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To GM crop or not to GM crop?

Analysis of the decision making process on GM crops in the European Union

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1 Introduction

The world population is growing exponentially. This causes multiple wicked problems, amongst which global food supply. Throughout the last century, initiated by the food shortages after World War 2, scientists have questioned our ability to provide a sufficient food supply for the growing population [Warren, 1957]. Projections of food supply up to 2050 show that the increase in food production likely cannot keep up with the worldwide population and economic growth (Gilland, 2002). When looking at food supply, crop losses still lead to a significant reduction in food production. Crop losses due to pests and pathogens lie between 20-40% of production. And perhaps even higher, as crop loss analysis primarily focuses on large plant disease epidemics and not necessarily on smaller epidemics with long felt effects (Savary et al., 2012). The presence of pests is also increasing due to climate change, leading to increased crop losses over time (Deutsch et al., 2018).

A proposed technical solution to crop losses due to pests are Genetically Modified (GM) crops. GM crops have been implemented from the mid 1990s in order to improve certain aspects of the crops, such as resistance to diseases and pests. Next to this, GM crops have decreased softening and rotting of vegetables, which allows for longer/further transportation worldwide (Ma et al., 2018). These adjustments in GM crops form strong advantages, along with the increased yield one receives from GM in comparison to regular crops (Rodriguez et al., 2022). However, GM crops have met a lot of resistance, due to concerns for public safety, superbugs and other environmental risks (Agarwal & Singh, 2021).

1.1 Wicked problem

The topic of GM crops is highly debated globally with contrasting sentiments, and can be categorized as a wicked problem based on the following 3 most relevant criteria by Rittel and Webber (Rittel & Webber, 1973): *There is no definitive formulation of a wicked problem:* the formulation depends on ones own perception of the problem. With GMO crops this extremely varied; from concerns on health safety, to biodiversity, to food supply, which makes it impossible to determine a "set" formulation of the GMO problem that needs to be solved.

Every solution to a wicked problem is a "one-shot-operation": if GM crops are implemented, they may cause (irreversible) damage to health, biodiversity or other aspects. If they are not, lower food supply may cause increased starvation. These effects cannot be undone when a solution to the problem is tried out.

Every wicked problem can be considered to be a symptom of another problem: GM crops are a symptom of crop loss problems, which is a symptom of low food supply, which is a symptom of world hunger as a wicked problem.

1.2 European Union

A majority of decisions regarding GM crops are made by governmental instances or overcoupling organisations such as the European Union. They write legislation on the use of crops, processes and standards in food production. Globally, there is a wide variance in the adoption of GM crops amongst the public and farmers. Legislation also strongly varies, where GM crops are sown and sold in the United States, whilst a various number of countries worldwide have banned GMO's completely (WorldPopulationReview, 2022). Therefore, when reviewing decision making process on the topic of GM crops, it is constructive to focus on a geographical or geopolitical area.

Within the European Union, the decision making process around GM crops has been particularly arduous, with many conflicting views and adjusted legislation. Although there is a well-documented regulatory framework by the EU on GM crops, there are also occurrences of major delays by the Commission in the legislation process, and countries still impose national bans, regardless of EU acceptance or rejection (Halford, 2019). The legislation in the European Union on GM crops also has a widespread influence, as it also places requirements on meticulous labeling and tracking of imported food, and therefore influences decision making of GM crops in low-income countries (R. L. Paarlberg, 2002). Lastly, in the European Union there is a high number of stakeholders with varying interests, which generates a fascinating and complex decision making process. These factors combined lead to an interest in GM crops in the European Union, where Directive (EU) 2018/412 is taken as starting point (see subsection 2.1).

Therefore, the research question in this paper is as follows:

What are the challenges that the European Union is facing on reaching a consensus regarding GM crops legislation between member states?

2 Description

2.1 Timeline



Discussion on whether or not to allow GM crops for farmers in the European Union has been a long one dating back to the 1990's. Over time, some GMO's were actually legalised in the EU and used as well. However, later on, the legality of these crops has changed as more scientific information gets published about them and sends public parties into an uproar. As of now, there are mainly national bans on GMO crops to which many countries take part. At the moment 19 out of 27 member states have voted to partially or completely ban the GM crops (Commission, 2022). The topic is still being discussed at an EU level as to make an EU wide decision on the matter. The road towards regulating GMO within the EU started in 2011 with the evaluation project of new plant breeding techniques. All the way up until the 2018 the European Food Safety Authority (EFSA) has been updating guidelines, recommendations and regulations.

The decision moment we want to look at and analyse is from the year 2015. The directive set in this year (Directive (EU) 2015/412) was pushed in places to bring a conclusion to the discussion on whether GM crops were allowed or not to be cultivated in Europe (Mampuy, 2021). The decision had been postponed or put off for some time, and stakeholders were getting quite vocal about the needs for a decision. The Directive was a two-step plan. First, for the authorisation for a GM crop, the member state may simply request to be excluded from the geographical scope of the decision for cultivation. Second, if the member state is denied exclusion, they may use reasoned and non-discriminatory measures to restrict/prohibit GMO cultivation in their territory. What was finally decided, is that member state can decide on a national level whether or not to allow GM crops and the decision can be based on non-safety reasons. So the decision whether or not to allow GM crops was pushed from an EU level to a national level.

