

Original Article

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Comparative study of genetically modified organism (GMO) policy in the United States and France

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Abstract

The imperative to augment food production and security, while concomitantly addressing concerns regarding health and environmental well-being, has given rise to contentious interactions among diverse stakeholders and the intervention of governments in the policy formulation process for genetically modified products. The examination of governance requirements in this domain provides a foundation for domestic policymakers to inform their decision-making processes. The objective of this study is to make a comparative analysis of the policies, institutions, and stakeholders of genetically modified products in the United States and France. These two countries are considered leading examples in the field of biotechnology and differ in terms of governance requirements. The research data is of a documentary nature, and the research method employed is a "comparative study." The findings suggest that the policies of both countries demonstrate elevated levels of efficiency and effectiveness with regard to genetically modified products. Product safety, food security, and consumer confidence are common policy goals in both countries. However, in the United States, innovation facilitation and support for industry and trade are prioritized, while in France, environmental protection and biodiversity are prioritized. In the United States, a developmental and promotional approach is employed by a single policymaking body under the federal government, which divides roles between the Food and Drug Administration (FDA), the Animal and Plant Health Services (APHIS), and the Environmental Protection Agency (EPA). In France, a precautionary and environmentalist approach is employed in the development and implementation of policies. These policies are overseen by the European Food Safety Authority (EFSA), in conjunction with the French Agency for Food, Environmental, and Occupational Safety and Health (ANSES), and the Independent Research and Information Committee on Genetic Engineering (CRIIGEN). A comprehensive analysis reveals that the observed discrepancies can be attributed to the disparate influences exerted by the stakeholders on the policy-making processes of the two nations.

Keywords Biotechnology policy, Genetically Modified Products, Food security, United States, France.

1. Introduction

In recent decades, Iran has increasingly recognized the importance of science and technology policy as a driver of development. Yet evaluating and revising policy frameworks for emerging technologies remains under-

developed, particularly in how international experiences can inform national strategies. A salient area within this domain is the governance of genetically modified (GM) products. The rapid expansion of GM-related industries has raised concerns about public health and environmen-



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tal impacts, while simultaneously creating opportunities for economic productivity and agricultural development. This tension generates a diverse set of stakeholders with conflicting views, underscoring the central role of public policy and government institutions in navigating contested policy landscapes.

Despite substantial work on GM policy, existing studies often focus on single-country or region-specific contexts and seldom adopt a comparative lens that systematically juxtaposes divergent institutional models. Moreover, most comparative analyses published prior to 2019 either emphasize one national case or juxtapose broadly different regulatory regimes without explicit attention to how institutional pathways shape policy choices, framing, and outcomes. This creates a significant gap in understanding how different governance architectures influence the trajectory, feasibility, and effectiveness of GM policy-making in distinct developmental contexts.

To address this gap, this study offers a focused, theory-informed comparison of GM crop policymaking in two industrialized democracies—the United States and France—which exemplify two distinct public-policy paradigms: a liberal-market, market-driven model (U.S.) and a precautionary, multi-stakeholder approach within a relatively centralized European framework (France). By integrating a cross-national analysis of policy processes, stakeholder dynamics, and regulatory developments since 2018, the study aims to reveal how institutional design, governance norms, and policy instruments shape (i) the prioritization of public health, environmental risk, and economic objectives; (ii) the balance between innovation incentives and precautionary safeguards; and (iii) the pathways through which scientific evidence informs decision-making.

This articulation of novelty yields three concrete contributions. Contribution 1: it provides a systematic, up-to-date comparative assessment of GM policy trajectories in the United States and France, highlighting how different institutional contexts produce distinct policy outcomes despite shared scientific and economic motivations. Contribution 2: it clarifies the mechanisms by which policy priorities are reframed in response to public-health and environmental risk concerns, stakeholder pressures, and political feasibility, offering a nuanced understanding of how governance structures shape policy stability and reform momentum. Contribution 3: it translates insights from the U.S.–France comparison into actionable implications for Iran, illustrating how international experiences can inform context-specific policy design, risk management, and stakeholder engagement strategies in a developing country pursuing agricultural modernization and food-security goals.

In sum, while GM policy is a globally salient issue, this study advances current knowledge by (a) explicitly analyzing how two distinct, well-established policy systems handle GM crops in the post-2018 era; (b) unpacking the causal linkages between institutional design and policy choices; and (c) offering a concrete, policy-relevant framework for Iran to reflect on potential reform pathways. The findings aim to inform both scholars concerned with comparative policy processes and policymakers seeking evidence-based guidance for GM governance in developing country contexts.

