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Unveiling the Impact: Mexico's Decree on Genetically Modified Corn and its Ramifications on Food Security

Lauren McShea
SIT Study Abroad

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Unveiling the Impact: Mexico's Decree on Genetically Modified Corn and its Ramifications on Food Security
Abstract:

This research delves into the repercussions of Mexico's presidential decree in late 2020, which imposed a ban on the human consumption of genetically modified (GM) corn by January 2024. In a trade dispute under the United States-Mexico-Canada Agreement (USMCA), the decree has sparked tensions between Mexico and the United States, particularly concerning the disruption of GM corn exports. Beyond trade dynamics, the study aims to address the broader impact on Mexico's food security landscape, exploring the intricate connections between the ban and various factors, including agricultural practices, economic implications, and shifts in the corn market dynamics. This research seeks to bridge the communication gap between policymakers and agricultural stakeholders in Mexico and the United States, focusing on the input of smaller producers in Oaxaca, Mexico. By addressing existing knowledge gaps, the research aims to provide a nuanced analysis of economic, agricultural, and cultural factors shaping the trajectory of food security in Mexico. The intention is to inform policymakers, agricultural stakeholders, and the broader community about the potential challenges and opportunities arising from Mexico's stance on GM corn and its implications for the nation's overall food security. The synthesis of findings suggests that the ban on genetically modified seeds has the potential to bolster food sovereignty in Mexico, safeguarding the food security of rural populations reliant on sustenance and traditional farming practices.
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I. Introduction
   a. Introduction

   Each year, on September 29\textsuperscript{th}, Mexico celebrates El Día Nacional del Maíz, a cultural, social, and economic commemoration of the utmost significance. On this day, Mexico pays homage to the intrinsic role of maize in its diet, traditions, and identity. Yet, this year on El Día de Maíz, a new reality unfolds: the looming ban on genetically modified (GM) corn, set to alter Mexican agriculture's landscape and test the fabric of the nation's cultural and nutritional heritage.

   The decree, aiming to halt human consumption of GM corn and eradicate the use of glyphosate—a herbicide integral to the cultivation of GM corn by January 2024—has not only sparked a trade dispute with the United States but has also thrust Mexico into the center of a global conversation about food safety, sovereignty, and the delicate balance between preserving tradition and embracing the future. My research seeks to unravel the intricate implications of Mexico's stance on GM corn, particularly with respect to the nation's food security. Beyond the trade intricacies, this decision delves into the heart of Mexican identity, questioning the essence and quality of a cultural and nutritional staple: maíz. As the United States and Mexico navigate trade disputes and the implications of the United States-Mexico-Canada Agreement (USMCA), the looming ban on GM corn for human consumption raises complex questions about food safety, security, and sovereignty.

   b. Situation - A Decree on Genetically Modified Corn

   In late 2020, Mexico released a presidential decree on genetically modified corn. The order intends to ban human consumption of GM corn in Mexico and cease using glyphosate, a herbicide commonly used in the United States to grow GM corn, by the end of January 2024.
The plan focuses on banning GM corn for dough and tortillas while allowing for a gradual transition for its use in animal feed and industrial purposes. Following this decree, the United States has initiated formal trade consultations with Mexico concerning the latter's proposed restrictions, which has developed into a trade dispute under the United States-Mexico-Canada Agreement (USMCA), which is a modern substitution for the North America Free Trade Agreement (NAFTA) (Garrison, 2023). The decree has become controversial, evidenced by mounting complaints from multinational corn seed corporations and the United States Department of Agriculture (USDA), citing a trade imbalance resulting from the halt of GM corn exports from the United States to Mexico.

However, beyond affecting the balance of imports and exports in North American trade, this decree takes a stance on the identity of a cultural and nutritional staple in Mexico: corn. By banning GM corn, the Mexican government signaled the importance of the essence and quality of the corn consumed in the nation. The decision brings complex questions to the table regarding the international approach to food safety and food sovereignty in light of binding trade policies—questions to be decided by March 2024 by a third-party panel.

c. Research Question and Investigation Objectives

This research investigates the potential impact of Mexico's decree on genetically modified (GM) corn on food security within the country. The central question guiding this study is: How will the regulatory measures taken by Mexico, set to ban GM corn imports for human consumption starting in 2024, influence the nation's food security? My investigation analyses the interplay between the ban and various factors affecting food security, including agricultural practices, economic implications, and potential shifts in the corn market dynamics. By delving into the multifaceted aspects of this decree, the research seeks to provide insights into the
broader implications for Mexico's food security landscape, contributing to a nuanced understanding of the consequences stemming from this policy decision.

