006, persistent gaps in enforcement, infrastructure, and administration continue to hinder its effective realization.

In the era of digital transformation, emerging technologies such as artificial intelligence, blockchain, and the Internet of Things (IoT) present significant opportunities to enhance food safety governance through improved traceability, real-time monitoring, and predictive regulation. However, their integration also raises critical concerns relating to data privacy, algorithmic accountability, and digital inequality.

This paper examines the intersection of food safety, human rights, and technological governance in India. It critically evaluates the existing legal framework, identifies structural gaps, and explores the potential of emerging technologies in strengthening regulatory mechanisms. Through a comparative and interdisciplinary approach, the study proposes a rights-oriented, technology-enabled framework that aligns constitutional mandates with innovation and ethical governance, ensuring more effective and equitable public health protection.

Keywords: Food Safety, Human Rights, Artificial Intelligence, Digital Regulation, & Ethical Governance.

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1. INTRODUCTION

Food safety constitutes a foundational element of public health and human dignity, yet it continues to be inadequately addressed within the broader framework of legal governance in India. While access to food has been increasingly recognized as a socio-economic necessity, the dimension of *safe and nutritious food* remains under-enforced and insufficiently conceptualized within the legal discourse. In a constitutional framework that guarantees the right to life under Article 21, the assurance of food that is free from contamination and harmful substances is not merely a policy objective but an essential component of the right to live with dignity.³ The magnitude of this issue is evident from global estimates, which indicate that unsafe food causes nearly 600 million cases of foodborne illnesses and 420,000 deaths annually worldwide (World Health Organization, 2015)⁴. Beyond its public health implications, unsafe food also imposes a significant economic burden, with low- and middle-income countries losing over \$110 billion each year in healthcare costs and reduced productivity (World Bank, 2019).⁵

The Indian Constitution, through Directive Principles of State Policy such as Articles 39(a) and 47, further imposes an obligation upon the State to secure an adequate standard of living, improve public health, and raise levels of nutrition.⁶ Although these provisions are non-justiciable, judicial interpretation has progressively expanded the scope of fundamental rights to include socio-economic entitlements, thereby bridging the gap between constitutional aspiration and enforceable rights.⁷ In this context, food safety emerges not only as a matter of governance but as an enforceable human rights concern.

The statutory framework governing food safety in India is primarily anchored in the Food Safety and Standards Act, 2006, which established the Food Safety and Standards Authority of India (FSSAI) as the central regulatory body.⁸ While the legislation aims to consolidate laws relating to food safety and ensure the availability of safe and wholesome food, its implementation has been marked by systemic deficiencies, including inadequate infrastructure,

³ Constitution of India, Article 21.

⁴ Food Safety and Standards Authority of India. (2022). Annual report.

⁵ World Bank. (2019). The safe food imperative: Accelerating progress in low- and middle-income countries.

⁶ Constitution of India, Articles 39(a) & 47.

⁷ *Olga Tellis v. Bombay Municipal Corporation*, (1985) 3 SCC 545 (India); *Francis Coralie Mullin v. Administrator, Union Territory of Delhi*, (1981) 1 SCC 608 (India).

⁸ Food Safety and Standards Act, No. 34 of 2006, India.

lack of testing facilities, and weak enforcement mechanisms.⁹ Incidents of food contamination, adulteration, and large-scale foodborne illnesses continue to highlight the limitations of traditional regulatory approaches.

In the contemporary landscape, characterized by rapid technological advancement, the governance of food safety is undergoing a significant transformation. Emerging technologies such as artificial intelligence (AI), blockchain, and the Internet of Things (IoT) have introduced new possibilities for real-time monitoring, predictive risk assessment, and enhanced traceability within food supply chains.¹⁰ These technologies have the potential to shift food safety regulation from a reactive model to a proactive and data-driven framework. However, their adoption also raises critical legal and ethical questions relating to data governance, privacy, algorithmic bias, and equitable access.¹¹

Against this backdrop, the present paper seeks to examine the evolving intersection of food safety, human rights, and technological governance in India. It aims to critically analyze the constitutional and statutory framework governing food safety, identify key implementation challenges, and evaluate the role of emerging technologies in addressing these gaps. Further, the paper explores the ethical and regulatory implications of technology-driven governance and draws comparative insights from global practices.

The central argument advanced in this study is that food safety must be reconceptualized as a technologically enabled human rights framework, wherein legal mandates, digital innovation, and ethical governance operate in tandem. Such an approach is essential to ensure not only the availability of food but also its safety, quality, and accessibility in a manner consistent with constitutional values and contemporary regulatory needs.