2. Methodology: Comparative study

The post-2018 policy landscape surrounding GMO governance reflects several interlocking trends that bear directly on a comparative study of the United States and France (and, by extension, the EU). First, the EU's Green Deal and Farm to Fork strategy signal a pronounced shift toward sustainability, biodiversity conservation, and public health considerations, shaping GM policy and the regulation of agricultural biotechnology across member states. These policy currents influence risk governance, labeling, and public engagement practices within the EU and—through alignment pressures and shared standards—across national regimes. Second, global stewardship and international standards continue to shape national risk governance choices. Instruments from Codex Alimentarius, FAO/WHO risk assessment guidelines, and OECD policy discussions inform harmonization efforts, risk communication, and cross-country comparisons of regulatory posture. Third, global supply chains and trade dynamics—driven by geopolitical shifts, sanctions regimes, and evolving export dependencies—alter national calculations about domestic production versus imports of GM products, situating policy choices within broader questions of supply-chain resilience and food security. Fourth, emerging GMO modalities, such as gene editing (e.g., CRISPR) and other next-generation trait technologies, compel a re-examination of regulatory boundaries, product safety, and labeling, with particular emphasis on pace, precaution, and proportionality in both the United States and the European Union. In this context, official guidance from the European Commission and EFSA from post-2018 updates—covering GMO labeling, risk assessment frameworks, and the regulatory status of genome-edited organisms—offers insight into how the EU's precautionary approach evolves in response to technological advances. On the other side of the Atlantic, the U.S. National Academies of Sciences, Engineering, and Medicine (NASEM) have produced updated reports on genome editing, plant crops, and regulatory pathways, providing evidence-based assessments of risk, oversight,

and implications for innovation. Complementing these national perspectives, OECD policy papers on biotechnology governance, innovation ecosystems, and their implications for agricultural policy provide cross-country comparability and benchmarking guidance. FAO/WHO/GSO and Codex guidelines further underpin global norms related to risk assessment, toxicology, labeling, and trade in GM foods, offering frameworks for aligning national policies with international standards. To broaden the comparative lens, recent case studies examine GM crop adoption, public acceptance, and governance in major producing and importing countries beyond the United States and France—including Brazil, Argentina, India, Kenya, and Southeast Asian economies—highlighting contextual factors that mediate policy outcomes. Collectively, these post-2018 developments situate the study within contemporary regulatory debates and enable more accurate assessments of convergence and divergence between the United States and France, and more broadly within the EU, in light of new technologies, international standards, and supply-chain considerations. This framing also has direct implications for Iran's policy design, emphasizing the need to balance innovation incentives with environmental safeguards, consumer protections, and transparent governance under resource and sanction constraints.

Researchers' interest in comparative studies in policymaking has been increasing because this methodological approach enables researchers to analyze issues and challenges from a comparative perspective and to leverage the experiences of other countries in the process of formulating and implementing policies (Arani; 2015:70). This interest is particularly pronounced among researchers in developing countries, who face the imperative of comprehending, acquiring knowledge, and attaining successful experiences in the domains of social and economic development (Qanvati and Mashayek; 2014:92).

A substantial corpus of comparative research currently exists, encompassing diverse scientific disciplines, including medicine, engineering, and communication sciences, as well as several fields of humanities, such as public policymaking. This research extends to more specific domains, including education and educational sciences, science, technology, and innovation. As posited by Ghaffari (2009: 77), comparative research is predicated on the examination of a specific topic across various contexts, with an emphasis on the identification of both similarities and differences. As stated by Qanvati and Mashayek (2010: 95), two central components are prioritized in comparative research. The initial step in the procedure is the selection of a sample. Subsequently, the variables must be specified. The number of samples, or observa-

tions, directly impacts the number of variables that can be analyzed. In scenarios where the number of samples is substantial, the number of variables is inherently constrained. Conversely, when the number of samples is limited, the analysis becomes feasible for a broader range of variables.

In the matter of sample selection and the emphasis on the identification of similarities and differences, the scenarios delineated in Table (2) can be conceptualized as follows:

Table 2. Proportion of samples by matching method

	Method of Similarities	Method of differences
The most similar examples	Analyzing similarities in similar examples	Analyzing differences in similar samples
The most different examples	Analyzing similarities in different examples	Analyzing differences in different samples

However, the main methodological considerations in the comparative study method are as follows: 1. Sample determination considerations, 2. Matching and equating variable considerations and 3. Analysis approach considerations. The present study is based on selecting the most similar samples and emphasizing both similarities and differences. These considerations are briefly introduced in Table 3.

3. United States Laws and Regulations in the Field of GMOs:

In 2018, the United States ranked first in this field, planting 75 million hectares of genetically modified crops, including rapeseed, soybeans, corn, cotton, alfalfa, sugar beets, papaya, squash, potatoes, and apple trees, which are resistant to pests and herbicides (Agricultural Biotechnology Information Base, 2019). (Agricultural Biotechnology Information Service, 2019).

In the United States, foods produced by biotechnology are subject to federal laws that generally control the production and use of all foods and chemicals. Most of these regulations were developed before recombinant DNA technology and its products were propagated. They were designed to address the products' properties, not their manufacturing method (Donna U. Vogt, 1999). Current federal policy is based on the premise that agricultural products derived from recombinant DNA technology can be regulated under existing laws because the safety of food and chemical products is assessed based on their

Table 3. Considerations for the comparative study method in the present study

Considerations for sample determination	Sample Selection: The United States and France are industrially developed countries and agricultural production pioneers. They are also considered liberal democracies, though they differ in terms of cultural norms and policy priorities. Level of Application: In terms of the spatial level, the two countries are on different continents with different geographies. In terms of the temporal level, however, the study focuses on a similar time period for both samples.
Equating variables	The main concepts in this study do not require adaptation or equivalence in the two countries. Food security, genetically modified products, policy-making institutions, and policy stakeholders are concepts and variables that are referred to by similar terms in both countries. This is one of the characteristics of a comparative study that helps determine a sample of similar cases.
Analysis approach	This research is "case-oriented," meaning it compares two specific cases (the United States and France) based on several variables, such as institutions, laws, policies, stakeholders, and policy outcomes. The qualitative research approach aims to describe and is based on comparative inference. The data is documentary and a combination of primary documents (official reports and the text of laws) and secondary documents (the content of analyses and research conducted on the subject).

characteristics, not their production methods. Federal agricultural biotechnology regulations apply to two aspects of product development: (1) the transgenic plant or animal itself and (2) products derived from it. (Pew Initiative on Food and Biotechnology, 2001).