d. Justification

This ban announced by Mexico has raised many flags, particularly by those invested in the US agricultural system, about the potential adverse effects of the GMO prohibition on both countries' economies, trade relations, and food security within Mexico. My research seeks to bridge the communication gap between policymakers and members of the agricultural systems of both countries to voice the input of smaller producers in Oaxaca, Mexico. This study is essential to fill existing knowledge gaps and provide a comprehensive analysis of the economic, agricultural, and cultural factors that may shape the trajectory of food security in Mexico. By unraveling the intricacies of this policy decision, the research aims to inform policymakers, agricultural stakeholders, and the broader community about the potential challenges and opportunities associated with Mexico's stance on GM corn and its implications for the nation's overall food security.

e. Key Terms and Definitions

Being that my investigation was carried out through a mix of Spanish and English, I have included several Spanish terms in my report, which I did not feel could be comprehensively captured through translation into English. Other words I have chosen to use interchangeably, such as 'maize,' 'maiz,' and 'corn'. Technically, maize refers to the crop being grown in the field. Maiz is the Spanish translation of this word. Corn typically refers to the harvested crop. Although this technical difference exists, I found that many of my sources, particularly my English sources, used the words interchangeably. In this report, I have used these terms interchangeably because I believe they hold their respective cultural significance. Furthermore, I
find that the mix of Spanish and English words gives a greater dimension to my discussion by recognizing the multicultural identity of many elements of the agricultural system.

f. Description of Format

This paper consists of a literature review and primary research through interviews. The report begins by laying out the historic landscape of food systems and the globalization of the agricultural system in the 20th century. Then, I will transition to reintroducing the ban on GMO corn and discuss some of the concerns and implications raised by the ban. From there, I will discuss food security, food security in Mexico, and the current sourcing of the Mexican food supply. Lastly, I incorporate research from interviews to synthesize my findings and conclude that the ban on genetically modified seeds will enhance food sovereignty in Mexico and protect the food security of rural populations that rely on sustenance farming and traditional farming practices.

II. Context

a. History of the Mexican Food System — 1910 Reforms

In understanding the significance of this decree on the Mexican food system, it is first crucial to understand the history and identity of the Mexican food system. This system reflects constant transformation shaped by several fundamental dramatic policy shifts. One such policy shift occurred during the Mexican Revolution in 1910 as a revolution sparked in response to historical injustices, harsh leadership, and the concentration of land ownership. The revolution led to a gradual but significant change in land distribution by breaking up large private landholdings known as haciendas. In place of haciendas, the government implemented a system of joint tenancy called ejidos, where ejido members collectively or individually worked lands but
could not be leased or sold. Through the redistribution of land and the consequent reimplementa-
tion of sustenance-based farming, these reforms enhanced food sovereignty among small farmers, who played a crucial role in national food production (Gálvez, 2018). Beyond the physical changes enacted through this legislation, the reforms also held symbolic significance by denying international and capitalist pressures to privatize land ownership and delocalize the agricultural system. However, this landscape of justice-focused reform evolved rapidly throughout the century as subsequent Presidents enacted policies that favored industrialization and globalization of the food system.

b. History of the Mexican Food System — Green Revolution and NAFTA

In the 20th century, the impact of the Green Revolution and the North American Free Trade Agreement (NAFTA) shifted the focus away from small farmers towards globalized, industrial agriculture. The Green Revolution began in the 1940s and gained momentum in the 1950s and 1960s. Through the introduction of high-yielding crop varieties, synthetic fertilizers, and pesticides, the Green Revolution aimed to address food security concerns, attract investment into the agricultural sector, and accommodate a growing urban population. In Mexico, this agricultural modernization was facilitated by governmental initiatives and collaboration with international organizations, such as the Rockefeller Foundation and the Ford Foundation (Mullaney, 2014). These initiatives led to a substantial increase in agricultural productivity, which contributed to the rise of large-scale agriculture in Mexico. However, it also raised environmental concerns due to the extensive use of chemical inputs and monoculture practices, sparking debates about the long-term sustainability of such intensive agricultural methods that caused future problems such as soil and nutrient depletion.
In 1992, in line with a trend of industrialization and neoliberalist policies, the North American Free Trade Agreement (NAFTA) came to the table as a landmark trade pact between the United States, Canada, and Mexico. NAFTA facilitated the removal of trade barriers, promoting increased economic integration and cross-border commerce. NAFTA brought about significant economic shifts, fostering expanded exports and foreign investment while contributing to structural changes in the economy. The agreement profoundly impacted income inequality, agricultural practices, and local industries, raising many critical perspectives on its influence on Mexico's economic landscape.