2. FOOD SAFETY AS A HUMAN RIGHT

Food safety, though often treated as a technical or regulatory concern, must be understood within a broader human rights framework that recognizes access to safe and nutritious food as essential to human dignity and survival. The distinction between *food security* and *food safety* is crucial in this regard. While food security focuses on the availability and accessibility of

⁹ Ministry of Health & Family Welfare, Government of India, Annual Report on Food Safety and Standards Authority of India.

¹⁰ World Health Organization. (2015). Food safety: What you should know.

¹¹ K.S. Puttaswamy v. Union of India, (2017) 10 SCC 1 (India).

sufficient food, food safety emphasizes the quality, hygiene, and nutritional integrity of that food.¹² The absence of safety in food consumption undermines not only health outcomes but also the foundational premise of food as a means of sustenance.

At the international level, the recognition of food as a human right is well established. Article 25 of the Universal Declaration of Human Rights (UDHR) affirms the right to an adequate standard of living, including food, while Article 11 of the International Covenant on Economic, Social and Cultural Rights (ICESCR) explicitly recognizes “the right of everyone to adequate food.”¹³ The Committee on Economic, Social and Cultural Rights, in General Comment No. 12, has clarified that the right to food encompasses not merely quantity but also quality, safety, and cultural acceptability.¹⁴ This interpretation firmly situates food safety within the ambit of internationally recognized human rights obligations.

In the Indian context, although the Constitution does not explicitly enumerate the right to food as a fundamental right, judicial interpretation has progressively expanded the scope of Article 21 to include socio-economic rights necessary for a life with dignity.¹⁵ The Supreme Court, in a series of decisions, has emphasized that the right to life includes the right to live with human dignity and access to basic necessities.¹⁶ The landmark case of *People’s Union for Civil Liberties v. Union of India* (Right to Food case) further reinforced the State’s obligation to ensure food security through the effective implementation of welfare schemes.¹⁷ While the judgment primarily addressed access to food, its implications extend to the quality and safety of food supplied under public distribution and welfare programs.

Food safety is inherently linked to public health and therefore engages both constitutional and statutory obligations of the State. Unsafe food, contaminated with pathogens, chemicals, or adulterants, poses a direct threat to life and health, thereby implicating the State’s duty under Article 21.¹⁸ Moreover, Directive Principles such as Article 47 impose a positive obligation on the State to improve public health and raise levels of nutrition, thereby reinforcing the

¹² Food and Agriculture Organization. (2008). An introduction to the basic concepts of food security.

¹³ Universal Declaration of Human Rights. (1948), art. 25; International Covenant on Economic, Social and Cultural Rights. (1966), art. 11.

¹⁴ Committee on Economic, Social and Cultural Rights, General Comment No. 12: The Right to Adequate Food (1999).

¹⁵ Constitution of India, art. 21.

¹⁶ Francis Coralie Mullin v. Administrator, Union Territory of Delhi, (1981) 1 SCC 608 (India).

¹⁷ People’s Union for Civil Liberties v. Union of India, (2001) 5 SCC 577 (India).

¹⁸ World Health Organization. (2015). Food safety: What you should know.

normative foundation for food safety regulation.¹⁹

Despite this normative recognition, food safety continues to be treated predominantly as an administrative or regulatory issue rather than a justiciable right. This fragmented approach limits the effectiveness of legal interventions and undermines accountability. A human rights-based approach to food safety would require the State not only to ensure access to food but also to guarantee that such food meets standards of safety, quality, and nutritional adequacy.²⁰

In recent years, the conceptual understanding of food safety has evolved further with the advent of technological interventions in food production, distribution, and monitoring. The integration of digital systems, surveillance technologies, and data-driven regulatory tools has transformed the governance of food safety into a multidisciplinary domain involving law, technology, and ethics. This shift necessitates a re-examination of traditional legal frameworks to ensure that technological advancements align with human rights principles, particularly in terms of accessibility, transparency, and accountability.²¹

Thus, food safety must be reconceptualized not merely as a component of food regulation but as an enforceable dimension of the right to life and health. Such a reconceptualization is essential to bridge the gap between constitutional guarantees, international obligations, and ground-level realities, thereby enabling a more holistic and rights-oriented approach to food governance in India.

3. CONSTITUTIONAL AND LEGAL FRAMEWORK GOVERNING FOOD SAFETY IN INDIA

The regulation of food safety in India is anchored in a combination of constitutional principles, statutory enactments, and judicial interpretation. While the Constitution does not explicitly recognize the right to safe food as a standalone fundamental right, its framework provides a strong normative basis for its protection through an expansive reading of the right to life and allied provisions.

3.1 Article 21 and the Right to Safe and Nutritious Food

Article 21 of the Constitution guarantees the protection of life and personal liberty, which has

¹⁹ Constitution of India, art. 47.

²⁰ Sen, A. (1999). *Development as freedom*. Oxford University Press.