3.1. Agencies Responsible for Regulating, Enforcing, and Overseeing GMOs in the United States

Federal law gives primary regulatory authority over agricultural biotechnology products to three agencies: 1) the Environmental Protection Agency, 2) the Food and Drug Administration, and 3) the Department of Agriculture's Animal and Plant Health Inspection Service. These agencies ensure that GMOs are safe for human, plant, and animal health, and they monitor their environmental impact. While each agency regulates GMOs from a different perspective, the Harmonized Framework for Biotechnology Regulation, established in 1986, defines how they collaborate. The major statutes that have given or revised regulatory authority to these agencies include:

The Federal Insecticide, Fungicide, and Rodenticide Act, the Toxic Substances Control Act, the Food, Drug, and Cosmetic Act, the Plant Protection Act, the Serum Toxin Act, the Public Health Service Act, the Dietary Supplement Health and Education Act, the Meat Inspection Act, the Poultry Products Inspection Act, the Egg Products Inspection Act, and the National Environmental Policy Act

(Pew Initiative on Food and Biotechnology, 2001).

3.1.1. Environmental Protection Agency

The EPA is responsible for protecting human health and the environment from potential threats, particularly those posed by pesticides. Under the Federal Insecticide, Fungicide, and Rodenticide Act (136 U.S.C.), the agency regulates the production, sale, and use of pesticides to protect the environment. Therefore, the EPA regulates substances produced and used in living plants for pest control, whether through conventional or genetic modification. (Code of Federal Regulations, 2018).

It is important to note that the agency's authority under the Federal Insecticide, Fungicide, and Rodenticide Act is limited to the pesticide properties of the plant, not the plant itself. Food-producing plants are subject to the Food and Drug Administration's food safety regulations, and plant pests are regulated under the Animal and Plant Health Inspection Service's regulations at the Department of Agriculture. (Pew Initiative on Food and Biotechnology, 2001).

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) ensures that pesticides do not cause "unreasonable adverse effects on the environment," which means any unreasonable risk to humans or the environment. This takes into account the economic, social, and environmental costs and benefits of using a pesticide. It also

considers the risk to the human diet from residues resulting from using a pesticide on or in any food that does not comply with the Federal Food, Drug, and Cosmetic Act (U.S.C. 136). (U.S.C. 136). The Act stipulates that no person may distribute or sell a pesticide in the United States without registration. Pesticides are defined in this Act as follows: (1) any substance or mixture of substances intended to prevent, destroy, repel, or reduce any pest; and (2) any substance or mixture of substances intended for use as a regulator, defoliant, or desiccant. Thus, the production and distribution of pesticides under this Act requires registration with the Environmental Protection Agency (EPA) and a permit obtained after expert reviews are conducted. (Pew Initiative on Food and Biotechnology, 2001).

First, the applicant must demonstrate that the pesticide is non-contaminating and will not cause unreasonable adverse effects on the environment when used in accordance with generally recognized practices. The agency then evaluates whether a pesticide has the potential to cause adverse effects on humans, target organisms, and possible contamination of surface or groundwater, wildlife, fish, plants, and endangered species according to its protocols.

Some items are exempt from registration and licensing. This includes pesticides that pose little risk to the environment, including humans, other animals, plants, water, air, and land (National Bioengineered Food Disclosure Standard, 2018). However, if a pesticide or its residue could be present in food, then it can only be exempt if it meets the food safety standards of the Federal Food, Drug, and Cosmetic Act, which aims to “provide reasonable assurance that no harm will result from exposure to the pesticide chemical.” This law gives the Environmental Protection Agency (EPA) the authority to set permissible levels of pesticide residues in food and exempt eligible pesticides from registration and licensing requirements under this standard. (21 U.S.C. § 346a).

According to this law, food containing toxic or harmful substances is considered adulterated, and selling it is prohibited. Pesticide residues are also considered poisons unless they meet the tolerance level established by the EPA or the pesticide in question is exempt from the tolerance requirement. (21) (U.S. Code § 346a).

3.1.2. Food and Drug Administration

The FDA is responsible for ensuring the safety of genetically modified foods consumed by humans or animals. Under a 1992 policy, the agency considers most genetically modified foods to be “equivalent” to non-genetically modified foods. In such cases, these foods are “generally recognized as safe” under the Federal Food, Drug,

and Cosmetic Act and do not require premarket approval. In other words, the standard for evaluating the safety of genetically modified foods is the same as the standard for evaluating other foods, unless proven otherwise. In that case, the FDA reserves the right to impose more stringent measures.

In 1997, the FDA established a voluntary consultation process for developers of genetically engineered crops to determine “substantial equivalence” before marketing a product, which includes assessing the toxicity and allergenicity of the gene product and the plant itself. If the food safety assessment data are satisfactory, the agency notifies the developer that the product can proceed with marketing. However, this voluntary process has its critics because some genetically engineered crops are used in non-food products, such as pharmaceuticals. This means that no information about their potential harm can be obtained until the drug is manufactured and tested.