Even though there was a lot of dissatisfaction regarding the standstill of decision-making on the topic of GM crops market authorisations, the reactions and opinions of NGOs and also the industry to this new directive were pessimistic to say the least (Mampuy, 2021).

2.2 Actor and Stakeholder Identification

The decision making process in a network requires cooperation amongst the actors as they try to push their agenda while keeping their cards (goals) close to their chest in a bid to reach a package deal. An actor analysis gives us a great understanding and perspective on the interests and influence of each actor in the decision making process which further helps formulate an effective strategy to reach a consensus. We use actor analysis to reconstruct the decision making process in this section. A comprehensive analysis is carried out in the subsection A.1 and a condensed summary is tabulated in Figure 1.



Stakeholder	Interests	Stakeholder	Interests
Producers	<ul style="list-style-type: none"> • Increase yield of farmers • Solve the food scarcity problem • Make Profits 	EU Member States	<ul style="list-style-type: none"> • Protect interests of citizens • Influence voter decisions • Build Trust • Economic Growth and prosperity
Biotechnologists & Biologists	<ul style="list-style-type: none"> • Provide innovative & technological solution to food scarcity problem • Build public trust for further research • Share opinions 	Farmers	<ul style="list-style-type: none"> • Make Profit • Avoid exploitation • Want their concerns & perspective to be taken into account during decision-making process • Easy to understand regulations
Ecologists	<ul style="list-style-type: none"> • Protect human and animal life • Share opinions • Conserve ecosystem and biodiversity 	European Commission & Court of Justice of the European Union	<ul style="list-style-type: none"> • Protect interests of EU Member states • Inclusive, unbiased & transparent regulations • Establish a standard for GMOs
Nongovernmental organizations (NGOs)	<ul style="list-style-type: none"> • Advocate for social justice • Thwart monopolistic and profit greed of producers • Protect farmers & planet • Increase number of volunteers 	European Food Safety Authority	<ul style="list-style-type: none"> • Create transparent and safe framework for GMO authorization • Provide scientific advice • Gain Trust • Increase Awareness
Media	<ul style="list-style-type: none"> • Build trust • Disseminate information in an unbiased way • Increase transparency • Increase viewership and credibility of their organization 	Consumers	<ul style="list-style-type: none"> • Safety and wellbeing of themselves and their family • Want to be informed of developments in GMOs

Figure 1: Stakeholder Analysis

2.2.1 Power-Interest Matrix

This method takes into account the influence / interest-based matrix for evaluating stakeholders (Bryson, 2004). Through the actor analysis, we notice a shortage of players (High Interest/High Power) resulting in a deadlock in the decision making process around GM crops legislation in the European Union.

The European Court of Justice, EU Member states and European Commission are established as context setters (High Power/Low Interest) as while they are in positions of tremendous power, the debate around GM crops authorization is not their utmost priority. Similarly, the bio-technologists, ecologists, farmers are established as subjects due to their high interest, yet relatively low power in the decision-making process around GM crops authorization. Based on our analysis, it is necessary to increase the interest of the context setters, so that they are identified as players in the decision making process for GM crops authorization. Similarly, the subjects should be given more power and involved in the decision making process in a bid to utilize their knowledge and expertise around GM crops.

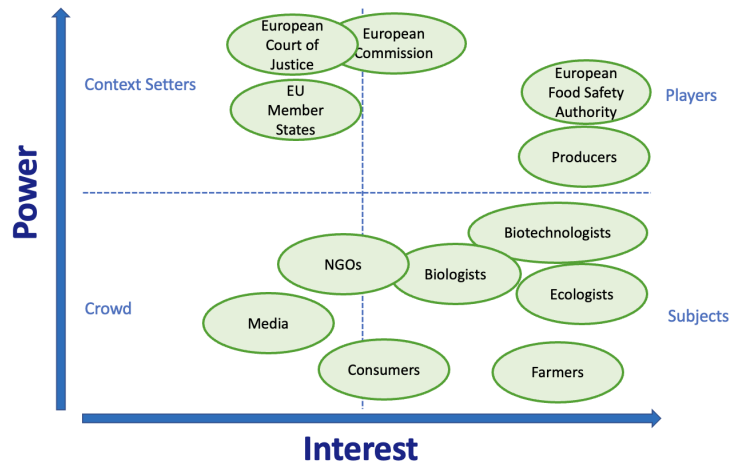


Figure 2: Stakeholder Analysis using Power-Interest Grid

2.2.2 Actor Coalitions on Shared Values

Concluding from the stakeholder analysis in subsection A.1, we identified coalitions being formed between various actors on aligned values as illustrated in Figure 3. A coalition is formed between a majority of Anti-GMO NGOs, ecologists, farmers, consumers and the media as they advocate for social justice, increasing awareness around GMOs and safety and well-being of themselves and the environment. As farmers share a pluralistic view on the subject, some also form coalitions with producers who claim GM crops increase the yield, hence aligning on the shared value of increasing profit. The European Commission, European Food Safety Authority, EU member states and the European Court of Justice advocate social justice, safety well being and hope to increase awareness and transparency to build trust around this technology. The media also shares a pluralistic view and disseminates information on the latest developments and opinions of the coalition formed between the producers, biologists and bio-technologists that align on building trust and increasing awareness on the technology.