²¹ Food and Agriculture Organization. (2019). *Digital technologies in agriculture and food systems*.

been judicially interpreted to include the right to live with dignity and access to basic necessities essential for survival.²² The Supreme Court has consistently expanded the scope of this provision to encompass socio-economic rights, including health, nutrition, and livelihood.²³

Food safety, as a critical determinant of public health, directly implicates the right to life. The consumption of contaminated or adulterated food poses a tangible threat to human health and survival, thereby bringing it within the ambit of Article 21. Although judicial pronouncements have primarily focused on access to food, the logical extension of this right necessarily includes access to food that is safe, hygienic, and nutritionally adequate.²⁴

3.2 Directive Principles of State Policy: Articles 39(a) and 47

The Directive Principles of State Policy further reinforce the constitutional commitment to food safety and nutrition. Article 39(a) obligates the State to ensure that citizens have the right to an adequate means of livelihood, which inherently includes access to food.²⁵ Article 47 explicitly mandates the State to raise the level of nutrition, improve public health, and enhance the standard of living of its people.²⁶

While these provisions are non-justiciable, they serve as guiding principles for legislative and policy formulation. The judiciary has repeatedly emphasized that Directive Principles must inform the interpretation of fundamental rights, thereby strengthening the constitutional foundation for recognizing food safety as an essential component of the right to life.²⁷

3.3 Statutory Framework: Food Safety and Standards Act, 2006

The primary legislative instrument governing food safety in India is the Food Safety and Standards Act, 2006 (FSSA), enacted to consolidate various food laws and establish a unified regulatory framework.²⁸ The Act led to the creation of the Food Safety and Standards Authority of India (FSSAI), which is tasked with laying down science-based standards for food products

²² Constitution of India, art. 21.

²³ *Olga Tellis v. Bombay Municipal Corporation*, (1985) 3 SCC 545 (India).

²⁴ *Francis Coralie Mullin v. Administrator, Union Territory of Delhi*, (1981) 1 SCC 608 (India).

²⁵ Constitution of India, art. 39(a).

²⁶ Constitution of India, art. 47.

²⁷ *Minerva Mills v. Union of India*, (1980) 3 SCC 625 (India).

²⁸ Food Safety and Standards Act, No. 34 of 2006, India.

and regulating their manufacture, storage, distribution, sale, and import.²⁹

The FSSA adopts a comprehensive approach by integrating food safety standards, licensing requirements, and enforcement mechanisms under a single statute. It also emphasizes risk-based regulation and seeks to align Indian food safety standards with international benchmarks. However, despite its progressive framework, the implementation of the Act has been fraught with challenges. Limited testing infrastructure, shortage of qualified food analysts, and inadequate enforcement capacity at the state level continue to impede its effectiveness.³⁰

3.4 Judicial Developments: Expanding the Right to Food

Judicial intervention has played a significant role in shaping the discourse on food as a right. In *People's Union for Civil Liberties v. Union of India*, commonly known as the Right to Food case, the Supreme Court transformed various food-related welfare schemes into enforceable legal entitlements.³¹ The Court directed the effective implementation of schemes such as the Public Distribution System (PDS) and Mid-Day Meal Scheme, thereby recognizing the State's obligation to prevent hunger and malnutrition.

Although the case primarily addressed food availability, its broader implications extend to the quality and safety of food distributed under such schemes. Incidents of food contamination in public welfare programs highlight the need to interpret the right to food as encompassing both access and safety.³² Further, consumer protection jurisprudence has also contributed to strengthening accountability in cases of food adulteration and unsafe food practices. The Consumer Protection Act, 2019 provides remedies against unfair trade practices and defective goods, including contaminated food products, thereby complementing the regulatory framework under the FSSA.³³

3.5 Limitations of the Existing Legal Framework

Despite the presence of constitutional backing and statutory regulation, the legal framework governing food safety in India suffers from significant limitations. The fragmented nature of enforcement, lack of coordination between central and state authorities, and insufficient

²⁹ Food Safety and Standards Act, 2006, § 16.

³⁰ Ministry of Health and Family Welfare, Government of India. (Year). FSSAI annual report.

³¹ *People's Union for Civil Liberties v. Union of India*, (2001) 5 SCC 577 (India).

³² National Human Rights Commission. (2018). Report on food safety and public health in India.

³³ Consumer Protection Act, No. 35 of 2019, India.

technological integration have resulted in a largely reactive regulatory model.³⁴

Moreover, the absence of explicit recognition of food safety as a justiciable right limits the scope of judicial intervention and accountability. While courts have expanded the ambit of Article 21, the lack of a clearly articulated rights-based framework for food safety continues to hinder effective enforcement. In the context of evolving technological landscapes, the existing legal framework also appears inadequate to address emerging challenges relating to digital governance, data protection, and algorithmic decision-making in food safety regulation. This necessitates a re-evaluation of regulatory mechanisms to ensure that they remain responsive, adaptive, and aligned with contemporary developments.