In 2004, a law was passed requiring premarket approval for any ingredient used in a food product, even if it does not reach the consumer. Therefore, the FDA’s Center for Food Safety and Applied Nutrition conducts a food safety analysis before any ingredient is used in a manufactured food product to ensure accidental human exposure through the food supply does not pose a health risk. Another relevant program is the Plant Biotechnology Consultation Program, a voluntary program with four key steps: First, the developer of a genetically modified plant consults with the agency about a potential new product for use in human and animal food. 2) The developer submits food safety assessment data to the agency. 3) The agency evaluates the data and resolves any issues with the developer. The consultation cycle is complete when the agency no longer has questions about the safety of human and animal food made from the new genetically modified plant variety. The results of the completed consultations are made public.

The National Environmental Policy Act requires federal agencies to assess the environmental impact of major federal actions significantly affecting the quality of the human environment. If an action falls within the scope of the Act, the agency will typically conduct a preliminary environmental assessment to determine if the environmental issues involved require a full environmental impact statement.

In 1992, the Food and Drug Administration (FDA) issued a statement titled “Foods Derived from New Plant Varieties.” In the statement, the FDA proposed treating foods derived from genetically modified plants the same way it has traditionally treated foods containing additives developed through traditional plant breeding methods. The FDA also established a voluntary process through which

manufacturers could consult with the agency on safety and regulatory issues before marketing foods derived from genetically modified technology.

In July 2016, Congress passed the National Bioengineered Food Disclosure Act, directing the U.S. Department of Agriculture to establish a mandatory national standard for disclosing foods that are or may be genetically modified. This standard defines bioengineered foods as foods containing detectable genetic material modified through specific laboratory techniques that cannot be created through conventional breeding or found in nature (U.S. Congress, 2016). (U.S. Congress, 2016).

The Agricultural Marketing Service developed the Bioengineered Foods Inventory to identify products that are available in a bioengineered form worldwide and that regulated entities must maintain records of. These records inform regulated entities whether they are required to disclose bioengineered foods. The standard requires certain food manufacturers, importers, and retailers to distinguish bioengineered foods properly. Regulated entities have several options for distinction, including text, a symbol, an electronic or digital link, or a text message. Additional options are available for small food producers, such as a telephone number or web address.

3.1.3. The Department of Agriculture's Animal and Plant Health Inspection Service

The importation, transportation, and planting of genetically modified plants are regulated by the APHIS under the Plant Protection Act. According to this Act, the Secretary of Agriculture may prohibit or restrict the importation, entry, export, or movement within interstate commerce of any plant, plant product, biological control organism, noxious weed, commodity, or conveyance if the Secretary deems it necessary to prevent the introduction or spread of a plant pest or noxious weed in the United States. The Act defines "regulated products" as "any living organism that has been genetically modified or produced by genetic engineering." (Pew Initiative on Food and Biotechnology, 2001).

4. French laws and regulations on GMOs

France, a major member of the European Union, has banned the cultivation and distribution of GMOs. In the 1990s, France was Europe's leading agricultural economy; thus, the fate of GMOs in this country has in some ways changed the fate of biotechnology products in Europe. (Kuntz, 2014) The arrival of the first shipment of GMO soybeans from the United States to Europe came at an inopportune time, as it coincided with the "mad cow" crisis and the subsequent food insecurity. The leftist French newspaper, *Libération*, launched a media attack

on GMOs with the front page headline "Beware of the Soybean Madness." The crisis forced the French government, which had been supporting agricultural biotechnology, to back down. (Flahault A, Setbon M, Raude J, Fischler C, 2005)

The French National Agricultural Union and its affiliated organizations, which are usually open to innovation, also opposed GM crops. One reason for this was that the "mad cow" crisis was widely perceived as the result of "modern" agriculture and "unnatural" intervention, and therefore the priority of these agricultural organizations was to restore public trust rather than to pursue modern innovation. (Kuntz, 2014) The destruction of GM crops in France can be analyzed in light of the balance of power in the dispute, the changing positions of governments, and the strategic use of intimidation by opponents. These factors created insurmountable problems for scientific experiments and technology evaluation, as well as for farmers who tried to grow GM corn in the country. (Kuntz, 2014)

4.1. The institutions responsible for regulating, implementing, and monitoring GMOs in France are:

France has been a testing ground for "green" activists in developing "science" and "expertise" in producing data that aligns with their views. The establishment of committees for independent research and information on nuclear energy, non-ionizing electromagnetic radiation, and genetic engineering can be seen as a result of such hegemonic dominance. In practice, green activists are a small minority who have gained political support. With generous government budgets, they have major influence on political decisions and "scientific" risk assessments as an organized partisan lobby (Kuntz, 2012).

4.1.1. The French Agency for Food, Environmental and Occupational Health and Safety

The Agency has played various roles in regulating genetically modified plants for food or feed. Since the beginning of the new century, when the scope of genetic modification expanded significantly following the rulings of the Court of Justice of the European Union and the French Council of State that organisms derived from recent mutagenesis techniques are subject to the same conditions as transgenics, discussions have taken place at the European level to determine if changes to the previous regulations are required for the framework for the assessment and authorization of organisms derived from newer technologies. The Agency has been the main body advising the French competent authorities on the health risks associated with the use of genetically modified plants. The agency also actively participates in consultations organized by

the European Food Safety Authority to develop guidance documents for industry and prepare marketing authorization programs for genetically modified plants.