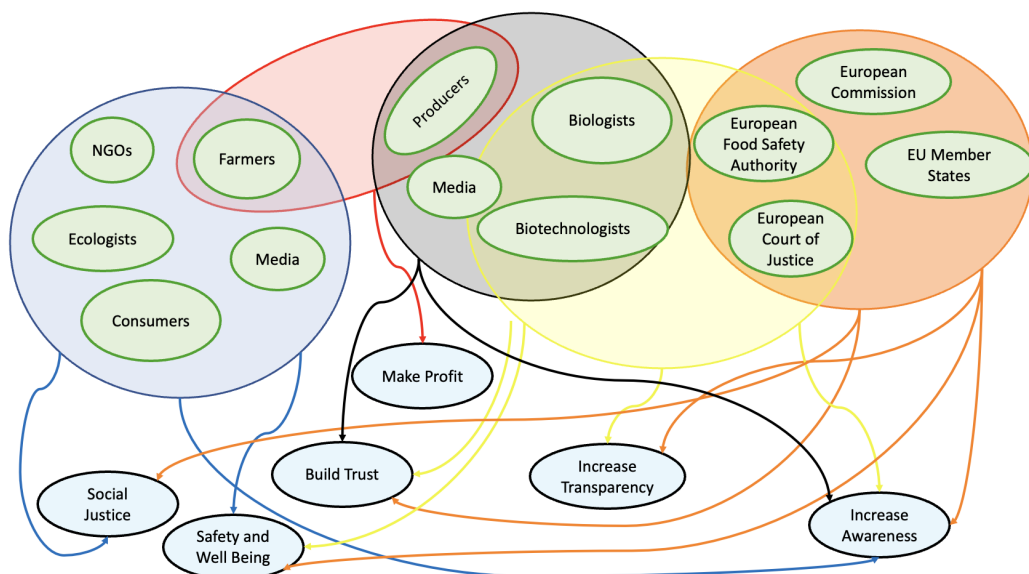


Figure 3: Coalition between actors on shared values

3 Analysis

3.1 Contributing decision making theories

3.1.1 Thinking Fast and Slow & Project-based communication

The general public in various European countries have strong objections to the use of GM crops and believe it is unsafe (Kennedy & Thigpen, 2020). Opposition to GMOs varies per country, and the fears and perceived risk span a wide range from health to environmental to socio-political areas (Bonny, 2003). Whether the attitude towards GMOs is changing over time in Europe is debated, but leans to no significant change over the last twenty years (Wozniak et al., 2021) (Ichim, 2020) ¹. The public opinion on the safety of GM crops conflicts with a significant number of scientific publications and research. The colossal amount of research on GM crops requires evaluation of overview studies, which indicate that there are no increased health risks when implementing GM crops (Nicolia, 2013), (Gould et al., 2016). However, resistance in insects can build up dangerously if not properly managed. So, why does the public's view deviate so strongly from scientific findings? This issue can be analyzed using two decision making models:

1. **Project-based versus process-based decision making.**

Whilst in project-based decision making objectively correct information exists, this is not the case for process-based decisions. Here "negotiated knowledge" is useful, where all relevant parties discuss what is counted as good information (de Bruijn & Heuvelhof, 2018). This negotiation of knowledge did not take place in the GM crops debate. Information and statements used by various parties are diverging, not converging. This allows for strongly varying views and therefore the lack of a (top-level) general consensus. In general it is recommended to combine process-based decision making ("backstage" activities) with project-based communication ("front-stage" activities) to prevent major disputes (de Bruijn & Heuvelhof, 2018). However, this only works if either all stakeholders are correctly included in the backstage process or the decision process is transparent. Currently, the general public is not aware of the arguments made for and against a certain decision. This is one of the major issues the public and low-power stakeholders have with the decision making process. This is not only the case in the governmental legislative process, but also in scientific institutions. This is demonstrated by the case of Pusztai, a scientist that prematurely shared research results that a GM potato crop might hinder digestion (Ujj, 2016). This led to suspension of Pusztai, blazing discussions on the safety of GM crops, and the controversy of scientific research being (partially) funded by profiting parties, leading to conflicts of interest (Pusztai, 2010). This strongly decreased the public's trust in scientific research and results on GM crop safety and performance, which contributes to the existing discordance between the public's opinion and scientific findings.