4. IMPLEMENTATION CHALLENGES AND STRUCTURAL GAPS IN FOOD SAFETY GOVERNANCE

In the Indian context, food safety challenges are further compounded by structural realities, including the dominance of the informal food sector, which accounts for a substantial share of food distribution and operates largely outside formal regulatory mechanisms (Food and Agriculture Organization, 2016)³⁵. Additionally, regulatory data indicates that a significant proportion of food samples tested continue to fail prescribed safety standards, reflecting persistent enforcement gaps (Food Safety and Standards Authority of India, 2022).³⁶

Despite a well-developed constitutional and statutory framework, the implementation of food safety laws in India remains fraught with systemic deficiencies. The gap between legal mandates and ground realities reflects deeper structural issues in governance, infrastructure, and regulatory capacity. Much like other socio-economic rights in India, the effectiveness of food safety regulation is undermined not by the absence of law, but by the limitations in its execution.

One of the most significant challenges lies in the inadequacy of institutional infrastructure, particularly in food testing and quality assurance. The number of accredited food testing laboratories in India remains insufficient relative to its population and scale of food production. Many states lack advanced laboratory facilities, and existing institutions often operate with

³⁴ Food and Agriculture Organization & World Health Organization. (2017). Food safety risk analysis guidelines.

³⁵ Food and Agriculture Organization. (2016). The informal food sector in India.

³⁶ Food Safety and Standards Authority of India. (2022). Annual report.

outdated equipment and limited technical capacity.³⁷ This deficiency severely constrains the ability of regulatory authorities to conduct timely and accurate testing, thereby weakening enforcement mechanisms.

Closely linked to infrastructural limitations is the issue of human resource constraints. State Food and Drug Administration's frequently function with a shortage of trained food safety officers and qualified analysts. In several instances, laboratories have faced operational disruptions due to the absence of certified personnel, leading to delays in inspection, certification, and prosecution.³⁸ This shortage not only affects regulatory efficiency but also reduces the deterrent effect of enforcement actions.

Another persistent concern is the fragmented nature of regulatory enforcement. Although the Food Safety and Standards Authority of India (FSSAI) operate as the central regulatory body, the responsibility for implementation largely rests with state authorities. This division often results in inconsistent enforcement, lack of coordination, and variation in standards across regions.³⁹ The absence of a unified and integrated monitoring system further exacerbates these inconsistencies, allowing gaps in compliance to persist.

The prevalence of food adulteration and contamination continues to highlight the limitations of existing regulatory approaches. Incidents of foodborne illnesses and contamination in mass feeding programs, including mid-day meal schemes, have raised serious concerns regarding quality control and accountability.⁴⁰ Such occurrences are not isolated but indicative of systemic lapses in monitoring, inspection, and regulatory oversight. The continued presence of harmful additives, pesticides, and substandard food products in the market reflects the inability of current mechanisms to ensure comprehensive compliance.

Economic factors also contribute significantly to the problem. The informal nature of India's food sector, characterized by small-scale vendors and unregulated supply chains, poses substantial challenges to enforcement. A large segment of food production and distribution operates outside formal regulatory frameworks, making it difficult to implement standardized

³⁷ Food Safety and Standards Authority of India. (n.d.). State of food testing infrastructure in India.

³⁸ Ministry of Health and Family Welfare, Government of India. (Year). Annual report on food safety administration.

³⁹ Food Safety and Standards Authority of India. (2018). Operational guidelines for state food safety authorities.

⁴⁰ National Human Rights Commission. (2018). Advisory on food safety in public welfare schemes.

safety protocols.⁴¹ This is further compounded by limited awareness among stakeholders, including producers, vendors, and consumers, regarding food safety standards and practices.

Moreover, the regulatory framework remains largely reactive rather than preventive. Inspections and enforcement actions are often initiated only after violations are detected or incidents occur, rather than through continuous monitoring and risk-based assessment.⁴² This reactive approach limits the capacity of the system to anticipate and mitigate risks in advance, thereby compromising public health outcomes.

A critical dimension of these challenges is the lack of technological integration within the regulatory framework. Despite the growing potential of digital tools in enhancing governance, the adoption of technology in food safety regulation remains limited and uneven. The absence of real-time monitoring systems, digital traceability mechanisms, and data-driven risk assessment tools constrains the ability of authorities to ensure effective oversight.⁴³

In addition, issues of accountability and transparency continue to persist. Regulatory actions are often opaque, with limited public access to inspection data, compliance reports, and enforcement outcomes. This lack of transparency weakens public trust and reduces the participatory role of consumers in ensuring food safety. These structural limitations necessitate a shift toward technology-driven governance mechanisms, discussed in the following section.