Starting in 2022, the Agency will be responsible for evaluating the environmental risks of organisms that meet the regulatory definition of transgenic. This includes cultivation in the field, such as field and clinical trials for veterinary medicinal products, as well as European-wide marketing authorizations for veterinary and human medicinal products. Along with the French Agency for Veterinary Medicinal Products, the Agency for Health and Safety will be responsible for assessing and approving any veterinary medicinal product derived from biotechnology. For human medicinal products, the French Agency for Health and Safety may request that the Agency assess the environmental risks of the products prior to their use.

4.1.2. The European Food Safety Authority

The EFSA focuses on the use of biotechnology in the food and agricultural sectors and the assessment of its health and environmental risks at the European level. Applications for industry authorizations reviewed by this organization are referred to EU member states for comments. After evaluation, the applications are put to a vote by the 27 member states of the European Commission, which makes a decision on the product. In practice, the EFSA is the highest authority on the assessment of the potential risks of GMOs to human and animal health and the environment in Europe. Its role is to provide scientific advice on the safety of GMOs to European risk managers, such as the European Commission and EU member states. However, it is the responsibility of risk managers to decide on the authorization of GMOs for the European market.

The European Food Safety Authority (EFSA) applies strict criteria within the EU regulatory framework when assessing the safety of genetically modified organisms (GMOs) before they are authorized for use as food or feed or for cultivation in the EU. Most of these assessments concern genetically modified plants. The Authority must also respond to urgent requests from the European Commission or the European Parliament regarding GMO safety.

The Authority assesses the following aspects:

1. Effects on human and animal health (e.g., toxicity and allergenic risks).
2. Environmental effects, such as the risk of genes introduced into the GMO being transferred to other organisms.
3. Molecular characterization: Assessment of the molecular structure, function, and potential interactions of the newly created proteins.
4. Comparative analysis: comparison of the GMO prod-

uct with its conventional counterpart.

5. Assessment of potential environmental effects.

Once a GMO is authorized by risk managers, it is usually granted a ten-year authorization for the EU market. However, after ten years, the European Food Safety Authority must reassess it before any decision on reauthorization can be made. Interestingly, as of 2021, only one genetically modified plant species (maize) has been authorized for cultivation within the EU. Each member state is free to authorize or prohibit the cultivation of crops within its borders. France banned the cultivation of genetically modified plants for commercial purposes in 2008. However, around 100 genetically modified crops have been authorized in the EU and France for import and use in food and feed. In other words, while the cultivation of genetically modified crops is banned in France, the import and consumption of imported genetically modified crops is authorized after approval by the relevant authorities.

At the request of the European Commission, the European Food Safety Authority (EFSA) has prepared several guidance documents for the risk assessment of GMOs and food and feed derived from them. These documents describe how to compile GMO application dossiers and the types of scientific data and other information that should be included. According to EU law, applications for the import, processing, and cultivation of GMO plants must include a post-market environmental monitoring plan, for which the Authority is responsible.

5. Comparing GM Policymaking in the United States and France

5.1. Policy Objectives

In both countries, institutions have been established to set and guide policies with various objectives. Table 3 lists the institutions related to GM policymaking in the two countries:

Table 3. Policy-Making Institutions for Genetically Modified Products in the United States and France

Policy-making institutions in France	Policy-making institutions in the United States of America
1. European Food Safety Authority (EFSA): 2. The French Agency for Food, Environmental and Occupational Health and Safety (ANSES). 3. French Independent Research and Information Committee on Genetic Engineering (CRIIGEN)	1. Food and Drug Administration (FDA) 2. Animal and Plant Health Inspection Service (APHIS), which is under the Department of Agriculture. 3. Environmental Protection Agency (EPA).

These institutions establish public policy objectives regarding genetically modified products in the form of laws and regulations and monitor their implementation. The

Table 4. Comparison of the Policy Objectives of the United States and France Regarding Genetically Modified Products

Objectives of the Policy on Genetically Modified Products in France	Objectives of the policy for genetically modified crops in the United States
1. Environmental protection and Biodiversity: As a member of the European Union, France pays special attention to preserving natural resources and mitigating the environmental impact of genetically modified products. 2. Consumer Confidence: In France, companies must provide comprehensive scientific evidence demonstrating that their products are safe for human health and the environment. 3. Ensuring Food Security: Using genetically modified products in agriculture can increase crop yields and provide society with sufficient food, as long as they do not threaten the environment. Therefore, France's policy goal is to import genetically modified products to ensure food security while partially prohibiting the domestic cultivation and production of these products.	1. Ensuring Product Safety: The main goal is to ensure the safety of products for consumers. 2. Facilitating Innovation and Development: As a world leader in biotechnology, the United States' policy focuses on facilitating the innovation and development of genetically modified crops. 3. Supporting the agricultural industry: The United States' genetically modified crops policy aims to support the country's agricultural industry. This includes increasing yields, improving resistance to pests and diseases, and reducing the use of chemical pesticides.

policy objectives of the two countries regarding genetically modified products are listed in Table 4:

The US prioritizes safety, innovation, and domestic agricultural support, reflecting a growth- and technology-forward stance that seeks to maintain global leadership in biotech while managing consumer risk through standards. France (EU context) foregrounds environmental protection, consumer trust, and a cautious approach to domestic cultivation, using imports to secure food supply while tightening environmental safeguards.