2. **Individual decision making processes: Thinking Fast and Slow.**

Each member of the public has internal individual decision making processes. Within this process, it can be viewed that two "systems" are active: system 1, which consists of impulsive, biased thinking and operates really fast, and system 2, which consists of well thought out, slower thinking (Kahneman, 2012). For important decision making, System 2 is necessary to prevent biases. The general public may resort to system 1 thinking and automatically relate GM crops to "unnatural" and "unsafe". The debate on GMOs is not held rationally, but with a lot of emotional and rhetoric reasoning (Hielscher et al., 2016). Where opinions are framed by existing beliefs and prejudice, this may indicate that system 1 dominates thinking and decision making. This view is also discussed by Blancke Et al., where three intuitive preferences are discussed: essentialism (should not interfere with existing codes), theological thinking (it is unnatural), and disgust (it is contaminated) (Blancke et al., 2015). These are system 1 responses of the public in the GMO debate, whilst system 2 thinking is desirable for more attentive and rational debate. However, system 2 thinking will only add value when negotiated knowledge is available and widely supported. Currently there is information available to support every possible viewpoint on GM crops, so even when members of the public activate their system 2 thinking and critically review all available sources, they may still adhere to their original (intuitive) viewpoint due to confirmation bias (Kahneman, 2012).

3.1.2 Multi-issue game

It is fair to say that the wicked problem of GM crops has not reached any consensus on European and population scale. This problem can be analyzed through the multi-issue game theory. The current state seems to be more single-sided and can be referred as the one-issue game: there is only one item on the agenda (de Bruijn & Heuvelhof, 2018). The multi-issue game helps solve complex decision making process by various means, one of them being an attractiveness for parties to participate. Some EU member states abstained from voting due

¹Conclusions drawn by Ichim (2020) are questionable, as for example a change in ranking does not necessarily represent a change in concern (p. 20).



to either risks to the national agri-food industry, no agreed national position or simply negative public opinion (Mampuy, 2021). Therefore the participation aspect of this decision making process is lacking. The politics of each country are different but it can be safely assumed that politicians are highly influenced by the opinion of the population. This opinion can be changed and participation improved by providing more relevant information through main media sources (Popp et al., 2018).

Another important trait of expanding the issue to a multi-issue game is that the parties have a clear perception of gain and benefits (de Bruijn & Heuvelhof, 2018). It seems that general consumers are lacking this understanding and rather are focused on the possible risks of mass adoption of GM food (Lucht, 2015). Again, studies show that exposure to proper and complete information can shift the public's opinion and at least improve their engagement in the discussion (Lucht, 2015). Some farmers have positive attitude towards the GM crops adoption due to the possible economical benefits. In some countries, the farmer's view collides with the consumer's view (Areal, Riesgo, & Rodriguez-Cerezo, 2011). This can create a deadlock as both parties can have high influence on the party that controls the regulations. According to the multi-issue game, losers of decisions made not in their favour can battle this through forming coalitions challenge the decisions (de Bruijn & Heuvelhof, 2018).



These coalitions can be formed based on the actors goals. A good example of such clustering is shown in a case of Hungary by (Popp et al., 2018). There the actors are framed in three cluster. An important take away from this analysis showed that the profit oriented and political actors are much closer related based on their goals than the actors that are against GM crops. Another observation was that the consumers and their welfare is left out from the three main clusters. These two factors can create further complications in solving the problem of the GM crops.

3.1.3 Open decision making

The decision making process on cultivation of GM crops in Europe has been troublesome for years now. The reason being that the member states are unable to reach to a conclusion either in favour of, or against, the market authorisation. Due to the political sensitivity of the topic, the European Commission has been hesitant to take an autonomous decision, even when the applications have passed the risk assessment (concluding that GM crops are safe for humans and environment). This has resulted in a deadlock where the member states on either side of the decision aren't getting their way (Mampuy, 2021).

As not all parties can win in this network, it makes the decision making for GM crops authorisation a win-lose game. In such a situation, a cut-and-dried decision would deprive the losing party of gaining any sort of profit and could try to adopt catch-as-catch-can behaviour, where every opportunity to overturn the decision or frustrate the implementation would be seized. Hence, we need an open-ended decision making to keep all parties (member states, EC, producers etc) interested even though the decision hasn't gone in their favour. In a network open-ended decision making, certain options are left open on purpose so every party believes in future opportunities. This has a positive connotation and promotes cooperative behaviour among the involved parties (de Bruijn & Heuvelhof, 2018).



The European Commission was concerned about the (mis-)use of the safety framework to object to licensing because of absence of any framework to express other national concerns related to non-safety issues of GMOs.² Hence, the new directive in 2015 was adopted which enabled the member states to restrict/prohibit the cultivation of GMO in their respective territories by taking into consideration the non safety concerns. The purpose of the Directive was to break the deadlock in decision making of GM crop authorisation in EU and provide autonomy to member states. This made the process more open-ended as it was always open to interpretation and provided member states with opportunities to prohibit GM crop cultivation. Even though a number of member states did use this Directive to opt-out from GM crops³ but the approach wasn't successful as it did not change the voting behaviour regarding the overall authorisation process in EU (Mampuy, 2021). It did lead to a lot of unanswered questions. It is still not known if the solution was a faulty one to the actual problem or a solution to the wrong problem? Or maybe both?






It portrayed the bounded rationality of decision-makers (Simon, 1991), which made the overall decisions impossible. The decision was maybe left partial/incomplete on purpose and open which leads up to possibilities for learning and make amendments to the Directive.