Collectively, these structural gaps indicate that the existing framework is insufficient to address the complexities of modern food systems. The challenges are not merely administrative but systemic, requiring a shift from traditional regulatory models to more integrated, technology-enabled, and rights-based approaches. Addressing these deficiencies is essential for transforming food safety from a formal legal obligation into a meaningful and enforceable public health guarantee.

5. ROLE OF EMERGING TECHNOLOGIES IN FOOD SAFETY GOVERNANCE

The increasing complexity of modern food systems, characterized by globalized supply chains, mass production, and diversified distribution networks, has exposed the limitations of traditional regulatory approaches to food safety. In this context, emerging technologies offer

⁴¹ Food and Agriculture Organization. (2016). The informal food sector in India.

⁴² World Health Organization. (2015). Strengthening food safety systems.

⁴³ Food and Agriculture Organization. (2019). Digital technologies in food safety management.

transformative potential in reshaping food safety governance from a reactive and inspection-based model to a proactive, data-driven, and predictive regulatory framework.

One of the most significant developments in this domain is the use of artificial intelligence (AI) in food safety monitoring and risk assessment. AI-powered systems can analyze large datasets to identify patterns of contamination, predict potential foodborne risks, and detect anomalies in food quality.⁴⁴ Machine learning algorithms, when integrated with surveillance data, can enable regulatory authorities to anticipate risks before they materialize, thereby reducing reliance on post-incident enforcement. This shift towards predictive governance enhances both efficiency and effectiveness in ensuring food safety.

The Internet of Things (IoT) further strengthens this framework by enabling real-time monitoring across various stages of the food supply chain. IoT-enabled sensors can track critical parameters such as temperature, humidity, and storage conditions, ensuring that food products are maintained within safe thresholds throughout transportation and storage.⁴⁵ This continuous monitoring reduces the likelihood of contamination and spoilage, particularly in perishable goods, and allows for immediate corrective action when deviations occur.

Another critical technological intervention is the use of blockchain technology to enhance traceability and transparency within food supply chains. Blockchain provides a decentralized and immutable ledger system that records every transaction and movement of food products, from production to consumption.⁴⁶ This ensures that the origin and journey of food items can be accurately traced, thereby facilitating swift identification of contamination sources and enabling targeted recalls. Enhanced traceability also strengthens consumer confidence and promotes accountability among stakeholders.

Digital platforms and smart regulatory systems are also playing an increasingly important role in modern food governance. The Food Safety and Standards Authority of India (FSSAI) has initiated digital compliance mechanisms, including online licensing, inspection management systems, and data-driven monitoring tools.⁴⁷ Such systems streamline regulatory processes, reduce administrative delays, and improve coordination between central and state authorities. They also create opportunities for integrating real-time data analytics into decision-making

⁴⁴ World Health Organization. (2021). Artificial intelligence for food safety risk assessment.

⁴⁵ Food and Agriculture Organization. (2019). Internet of Things in food safety and supply chain management.

⁴⁶ OECD. (2020). Blockchain technology and food traceability systems.

⁴⁷ Food Safety and Standards Authority of India. (2022). Digital initiatives and food safety compliance systems.

processes.

In addition to regulatory applications, emerging technologies are contributing to improved consumer awareness and participation. Mobile applications and digital interfaces enable consumers to access information about food products, verify authenticity, and report violations.⁴⁸ This participatory model of governance strengthens accountability and aligns with the principles of transparency and public engagement in regulatory systems.

However, while the integration of technology offers substantial benefits, it also necessitates a fundamental shift in regulatory philosophy. Traditional legal frameworks, designed for static and localized systems, may not be adequately equipped to address the dynamic and transnational nature of technology-driven food governance. The adoption of digital tools must therefore be accompanied by corresponding legal and institutional reforms to ensure effective implementation.

Furthermore, the deployment of these technologies must be viewed through a rights-based lens. While technological solutions enhance efficiency, their effectiveness ultimately depends on accessibility, inclusivity, and equitable distribution. The benefits of digital governance must extend across urban and rural areas, formal and informal sectors, and all socio-economic groups to ensure that food safety is universally guaranteed.

In essence, emerging technologies have the potential to redefine food safety governance in India by introducing greater precision, transparency, and accountability. However, their successful integration requires not only technological advancement but also a coherent legal framework that aligns innovation with constitutional values and public health objectives. The challenge, therefore, lies not merely in adopting technology but in embedding it within a broader regulatory and ethical architecture that ensures its responsible and inclusive use.