While NAFTA was presented as a method to create a fair and barrier-free global trade, it required smaller economies, including Mexico, to pay the price by relinquishing subsidies, protections, tariffs, and price supports. On the contrary, larger economies, including the United States, heavily subsidize their agricultural commodities and manipulate national and international markets. In these negotiations, Given the unequal rules on subsidies and protections, NAFTA allowed big corporations to exploit the food market and, in turn, cause unsubsidized Mexican corn producers to go out of business because they could not compete with the lower price of heavily subsidized US corn (Gálvez, 2018). Ultimately, NAFTA marked a mindset shift for Mexico, including an increased reliance on imported food, increased investment into the industrialization of the agricultural sector, and a decrease in food sovereignty, as evident through a growing distance between the population and their food sources. The surge in agricultural trade and foreign investment prompted shifts in production practices. This transition sets the stage for an examination of another critical aspect of Mexico's agricultural evolution — the contemplation and regulation of genetically modified seeds in response to the growing agricultural trend and international pressures.
c. A Reintroduction to the GMO Debate

In recent years, agricultural innovation has brought a new topic into the hotspot: GMOs. GMOs result from a process in which the genetic material from one organism is inserted into another organism to impart specific and desirable traits to the recipient crop, such as resistance to pests or herbicides (Hernandez-Lopez, 2020). GMOs were created to mitigate the negative consequences of implementing large-scale farming practices and the industrialization of the agricultural system. By genetically modifying seeds to have certain traits, such as resistance to herbicides, farmers can spray entire fields of crops with herbicides that intend to kill weeds without the threat that the sprayed herbicides will affect the growth or abundance of the desired plant.

While many agricultural specialists in the US hail the creation of GMOs, their use in other parts of the world remains controversial. In Mexico, GMO criticisms fit primarily into three distinct frames: health and safety outcomes, questions of legal property, and impact on biodiversity. In order to understand the full effect that the introduction of GM seeds would have on Mexico, it is crucial to evaluate the subject through these three lenses.

One public criticism of GMO corn, mainly stemming from critics of the industrialized agriculture system, is that GMO corn threatens Mexico's vast seed biodiversity. This threat is primarily demonstrated through the ease with which their genetic material can spread. Maize is an open-air pollinating crop, meaning its pollen can travel unintentionally for up to one or two miles through uncontrollable factors such as wind and insects. Due to the ease with which the pollen can spread, the risk of unintended DNA mixing with nearby GMO corn is substantial. To date, evidence of genetic material from GMO corn has already been found in seeds in Oaxaca, sparking controversy over how the material was introduced and how easily that material spread
This widespread cross-pollination poses a significant threat to seed diversity across Mexico as traditional landrace corn varieties become increasingly vulnerable to contamination by genetically modified traits.

The second category of criticisms of GMOs surrounds the ownership of GMO technology. Companies that develop genetically modified corn varieties assert their right to protect their investment in research and development through intellectual property (IP) rights. However, this approach can stifle competition and limit farmers' choices since patented seeds often come with restrictions on seed saving and replanting, a traditional practice for many farmers in Mexico. Additionally, concerns have been raised about the potential for unintentional crossbreeding with non-GMO crops, leading to legal liability for farmers whose crops may inadvertently contain patented genetic material. Furthermore, IP technology is owned by a highly concentrated collection of corporations known for shaping national regulations in their favor and pursuing aggressive litigation against farmers and sustainability advocates (Hernandez-Lopez, 2020). In navigating the complex landscape of GMO technology, addressing intellectual property rights is critical to construct a comprehensive vision of GMO technology's impact on farmers' autonomy, protection, and security in their land practices and food production.

Lastly, and perhaps the most legally significant, the third category of criticisms pertains to the safety of GMO consumption. While the US Food and Drug Administration (FDA) holds the position that GMOs currently on the market are safe to eat and that they are substantially equivalent to traditional plants, contrasting studies presented by biotechnology experts and public agencies from Mexico and the European Union have raised concerns that GMOs and glyphosate, a herbicide commonly used on GM seeds, may lead to an increased risk of lymphoma (Hernandez-Lopez, 2020). The US, backed by farm lobby groups and the biotech
industry, object to Mexico's proposed ban on the assertion that Mexico's health concerns lack a scientific basis. Traditionally, governments, exercising their sovereign authority, are tasked with developing and implementing their own GMO policies. However, due to the international nature of the food market, these disagreeing findings held by the US and Mexico have sparked broader philosophical questions about food safety and national sovereignty in the developing trade dispute.

The ongoing disagreement between the US and Mexico on the safety of GMOs, encapsulated within the broader trade dispute, underscores the complex interplay of scientific, economic, and regulatory factors shaping the GMO landscape. As Mexico grapples with concerns over seed biodiversity, health implications, and intellectual property rights, it becomes increasingly evident that the resolution of these contentious issues will significantly influence the trajectory of the proposed GMO ban and, consequently, its impact on food security in the region. The intricacies of this debate highlight the need for a comprehensive assessment to understand how the GMO ban may resonate across multiple dimensions and ultimately shape the food security landscape in Mexico.