²Directive (EU) 2015/412 of the European Parliament and of the Council on 11-03-2015 amending Directive 2001/18/EC on the possibility for Member States to restrict or prohibit the cultivation of genetically modified organisms (GMOs) in their territory.



³European Commission 'Restrictions of geographical scope of GMO applications/authorisations: Member States demands and outcomes' <http://ec.europa.eu/food/plant/gmo/authorisation/cultivation/geographical_scope_en> Accessed 16 April 2018.

3.2 Framing strategies used by the actors


Language frames the way the world is perceived and actors in position  power use framing strategies to influence and shape our perspective (de Bruijn, 2019). In this section, we highlight the various framing strategies used by actors and shift in stance if any over the period analysed in this report. It is important to note how certain actors have pluralistic frames and certain frames are far from reality, yet they were used by actors  to influence various stakeholders. We will look at some of the important stakeholders here and framing strategies for remaining stakeholders can be found under [subsection A.2](#)

EU Member States: A majority of the EU Member states have framed the public health and environmental concerns of GMOs as the reasons behind pushing for a ban on the cultivation of GM crops. Post the 2015 directive, the Election Commission  was hopeful that giving the authority to member states to decide would result in support from more countries in favor of the technology, however, there has been no change in their frame and nineteen out of twenty-eight states banning cultivation of GM crops in their territory (Union, 2019).

European Commission, Court of Justice of the European Union, European Food Safety Authority: The European commission has had multiple shifts in frame through the timeline observed. They were left frustrated as the decision-making on the market authorisation of GM crops for cultivation in Europe was hampered by the Member State's inability to obtain a majority in favor of or against the market authorisation. This prompted the EC to shift their frame by giving Member states the autonomy to legally restrict cultivation of GMOs in a bid to remove the deadlock in decision making on EU market authorizations (Mampuy, 2021). The European Commission has worked in tandem with the Court of Justice of the European Union European Food Safety Authority to establish a standard and framework around the safety and legal processes inline with GMOs. They use the 3P framework with principles of transparency and inclusion translating in policy.

Farmers: The farmer represents a diverse and heterogeneous group - with a stark difference in knowledge and awareness  but GMOs often seen across this group. They frame their views from a personal perspective - with transparency , easy to understand rules, and prevention from exploitation a common theme in these stories.

Consumers: Consumers also consist of a rather diverse and heterogeneous group. They frame their viewpoint from a personal perspective but often lack awareness and hence their frame is influenced by the media. Multiple surveys have been conducted to understand consumer perception and a majority of them state consumers perceive more risks than benefits (Wunderlich & Gatto, 2015).

Producers: The producers claim they are framed as villains in the perception of the general audience as they are deemed to put their profitability over the health of the people and environment . With the safety clearance of GM crops by the EFSA, the producers shift their frame using the PAS framework with a narrative that they are providing a solution to world hunger and food scarcity.

4 Conclusion & Recommendations

In order to answer the research question "*What are the challenges that the European Union is facing on reaching a consensus regarding GM crops legislation between member states?*", a description is given of the timeline around the decision moment and relevant actors. The decision making process is analysed using various theories, which enabled us to identify the following challenges:

- There is insufficient inclusion and representation of the general public as stakeholder in the process-based decision making, which leads to resentment and protest towards the project-based communication.
- An overload of framed information is present that represents and validates various opinions on GM crops, enabling stakeholders with a confirmation bias to select information that matches their viewpoint.
- The general public lacks recognition on the benefits of participating in the multi-issue game, leading to little engagement or willingness to negotiate.
- Although open ended decision making was implemented by giving member states the autonomy to decide on their own, the decision making process was not improved as there were still many stalemates on a national level.

By reflecting on our findings it is noteworthy that the majority of decision making processes revolves around the general public. This may be because the largest issues lie there. However, it would be valuable to evaluate the European Union itself and her member states in more detail as well.

The following recommendations are made to improve the decision making process:

- Create negotiated knowledge to increase coherence and enable all actors to form unbiased opinions.
- Increase interest and influence of the general public through discussion platforms and referendums.
- Urge actors to form coalitions to increase engagement and power.
- European Union: make more (open-ended) decisions which can still be adjusted throughout the course of time, to keep the decision making process active and relevant.

We hope that implementing these recommendations will lead to an improved decision making process within the European Union on GM crops.