6. ETHICAL AND LEGAL CHALLENGES OF TECHNOLOGY-DRIVEN FOOD SAFETY GOVERNANCE

While emerging technologies offer significant potential in enhancing food safety governance, their integration into regulatory systems raises complex ethical and legal challenges. The transition from traditional regulatory frameworks to technology-driven governance must

⁴⁸ Ministry of Consumer Affairs, Government of India. (2021). Digital consumer protection initiatives.

therefore be critically examined to ensure that efficiency does not come at the cost of fundamental rights, accountability, and inclusivity.

A primary concern relates to data privacy and surveillance. The deployment of artificial intelligence (AI), Internet of Things (IoT) devices, and digital monitoring systems involves the large-scale collection and processing of data across the food supply chain. This may include information relating to producers, distributors, and even consumer behavior. In the absence of robust data protection frameworks, such practices risk infringing upon the right to privacy, which has been recognized as a fundamental right under Article 21.⁴⁹ The landmark judgment in *K.S. Puttaswamy v. Union of India* underscores the necessity of ensuring that any data collection is lawful, proportionate, and subject to adequate safeguards.⁵⁰

Closely linked to privacy concerns is the issue of algorithmic accountability and bias. AI systems used in food safety regulation rely on data-driven decision-making, which may be susceptible to inherent biases in data collection and processing.⁵¹ For instance, regulatory algorithms may disproportionately target certain categories of food producers or regions based on incomplete or skewed datasets. The lack of transparency in algorithmic processes further complicates accountability, making it difficult to challenge or review automated decisions. This raises significant concerns regarding fairness, due process, and the rule of law.

Another critical challenge is the digital divide and issues of accessibility. The benefits of technology-driven governance are unevenly distributed, particularly in a country like India where a substantial portion of the food sector operates within the informal economy. Small-scale vendors, rural producers, and marginalized communities often lack access to digital infrastructure, technological literacy, and financial resources required to comply with advanced regulatory systems.⁵² This creates a risk of exclusion, where technological compliance becomes a barrier rather than an enabler, thereby exacerbating existing socio-economic inequalities.

The integration of technology also raises questions of institutional accountability and regulatory oversight. As regulatory functions increasingly rely on automated systems and digital platforms, the locus of accountability becomes diffused. Determining responsibility in cases of system failure, erroneous data interpretation, or regulatory lapses becomes legally

⁴⁹ Constitution of India, art. 21.

⁵⁰ *K.S. Puttaswamy v. Union of India*, (2017) 10 SCC 1 (India).

⁵¹ OECD. (2019). Artificial intelligence, data governance and ethics.

⁵² World Bank. (2020). Digital divide and inclusive technology access in developing economies.

complex.⁵³ Traditional accountability mechanisms, designed for human decision-making, may not be adequate to address the challenges posed by automated governance systems.

Furthermore, there are concerns regarding the standardization and interoperability of technological systems. The absence of uniform standards for data collection, processing, and sharing across different jurisdictions and agencies can lead to fragmentation and inefficiencies.⁵⁴ Without a coherent regulatory framework governing the use of technology, the adoption of digital tools may result in inconsistent practices and undermine the very objective of improving food safety governance.

The ethical dimension of technology integration also extends to questions of transparency and public participation. Technology-driven systems often operate as “black boxes,” with limited visibility into decision-making processes. This lack of transparency undermines public trust and restricts the ability of stakeholders to engage meaningfully with regulatory systems. Ensuring openness, explainability, and participatory mechanisms is therefore essential for maintaining legitimacy in governance.

In addition, the increasing reliance on private technological solutions raises concerns about corporate control and commercialization of regulatory functions. The involvement of private entities in developing and managing technological systems may lead to conflicts of interest, particularly where profit motives intersect with public health objectives.⁵⁵ This necessitates clear regulatory boundaries and oversight mechanisms to ensure that public interest remains paramount.

In light of these challenges, it becomes evident that the integration of emerging technologies into food safety governance cannot be approached as a purely technical exercise. It requires a carefully balanced framework that aligns technological innovation with constitutional principles, ethical standards, and regulatory safeguards. A rights-based approach must guide the adoption and implementation of such technologies, ensuring that they enhance, rather than undermine, the fundamental objectives of equity, accountability, and public health protection.

The effectiveness of such technology-driven governance is further constrained by the digital

⁵³ European Commission. (2019). Ethics guidelines for trustworthy AI.

⁵⁴ Food and Agriculture Organization. (2019). Digital innovation and standards in food systems.

⁵⁵ UNCTAD. (2019). Digital economy report: Value creation and capture.

divide, as a significant proportion of the population lacks reliable access to digital infrastructure, thereby limiting inclusive participation in regulatory systems (World Bank, 2020).⁵⁶

7. REGULATORY FRAMEWORK AND POLICY GAPS IN TECHNOLOGY INTEGRATION

The integration of emerging technologies into food safety governance in India remains uneven and largely underdeveloped within the existing legal and regulatory framework. While initiatives undertaken by the Food Safety and Standards Authority of India (FSSAI) reflect a gradual shift toward digitalization, the absence of a comprehensive and coherent policy framework limits the effective deployment of technology in ensuring food safety.