For Iran, these contrasts suggest a policymaking fork: pursue a growth-oriented, innovation-friendly model with strong biosafety and pesticide risk management (US-like), or adopt a precautionary, environment-first model with robust consumer protections and controlled domestic production (France-like). A hybrid approach could blend risk-based innovation with transparent labeling, public engagement, and import-augmented food security, tailored to Iran's water, energy, and sanctions realities.

5.2. Stakeholders:

Stakeholders play a major role in determining policy goals and formulating policies. The differences in public policies between countries reflect the differences in the interests of the main stakeholder groups. Therefore, similarities and differences in GM policymaking between the United States and France can be identified by comparing their stakeholder groups. Table 5 lists the main actors and stakeholder groups in GM policymaking in the United States and France.

The US stakeholder landscape favors innovation, market expansion, and competitive performance, with strong industry and producer influence and a focus on consumer

safety. France, by contrast, shows greater EU-institutional, environmental, and civil-society influence, leading to more precautionary, environment-centric policymaking and tighter regulation.

For Iran, recognizing these contrasting stakeholder dynamics suggests designing governance that ensures credible risk assessment and public legitimacy: include industry, producers, health and biosafety authorities, consumer groups, and environmental civil society in a transparent, deliberative process.

The differences imply that any Iran GM policy framework should explicitly balance innovation incentives with environmental and consumer protections, and establish clear channels for stakeholder input to maintain legitimacy under sanctions and resource constraints.

5.3. General Similarities and Differences in GM Policy in the United States and France

Public policies in the two countries are similar in many ways, but in some cases, they differ significantly. Tables 6 and 7 list these similarities and differences in a comparable way.

The shared emphasis on safety, labeling, and independent oversight suggests a convergent baseline for credible governance in GM policymaking, reinforcing the importance of transparent risk assessment and public communication in both contexts.

The common commitment to food security indicates that gains in yield or production efficiency are viewed within a safety and environmental stewardship frame, not solely as economic objectives.

The polarized public attitude, coupled with differing influential actors (economy-driven in the US vs. civil society-driven in France), implies that legitimacy and policy

Table 5. Stakeholders in GM Policymaking in the United States and France by Role and Priority

Stakeholders in France	Stakeholders in the United States
1. Institutions and organizations related to the European Union: European identity is tied to environmental protection and sustainable development, and the institutions of the European Union represent these values. Leading in environmentalism is a policy priority in the European Union, so the Union is the most important stakeholder among European governments in matters related to green policy and acts in a way independent of them. 2. Environmental associations: These associations, which also enjoy the support of the French government in a special way, considering the components of the European identity, are considered the second stakeholder group in the policy-making of transgenic products, especially in the field of production. 3. Human rights associations: These associations play a role as public representative institutions, especially where the issue of ensuring food security and consumer living standards is raised, as stakeholders who support the import of safe transgenic products within existing restrictions. 4. Farmers and livestock producers: France is the leading country in agricultural production and one of the largest dairy producers in the European Union. Although increasing production and reducing costs is one of the most important goals of producers, due to environmental policy restrictions and the share of these producers in the organic market, they have not exerted significant political pressure on French policymakers to further liberalize the field of genetically modified products.	1. Biotechnology and agricultural industries: Companies and organizations in these industries, including those producing genetically modified products and research organizations, seek to streamline the production and marketing of their products given their significant market share in the US. 2. Farmers and Livestock Producers: Due to the priority of agricultural and livestock production in the US economy, farmers and livestock producers have a significant share of the economy. They are seeking to use genetically modified products to improve product performance, reduce costs, and increase profitability. 3. Consumers: As taxpayers and voters, American consumers seek to provide safe, quality products and ensure food security. 4. Environmental Associations: As public representative institutions, environmental associations are seeking to reduce environmental concerns related to the cultivation of genetically modified products.

acceptance in Iran may depend on balancing scientific rigor with inclusive deliberation and transparent process design.

The existence of trade controls in both systems underscores the relevance of border and trade policies for Iran, especially under sanctions and resource constraints, where policy must weigh import safety, domestic production capacity, and food security.

Policy posture and risk appetite: France's policy is more precautionary with strong environmental safeguards and a focus on domestic production constraints, while the United States emphasizes market-driven production and export-oriented agriculture. For Iran, this contrast maps to a choice between a precautionary, environment-forward pathway (France-like) and a growth-oriented, innovation-friendly pathway (US-like), or a hybrid that blends safeguards with selective commercialization.

Regulatory approach: France relies on clear procedural rules and stringent implementation criteria, which suggests that Iran could benefit from codified, transparent regulatory processes that specify step-by-step requirements for approval, monitoring, and post-market surveillance. The US approach emphasizes regulatory facilitation,

which can speed innovation but requires robust risk management to maintain public trust.

Domestic production vs. imports: France's preference for domestic production with import safeguards contrasts with the US emphasis on export-oriented production. Iran's context (water, energy, sanctions) may require a balanced stance that protects food security through a mix of domestic capability building and carefully managed imports.

Organizational ownership: The French model highlights the role of specialized safety and environmental agencies with a precautionary mandate, whereas the US model centers on health and safety regulators that are market-facing. Iran could design a hybrid governance structure that ensures strong environmental and public health safeguards while maintaining a clear regulatory authority for innovation.