References



- Agarwal, A. V., & Singh, R. P. (2021). Assessment of the environmental and health impacts of genetically modified crops. *Policy Issues in Genetically Modified Crops*, 335-354. doi: 10.1016/B978-0-12-820780-2.00015-7
- Areal, F. J., Riesgo, L., & Rodriguez-Cerezo, E. (2011). Attitudes of european farmers towards gm crop adoption. *Plant Biotechnology Journal*, 9(9), 945-957. doi: 10.1111/j.1467-7652.2011.00651.x
- Blancke, S., et al. (2015). Fatal attraction: the intuitive appeal of gmo opposition. *Trends in Plant Science*, 20(7), 414-418. doi: 10.1016/j.tplants.2015.03.011
- Bonny, S. (2003). Why are most europeans opposed to gmos? factors explaining rejection in france and europe. *Electronic Journal of Biotechnology*, 6(1), 50-71. doi: 10.2225/vol6-issue1-fulltext-4
- Bryson, J. M. (2004). What to do when stakeholders matter. *Public Management Review*, 6(1), 21-53. Retrieved from <https://doi.org/10.1080/14719030410001675722> doi: 10.1080/14719030410001675722
- CBAN. (2019). *Environmental Impacts of GMOs*. Retrieved from <https://cban.ca/gmos/issues/environmental-impacts/>
- Commission, E. (2018). *Gmo legislation*. Retrieved from https://ec.europa.eu/food/plants/genetically-modified-organisms/gmo-legislation_en
- Commission, E. (2022). *European Green Capital*. Retrieved from <https://ec.europa.eu/environment/europeangreencapital/countriesruleoutgmos/>
- Cornish, L. (2018). *How do corporations perceive their role in the GMO debate?* Retrieved from <https://www.devex.com/news/how-do-corporations-perceive-their-role-in-the-gmo-debate-92507>
- de Bruijn, H. (2019). *The art of political framing*.
- de Bruijn, H., & Heuvelhof, E. T. (2018). *Management in networks*. Taylor & Francis Ltd. doi: 10.4324/9781315453019
- Deutsch, C., et al. (2018). Increase in crop losses to insect pests in a warming climate. *Science*, 361. doi: 10.1126/science.aat3466
- EFSA. (2018). *GMO*. Retrieved from <https://www.efsa.europa.eu/en/topics/topic/gmo>
- Ganev, D. (2019). *Gmos in the media: The genetics of a spicy debate*. Retrieved from <https://commetric.com/2019/06/21/gmos-in-the-media-the-genetics-of-a-spicy-debate/>
- Gilland, B. (2002). World population and food supply - can food production keep pace with population growth in the next half-century? *Food Policy*, 27, 47-63. doi: 10.1016/S0306-9192(02)00002-7
- Gould, F., et al. (2016). *Genetically engineered crops: Experiences and prospects*. doi: 10.17226/23395
- Greenpeace. (2021). *Danger ahead*. Retrieved from <https://www.greenpeace.org/static/planet4-eu-unit-stateless/2021/04/20210331-Greenpeace-gene-editing-position-paper-EN.pdf>
- Gregory D. Graff, G. H. c., & Zilberman, D. (2015). *Oxford handbook of food, politics, and society*. Oxford University Press.
- Halford, N. G. (2019). Legislation governing genetically modified and genome-edited crops in europe: the need for change. *Journal of the Science of Food and Agriculture*, 99, 8-12. doi: 10.1002/jsfa.9227
- Hielscher, S., et al. (2016). Rationalizing the gmo debate: The ordonomic approach to addressing agricultural myths. *International Journal of Environmental Research and Public Health*, 13(5). doi: 10.3390/ijerph13050476
- Holliman, R. (2002). *Media coverage of genetically modified organisms*.
- Ichim, M. C. (2020). The more favorable attitude of the citizens toward gmos supports a new regulatory framework in the european union. *GM Crops and Food*, 12(1), 18-24. doi: 10.1080/21645698.2020.1795525
- Jamil, K. (2018). *Biotechnology – A Solution to Hunger?* UN Chronicle. Retrieved from <https://www.un.org/en/chronicle/article/biotechnology-solution-hunger>
- Kahneman, D. (2012). *Thinking fast and slow*. Penguin Books Ltd.
- Kennedy, B., & Thigpen, C. L. (2020). *Many publics around world doubt safety of genetically modified foods*.
- Lucht, J. (2015). Public acceptance of plant biotechnology and gm crops. *Viruses*, 7(8), 4254-4281. doi: 10.3390/v7082819
- Ma, X., et al. (2018). Genome editing for global food security. *Trends in Biotechnology*, 36(2), 123-127. doi: 10.1016/j.tibtech.2017.08.004
- Mampuy, R. (2021). The deadlock in european decision-making on gmos as a wicked problem by design: A need for repoliticization. *Science, Technology, & Human Values*. Retrieved from <https://doi.org/10.1177/01622439221097206> doi: 10.1177/01622439221097206
- Nicolia, A. (2013). An overview of the last 10 years of genetically engineered crop safety research. *Critical Reviews in Biotechnology*, 34(1), 77-88. doi: 10.3109/07388551.2013.823595
- Paarlberg, R. (2014). A dubious success: The ngo campaign against gmos. *GM Crops & Food*, 5(3), 223-228. Retrieved from <https://doi.org/10.4161/21645698.2014.952204> doi: 10.4161/21645698.2014.952204