A key limitation lies in the absence of explicit legal recognition of technology-driven governance mechanisms within the Food Safety and Standards Act, 2006.⁵⁷ The Act, though progressive at the time of its enactment, does not adequately account for contemporary developments such as artificial intelligence-based risk assessment, blockchain-enabled traceability, or real-time monitoring systems. As a result, technological initiatives operate largely at the level of administrative innovation rather than being anchored in a binding legal framework.⁵⁸

Another critical gap is the lack of a dedicated regulatory framework governing the use of data and digital systems in food safety administration. The increasing reliance on data-driven tools necessitates clear guidelines on data collection, storage, sharing, and protection. In the absence of sector-specific data governance standards, there is a risk of inconsistent practices and potential misuse of information.⁵⁹ Although broader data protection developments in India indicate a move towards regulating personal data, their application within sectoral domains such as food safety remains limited and undefined.

The regulatory framework also suffers from institutional fragmentation and lack of coordination. While the FSSAI functions as the central authority, the implementation of food

⁵⁶ World Bank. (2020). Digital divide and inclusive technology access in developing economies.

⁵⁷ Food Safety and Standards Act, No. 34 of 2006, India.

⁵⁸ Food Safety and Standards Authority of India. (2022). Digital food safety initiatives and compliance mechanisms.

⁵⁹ Ministry of Electronics and Information Technology, Government of India. (2022). Data governance framework report.

safety regulations is largely decentralized, with significant responsibilities vested in state-level agencies.⁶⁰ This multi-layered structure, coupled with varying levels of technological capacity across states, results in uneven adoption of digital tools and inconsistent enforcement practices. The absence of an integrated, nationwide digital infrastructure further exacerbates these disparities.

Additionally, there is a notable lack of standardization and interoperability in technological systems used for food safety regulation. Different states and agencies often employ disparate platforms and processes, leading to inefficiencies in data sharing and regulatory coordination.⁶¹ Without uniform standards and protocols, the potential of technology to create a seamless and transparent regulatory ecosystem remains underutilized.

The existing framework also fails to adequately address the need for capacity building and institutional preparedness. The successful integration of emerging technologies requires not only technological infrastructure but also trained personnel capable of operating and interpreting digital systems. However, regulatory agencies often lack the necessary technical expertise and training mechanisms, resulting in a gap between technological potential and practical implementation.⁶²

Furthermore, the absence of clear accountability mechanisms in technology-driven regulation presents a significant legal challenge. As regulatory processes become increasingly automated, it becomes difficult to assign responsibility for errors, system failures, or regulatory lapses. The current legal framework does not sufficiently address issues of liability arising from the use of automated systems, thereby creating ambiguity and limiting effective redressal mechanisms.⁶³

These gaps collectively indicate that while technological adoption is underway, it remains fragmented, unregulated, and insufficiently aligned with the broader objectives of food safety governance. To fully realize the benefits of emerging technologies, there is an urgent need for a comprehensive regulatory framework that integrates legal mandates with technological innovation. Such a framework must ensure clarity, consistency, and accountability, while also addressing concerns relating to data governance, institutional coordination, and equitable

⁶⁰ Food Safety and Standards Authority of India. (2018). Operational structure and state-level implementation guidelines.

⁶¹ OECD. (2020). Data interoperability and digital governance standards.

⁶² World Health Organization. (2021). Capacity building for digital health systems.

⁶³ European Commission. (2020). Liability for artificial intelligence and emerging technologies.

access.

8. COMPARATIVE ANALYSIS: GLOBAL BEST PRACTICES IN TECHNOLOGY-DRIVEN FOOD SAFETY

A comparative analysis of global food safety regimes reveals that several jurisdictions have successfully integrated emerging technologies into regulatory frameworks, thereby enhancing efficiency, transparency, and accountability. These models offer valuable insights for India in reconfiguring its food safety governance. The European Union (EU) has developed one of the most advanced food safety systems, emphasizing traceability, risk assessment, and transparency. Under the General Food Law Regulation, food business operators are required to ensure full traceability across all stages of production and distribution.⁶⁴ The EU has increasingly adopted digital tools and blockchain-based systems to monitor food supply chains, enabling rapid identification and recall of contaminated products. The European Food Safety Authority (EFSA) further employs data-driven risk analysis models to support scientific decision-making.

Similarly, the United States has strengthened its food safety framework through the Food Safety Modernization Act (FSMA), which shifts the focus from reactive enforcement to preventive controls.⁶⁵ The U.S. Food and Drug Administration (FDA) has actively explored the use of artificial intelligence, big data analytics, and digital traceability systems under its “New Era of Smarter Food Safety” initiative.⁶⁶ These measures aim to enhance predictive capabilities and ensure faster response to food safety risks.