Trade orientation: France's emphasis on domestic production and import controls versus the US focus on trade and export suggests different leverage points for Iran: build domestic capacity where feasible, but also establish risk-based import protocols and transparent labeling to

manage cross-border trade under sanctions.

Cultivation intensity: The stark contrast in cultivation levels underscores how public policy and societal norms shape adoption rates. For Iran, this implies that policy design should anticipate public perception, environmental

constraints, and the feasibility of large-scale cultivation given water and energy realities.

6. Policy Recommendations for Iran

In order to more accurately assess the debate on GM policymaking in Iran, a thorough analysis of the country's

Table 6. Similarities in GM Policy in the United States and France

Priority in ensuring product safety	Both countries emphasize the safety and availability of genetically modified products for consumers. Independent regulatory organizations have been established to evaluate and certify the safety of these products.
Ensuring food security	Both countries prioritize ensuring food security for society and increasing agricultural production using genetically modified crops.
Existence of supervisory organizations	Both countries have formed independent regulatory organizations to control and monitor the production and use of GMOs.
Scientific support while also resisting science	In both countries, elites and researchers in the fields of GM and biotechnology development engage in scientific research, and political actors have a practical belief in the importance of using scientific knowledge and technology to develop agriculture and ensure food security. At the same time, both countries are conducting careful studies and scientific research focused on the effects of GM crops on the environment, human health, and agricultural production.
Labeling rules	Both countries have implemented effective regulation in terms of monitoring and control and have implemented laws for labeling genetically modified products to provide consumers with the necessary information about whether the products are genetically modified.
Public participation	Both countries have prioritized public participation in GMO policymaking by being transparent about the decision-making process, listening to public opinions, and assigning different roles to the public.
Public attitude	In both countries, public attitudes toward the production and consumption of genetically modified products have become polarized. Supporters and opponents compete with each other to influence policies through representative institutions. The difference is that economic actors have greater influence in the United States, while civil society institutions have greater influence in France.
Creating trade barriers	In some cases, both countries have established and implemented trade restrictions on the import and export of genetically modified products.
Paying attention to environmental impacts	Both countries have considered the environmental impact of genetically modified products in their policies and have tried to identify, control, and manage it.

Table 7. Differences in GM Crop Policies in the United States and France

Subject	United States of America	France
Rules and regulations	Emphasis on procedures and implementation criteria	Emphasis on rules
Consumption of genetically modified products	High and common	Low and restricted
Policy-making approach	Regulation and facilitation	Cautious and strict
Policy objectives	Greater emphasis on the economy while paying attention to food security and the environment	Greater emphasis on environmental sustainability while paying attention to the economy and food security
Organizational dominance in transgenic policymaking	The superiority of the Food and Drug Administration with an emphasis on food health and safety	The superiority of the Food, Environmental and Occupational Health and Safety Organization with an emphasis on environmental damage
Trade policies	Emphasis on commercial production and extensive exports	Emphasis on supporting domestic production and local agriculture and monitoring import safety
Amount of cultivation of transgenic crops	Very high (over 90% herbicide-resistant GM corn, soybeans, and rice)	Very limited and subject to legal prohibitions

specific details and conditions is necessary. While other countries' experiences in this field can provide a basic model for policymakers, further research is needed to develop a more comprehensive understanding of the situation in Iran. Based on the experiences of the United States and France, as well as a review of the status of GM policymaking in Iran, the following criteria can be considered for providing policy recommendations: deficiencies in laws and regulations, weaknesses in safety and environmental protection, deficiencies in labeling and information, a lack of attention to research and development, and the need for international cooperation. However, it is clear that policy recommendations must be tailored to the unique circumstances and requirements of each country.

6.1. Strengthening the system of supervision, safety, risk management, and environmental protection

A robust regulatory and safety system is essential to ensure safety across research, testing, and deployment stag-

es. Institutional coherence is a prerequisite for effective governance, particularly in the food security sector.

Policy actions:

Overcome institutional interference and create a specialized working group with representatives from the Ministry of Jihad and Agriculture, the Ministry of Health and Treatment, the Ministry of Immunization, the Food and Drug Administration, the National Standards Organization, and other relevant bodies.

Design and implement independent monitoring mechanisms, with clear accountability and performance metrics. Develop a staged regulatory framework outlining research, testing, risk assessment, and post-market surveillance requirements.

Future research directions: Analyze institutional bottlenecks and propose governance reforms; evaluate the effectiveness of specialized working groups in similar regulatory domains; model risk assessment protocols and their resource requirements in Iran's context.

6.2. Encouraging scientific research and the development of new technologies

Biotechnology and transgenic research can drive productivity, sustainability, and resilience, but require sustained investment and strong linkages between research institutions and industry.

Policy actions:

Increase funding and create facilities for transgenic R&D; promote university–industry collaboration; support start-ups and incubators in biotechnology and agriculture.

Promote educational programs and international exchanges to build local expertise; sponsor international conferences and knowledge exchanges.

Future research directions: Assess current Iran-specific R&D capacity, identify bottlenecks in funding, talent, and infrastructure; evaluate the economic and environmental impacts of domestic transgenic programs; study the optimal mix of public funding and private investment for biotech innovation in Iran.