- Paarlberg, R. L. (2002). The real threat to gm crops in poor countries: consumer and policy resistance to gm foods in rich countries. *Food Policy*, 27, 247-250. doi: 10.1016/S0306-9192(02)00014-3
- Popp, J., et al. (2018). The gm-regulation game – the case of hungary. *International Food and Agribusiness Management Review*, 21(7), 945–968. doi: 10.22434/ifamr2017.0065
- Pusztai, A. (2010). Gm food safety: Scientific and institutional issues. *Science as Culture*, 11(1), 69-92. doi: 10.1080/09505430120115734
- Rittel, H. R., & Webber, M. M. (1973). Dilemmas in a general theory of planning. *Policy Sciences*, 4, 155-169. doi: 10.1007/BF01405730
- Rodriguez, A. V., et al. (2022). Myths and realities about genetically modified food: A risk-benefit analysis. *Applied Sciences*, 12. doi: 10.3390/app12062861
- Savary, S., et al. (2012). Crop losses due to diseases and their implications for global food production losses and food security. *Food Security*, 4, 519-537. doi: 10.1007/s12571-012-0200-5
- Simon, H. A. (1991). Bounded rationality and organizational learning. *Organization Science*, 2(1), 125–134. Retrieved 2022-05-30, from <http://www.jstor.org/stable/2634943>
- Stevens, B. M., Reppen, R., Linhart, M., Gibson, K., Parafiniuk, A., Roberts, A., ... Johnson, N. C. (2021, jul). Analysis of biased language in peer-reviewed scientific literature on genetically modified crops. *Environmental Research Letters*, 16(8), 084035. Retrieved from <https://doi.org/10.1088/1748-9326/ac1467> doi: 10.1088/1748-9326/ac1467
- Tagliabue, G. (2017). The eu legislation on “gm” between nonsense and protectionism: An ongoing schumpeterian chain of public choices. *GM Crops & Food*, 8(1), 57-73. Retrieved from <https://doi.org/10.1080/21645698.2016.1270488> doi: 10.1080/21645698.2016.1270488
- Ujj, O. (2016). *European and american views on genetically modified foods*. Retrieved 2022-05-29, from <https://www.thenewatlantis.com/publications/european-and-american-views-on-genetically-modified-foods>
- Union, E. (2018). *Commission directive (eu) 2018/350*. Retrieved from <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32018L0350>
- Union, E. (2019). *Several european countries move to rule out gm*. Retrieved from <https://ec.europa.eu/environment/europeangreencapital/countriesruleoutgm/>
- WorldPopulationReview. (2022). *Countries that ban gm 2022*. Retrieved 2022-05-29, from <https://worldpopulationreview.com/country-rankings/countries-that-ban-gm>
- Wozniak, E., et al. (2021). A shift towards biotechnology: Social opinion in the eu. *Trends in Biotechnology*, 39(3), 214-218. doi: 10.1016/j.tibtech.2020.08.001
- Wunderlich, S., & Gatto, K. A. (2015, 11). Consumer perception of genetically modified organisms and sources of information. *Advances in Nutrition*, 6(6), 842-851. Retrieved from <https://doi.org/10.3945/an.115.008870> doi: 10.3945/an.115.008870

A Appendix

A.1 Actor and Stakeholder Identification

Producers: Categorized as management representatives from the food, agriculture, pharmaceutical, and agro-chemical industry and organizations related to or with potential interest in biotechnology. The primary aim of these producers is to support farmers and help them improve their productivity and profitability, while also playing a pivotal role in food security (Cornish, 2018). They have come under increased scrutiny and are perceived to have been compromising public health issues to make greater profits.

Nongovernmental organizations: Organization leaders from not-for-profit organizations which are actively involved in the debate. They represent both sides, but the majority are against the implementation due to societal and environmental concerns. As these firms don't seek profit from their campaigns, they reap benefits of social trust from the wider audience and which helps them in their position as advocates of social justice (R. Paarlberg, 2014). Prominent organizations like Greenpeace International and Friends of the Earth International have been able to exert significant pressure on legislation and regulations banning the cultivation of GM crops.

EU Member States: Representatives of parliament of European Union countries in positions of power who represent the voice of their nation and have the ability to influence regulations and legislations on GM crops through a voting process. Before the new directive on GM crops came into effect in 2015, the member states were either in favor, against, or abstained from voting on the issue. They have come under increased scrutiny because of their double standards as they have been importing large quantities of GMO crops and food (primarily for feedstuff) yet are against the cultivation of GM crops in their countries. They find themselves in this precarious situation as they balance the trade off between 'protecting the interests of farmers, maintaining strong support from the public large corporations that are suspicious about the technology' and preventing their country from serious economic problems that may arise due to a decrease in quantity of imported GMO used for animal feed (Tagliabue, 2017).

European Commission: The European Commission is the executive of the European Union. It operates as a cabinet government, with 27 members of the Commission headed by a President. It includes an administrative body of about 32,000 European civil servants. The European Commission tries to find the right balance through regulations to keep both the proponents and opponents of this technology happy while keeping the best interests of the citizens as a major priority. They have installed a legal framework with the aim to protect human life, animal life, and the environment through strict safety and risk assessment of GM Crops which includes labeling, tracking, and transparency from start to end (Commission, 2018). In a bid to find a solution to the long-standing issue of the deadlock between the Member States, the European Commission pushed for a directive to decentralize the decision-making process and give member states the power to decide if they wanted to cultivate GM crops in their territory.