In China, technological integration has been a central feature of food safety governance. The government has implemented digital tracking systems and blockchain-enabled platforms to monitor food production and distribution, particularly in response to past food safety scandals.⁶⁷ These systems enable real-time data collection and strengthen regulatory oversight across the supply chain. International organizations such as the Food and Agriculture Organization (FAO) and the World Health Organization (WHO) have also emphasized the importance of digital transformation in food safety systems. They advocate for the adoption of integrated, technology-driven approaches that combine risk assessment, real-time monitoring,

⁶⁴ Regulation (EC) No 178/2002 of the European Parliament and of the Council. (2002). General food law.

⁶⁵ Food Safety Modernization Act, Pub. L. No. 111–353, 124 Stat. 3885 (2011).

⁶⁶ U.S. Food and Drug Administration. (2020). New era of smarter food safety blueprint.

⁶⁷ State Council of China. (2018). Food safety law and digital monitoring systems.

and global data sharing.⁶⁸

These global practices highlight a common trend towards preventive, technology-enabled, and integrated regulatory models. They demonstrate that effective food safety governance requires not only robust legal frameworks but also the strategic use of technology to enhance enforcement and accountability. For India, these models provide a blueprint for transitioning from a fragmented and reactive system to a more cohesive and forward-looking regulatory regime.

9. RECOMMENDATIONS AND WAY FORWARD

In light of the identified challenges and comparative insights, it is imperative to adopt a comprehensive and forward-looking approach to food safety governance in India. The following recommendations seek to align legal frameworks with technological innovation and constitutional principles:

- I. **Legal Recognition of Technology-Driven Governance:** The Food Safety and Standards Act, 2006 should be amended to explicitly incorporate provisions for the use of emerging technologies such as artificial intelligence, blockchain, and IoT in regulatory processes. This would provide a formal legal basis for digital governance mechanisms.
- II. **Development of a Sector-Specific Data Governance Framework:** Clear guidelines must be established for data collection, storage, sharing, and protection within the food safety domain. Such a framework should align with broader data protection principles while addressing sector-specific requirements.
- III. **Strengthening Institutional Capacity and Infrastructure:** Investment in modern laboratory infrastructure, digital monitoring systems, and training programs for regulatory personnel is essential. Capacity building should focus on enhancing both technical expertise and technological literacy.
- IV. **Creation of an Integrated National Digital Food Safety Platform:** A unified digital platform should be developed to enable real-time monitoring, data sharing, and

⁶⁸ Food and Agriculture Organization & World Health Organization. (2020). Digital transformation of food safety systems.

coordination between central and state authorities. This would reduce fragmentation and improve regulatory efficiency.

- V. **Ensuring Inclusivity and Bridging the Digital Divide:** Policies must be designed to ensure that small-scale vendors, rural producers, and informal sector participants are not excluded from the regulatory framework. Simplified compliance mechanisms and capacity-building initiatives are necessary to promote inclusivity.
- VI. **Establishing Accountability and Transparency Mechanisms:** Regulatory systems must incorporate clear accountability structures, particularly in the context of automated decision-making. Public access to compliance data and inspection reports should be enhanced to strengthen transparency.
- VII. **Encouraging Public-Private Collaboration with Safeguards:** While private sector participation can facilitate technological innovation, appropriate safeguards must be instituted to prevent conflicts of interest and ensure that public health objectives remain paramount.

10. CONCLUSION

Food safety in India stands at a critical juncture, where traditional regulatory approaches are increasingly inadequate to address the complexities of modern food systems. While the constitutional framework provides a strong normative foundation, and statutory mechanisms such as the Food Safety and Standards Act, 2006 establish a structured regulatory regime, persistent gaps in implementation and enforcement continue to undermine their effectiveness.

The emergence of advanced technologies presents a significant opportunity to transform food safety governance by introducing greater efficiency, transparency, and predictive capability. However, the integration of such technologies must be approached with caution, ensuring that it aligns with constitutional principles, ethical standards, and the broader objective of public welfare.

This paper has argued that food safety must be reconceptualized as an integral component of the right to life, requiring a shift from a purely regulatory perspective to a rights-based and technology-enabled framework. Such a transformation demands not only legal reform but also institutional strengthening, policy innovation, and a commitment to inclusivity and

accountability.

Ultimately, the realization of food safety as a fundamental human right depends on the ability of the State to harmonize law, technology, and ethics in a manner that ensures safe, accessible, and equitable food systems for all. This integrated approach is essential for advancing public health, strengthening governance, and fulfilling the constitutional promise of dignity and well-being.