6.3. Increasing Public Awareness

Transparent, science-based information and stakeholder engagement are crucial for public trust and policy legitimacy.

Policy actions:

Develop and disseminate accessible, scientifically robust information about GMOs; implement public outreach through media, farmer training, and consumer education programs.

Create channels for stakeholder dialogue (farmers, consumers, academia, industry) and organize public forums and consultations.

Future research directions: Examine public perceptions of GMOs in different Iranian demographics; test communication strategies and labeling messages for effectiveness and trust; evaluate the impact of awareness campaigns on policy acceptance and consumer choices.

6.4. Development and Support of Domestic Production

Domestic production can enhance food security and reduce import dependence, but must be aligned with safety and environmental safeguards.

Policy actions:

Implement targeted support for domestic transgenic production aligned with water, energy, and environmental constraints; create markets for domestically produced transgenic inputs and products.

Coordinate with biosafety and environmental agencies to prevent adverse impacts; use biotechnology to optimize resource use (water, soil, nutrients).

Future research directions: Model resource allocation and

environmental trade-offs of expanded domestic transgenic production; assess the competitiveness of domestic transgenic products in domestic and export markets; explore supply chain resilience under water and energy constraints.

6.5. Setting standards and laws for labeling and information

Clear labeling and information standards can enhance transparency and consumer choice, though food security considerations may affect prioritization.

Policy actions:

Establish clear labeling standards for GMO content and provide accessible, scientifically grounded information to consumers.

Build public-facing information portals and hold regular public briefings to maintain trust.

Future research directions: Evaluate labeling impacts on consumer behavior and market outcomes; study the cost and feasibility of implementing labeling standards given domestic supply pressures; assess how labeling interacts with public health communications.

6.6. Importance of encouraging international cooperation and facilitation of GM crop trade

International cooperation can accelerate technology transfer, risk management, and market access, but sanctions and geopolitical realities constrain engagement.

Policy actions:

Develop a strategic plan to engage with international partners, align with global standards, and participate in technical collaborations where feasible.

Create procedural pathways to import/export GM crops and share information under applicable legal and security constraints.

Future research directions: Map Iran's potential international partners and identify feasible cooperation avenues; analyze the impact of sanctions on biotechnology trade and how to mitigate risks; study spillover effects of international collaborations on domestic innovation.

6.7. Strengthening the Legal System

A strong legal framework is fundamental to transparency, accountability, and innovation in GM policymaking.

Policy actions:

Update and harmonize GMO-related laws and regulations; establish clear intellectual property protections; enhance enforcement mechanisms and sanctions for non-compliance.

Build institutions capable of independent oversight, risk assessment, and consumer protection.

Future research directions: Conduct comparative legal

analyses to identify best practices in GMO governance; evaluate the effectiveness of legal reforms in other jurisdictions and adapt lessons to Iran's context; assess enforcement capacity and compliance behavior among industry actors.

Notes on Implementation under Iran's Context

Given Iran's resource constraints, water and energy challenges, and sanctions environment, prioritization should favor actions with high impact and feasible regulatory readiness.

Establish a phased timetable with explicit milestones: (i) governance reform and stakeholder coordination; (ii) development of a transparent information framework; (iii) piloting domestic production under strict biosafety regimes; (iv) gradual expansion aligned with international cooperation where possible.

Build robust monitoring, evaluation, and learning mechanisms to adapt policies based on evidence and feedback.

Conclusion

The framework proposes a cohesive policy architecture for agricultural biotechnology that rests on five interrelated pillars. First, a strengthened and coherent governance structure with clearly delineated responsibilities to ensure accountability, transparency, and efficient decision-making. Second, robust safety, risk assessment, and environmental protection mechanisms designed to anticipate, monitor, and mitigate potential adverse effects of transgenic and agricultural biotechnologies. Third, a forward-looking R&D and innovation policy that actively supports transgenic research and related biotechnologies while aligning with safety standards and market needs. Fourth, transparent public communication and labeling standards intended to build trust, enable informed choice, and enhance public legitimacy of biotechnological applications. Fifth, an integrated approach that supports domestic production alongside international cooperation, contingent on safety, market conditions, and sanctions constraints.

Implementing these components can enhance food security, protect public health, and bolster economic resilience. Realizing these benefits, however, requires sustained political will, institutional reforms, adequate funding, and alignment with international norms and sanctions regimes. At present, Iran-specific evidence on risk assessment protocols, labeling efficacy, public perception, and domestic biosafety capacity remains limited. Future research should aim to quantify environmental and health risk profiles associated with local GM applications, evaluate existing regulatory bottlenecks, and test communication strategies to raise public awareness

and understanding. Comparative case studies focusing on Iran's agricultural sector, water scarcity, and energy constraints will help tailor policy instruments to national circumstances.

From a policy and research perspective, the following steps are recommended. First, develop an action plan with phased milestones, comprehensive stakeholder mapping, and clear performance indicators to monitor progress. Second, establish an Iran-specific GM policy sandbox (pilot programs) to assess regulatory feasibility and social acceptance prior to broader deployment. Third, align domestic research and development incentives with regulatory readiness and opportunities for international collaboration, ensuring that innovation advances are matched by safety and governance safeguards. Finally, pursue ongoing integration with international norms and cooperative mechanisms to enhance knowledge exchange, mutual recognition where appropriate, and access to global safety and market standards.

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