European Food Safety Authority: The EFSA is an agency that provides scientific guidance and advice to the European Commission and Member states on the safety of GMOs to safeguard customers from potential risks and dangers in the food chain. They play a pivotal role in evaluating and assessing the risks of GM crops by carrying out a series of assessments before approving it for the European market (EFSA, 2018).

Biotechnologists: Scientists who create and improve products and processes for agriculture, medicine, and conservation using biological organisms. They believe biotechnology offers a very promising alternative to synthetic foods and an improvement on conventional plant-breeding technologies which can be used to meet consumer demand for sustainable agriculture (Jamil, 2018). They have received backlash from activists and non-biotech companies who were motivated by political ideology and/or financial gain, with wealthy philanthropists, anonymous donors, and some elements of the organic food industry.

Ecologists Biologists: Scientists and Health professionals who aren't directly involved in RD for GM crops but are focused on the impact and consequences of this technology. Their major stand is for the environment, humans, and their safety which some of them believe is hindered by the extensive cultivation and consumption of GM crops.

Media: It provides facts to better inform the public about the issues that matter to them. It provides criticism and debate to test and examine the information from all points of view. Media plays a critical role in shaping the public's perspective on the subject. Biases may be involved in media reporting in order to manipulate the public in favor or against an agenda, such as GMOs (Stevens et al., 2021).

Legislators: Individuals who are members of the European Parliament and often elected by the people of the EU member states. They are responsible for writing/passing laws. They represent the viewpoint of their respective member state and are not always on the same page when finalizing a decision. There have been conflicting views on the GM crop cultivation issue and the GMO legislation has been a work in progress for a long time now ([Mampuy, 2021](#)).

Farmers: A farmer is a person engaged in agriculture, raising living organisms for food or raw materials. The term usually applies to people who do some combination of raising field crops, orchards, vineyards, poultry, or other livestock. Threatened by competition from lower-priced GM imports, some farmers have been against the import of GMO foods in member states ([Gregory D. Graff & Zilberman, 2015](#)).

Court of Justice of the European Union: Their primary role is to ensure EU legislation and regulation is interpreted and applied the same way in every EU country; ensuring countries and EU institutions abide by EU law, and settle legal disputes between national governments and EU institutions.

A.2 Framing Strategies used by other actors

Biotechnologists Biologists: With widespread applications of advancement in science seen across industries, the development and introduction of GMOs was the window of opportunity for biotechnologists to showcase their progress and get the spotlight. Throughout the timeline analyzed in this report, biotechnologists were confident that the technology would not have a negative effect on the well-being of humankind and instead could be seen as a solution for improvement in food production and supply. The EFSA and several other independent research organizations validating this claim post the 2015 directive were viewed as a positive sign for science and technology. Their frame of Problem - Analysis - Solution has remained the same.

Ecologists: Throughout the conversation on GMOs, ecologists have maintained a stance that despite the perceived benefits, the environmental harm caused due to contamination, increased pesticide use, and loss of biodiversity could not be neglected was against the principle of their profession ([CBAN, 2019](#)). While the European Union Environment Council supported the 2015 directive, using the 3P framing strategy(policy), they exerted pressure to strengthen the environmental risk assessment of GMOs, particularly concerning the assessment of long-term environmental effects passed in 2018 ([Union, 2018](#)).

Nongovernmental organizations: They have used the victim-villain-hero framework as they depict themselves as advocates for social justice with the goal of spreading awareness about the harmful effects of GMOs on human life and the environment ([Greenpeace, 2021](#)). They strongly believe GMO technology is not the solution and frame the producers of GMOs as villains with their only goal being to increase profitability and maintain a strong influence over the market. There has been no shift in their frame and post the 2015 directive on GMOs giving EU Member states the authority to vote in favor of GMOs in their country, the fact that nineteen out of 27 states voted against the cultivation in their home country has been well received by most of the organizations ([Union, 2019](#)). On the contrary, alliances of scientists and producers see them as a villain and believe most of the anti-GMO NGOs are being influenced by the rich and further increasing the gap between the rich and the poor - terming their success as a dubious scandal ([R. Paarlberg, 2014](#)).

Media: There are multiple frames that the media has portrayed and share a pluralistic perspective on the issue of GMOs. Their sole goal is to uncover facts and disseminate information on the latest developments on the topic. Considering the topic of GMOs is rather complex with the involvement of numerous actors, there has been a wide range of coverage which has included discussions of the relative benefits, challenges to implementation, and safety of GMOs from a range of actors ([Holliman, 2002](#)) While the media outlets position themselves as unbiased, it is a common theme to see them change their perspective and viewpoint multiple times based on key events and controversies that may arise. It doesn't take them long to point fingers and influence the perception of the public on key issues. While scientists see journalists as a key resource to share their scientific findings, numerous reports suggest traditional approaches in science communication have largely failed to shift public opinions toward more scientifically informed viewpoints ([Ganev, 2019](#)).

A.3 Work division

The work division can be viewed in the contribution table in [Figure 4](#) and the signatures of each group member [Figure 5](#).