III. Food Security

a. Definitions

As the discourse surrounding Mexico's proposed GMO ban intensifies, arguments surrounding the theme of food security arise from both countries. Yet, as I considered my primary question: how a prohibition on GM seeds in Mexico might affect food security, I first needed to take a step to evaluate what 'food security' means and what food security means for Mexico.
The term 'food security' was derived through a series of international food summits in the late 20th century. According to the commonly cited Food and Agricultural Organization (FAO) definition, food security encompasses the availability, access, utilization, and stability of access to sufficient, safe, and nutritious food for all individuals within a given population. The World Food Summit of 1996 defined it as "When all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life." These definitions highlight the multifaceted nature of food security, recognizing the importance of not only food quantity but also quality, accessibility, and the resilience of food systems. However, these definitions, highly influenced by the Western perspectives embodied by the FAO and UN institutions, bear layers of subjectivity.

Simultaneously to the defining of the term food security at the World Food Summit, the Vía Campesina, an international coalition of peasants, landless people, indigenous communities, and rural workers, introduced the concept of food sovereignty as the inherent right of each nation to maintain and develop its own capacity to produce basic foods while respecting cultural and productive diversity (Lemos Figueroa, Baca del Moral, & Cuevas Reyes, 2018). This concept emphasizes local control over food systems, empowering communities to shape their agricultural practices in line with their traditions and preferences. It extends beyond mere access to food, highlighting the importance of communities determining the methods and types of food production that best suit their needs.

Ultimately, to navigate the complexity and subjectivity of terms like food security and food sovereignty, my research aims to enrich understanding by exploring perspectives and conceptualizations among local farmers.
With this in mind, my focus now shifts to a critical examination of key statistical aspects. The upcoming sections will delve into 1) examining statistics about food security in Mexico, 2) scrutinizing statistics about food sourcing within the country, and 3) analyzing statistics about corn imports, a central component in the context of the GMO ban and its potential ramifications on food security in Mexico. These analytical insights are crucial for a comprehensive understanding of the relationship between the GMO ban, food security, and the broader agricultural landscape in Mexico.

b. Food Security in Mexico

The intricacies of food security in Mexico come sharply into focus through statistical revelations. According to the FAO, the three-year average between 2020 and 2022 of the number of people with moderate to serious food insecurity in Mexico was 35 million (FAOSTAT). This alarming number constitutes about 27% of the national population and is concentrated in higher percentages among rural areas than urban ones (FAOSTAT). As per data published in 2015 from the Consejo Nacional de Evaluación de la Política de Desarrollo Social (CONEVAL), the following observations are outlined: 1) the period spanning 1994 to 1996 witnessed the most substantial surge in national food poverty, surging from 21.2% to 37.4%. This increase occurred at the same time as a 6.6% decline in GDP and a 4.8% upswing in global food prices. 2) In 2006, a historic low of recorded food poverty was documented, plummeting to 13.8% nationwide. This period was marked by consistent GDP growth in the preceding five years, and although food prices had begun rising, their rate of ascent did not match the acceleration of GDP. 3) Between 2006 and 2008, there was a 4.6% increase in national food poverty, aligning with a 3.7% contraction in GDP during the same period and a substantial 58.7% surge in international food prices. 4) From 2008 onward, food poverty across the nation has exhibited an upward trajectory,
accompanied by a sustained elevation in global food prices (CONEVAL, 2015; Lemos Figueroa, Baca del Moral, & Cuevas Reyes, 2018). These numbers demonstrate the general trend that food insecurity rises in Mexico as international food prices rise, especially in cases where the rates of increase in Mexican GDP and rate of increase in international food prices differ. If this trend were to continue, it would imply that if the GM ban caused international food prices to rise, then the food insecurity rate in Mexico would also increase.

c. Sourcing of the Mexican Food Supply

Although in 2020 NAFTA was renewed under the name USMCA with little significant change to agricultural trade policy, recent Mexican government efforts have aimed to reverse the increasing dependence on international food sources, with programs providing technical and financial support to small farmers (Ibarrola-Rivas et al., 2023). While these measures signify a step towards national food sovereignty and rural poverty alleviation, the effectiveness of these initiatives remains debatable. Furthermore, despite neoliberal policies that favored big corporations, small farmers remained significant in Mexico's food supply. As of 2021, the Mexican government estimates that 40% of the country's food comes from farms smaller than 5 hectares (Gobierno de México, 2021). However, after a more specific review, researchers at the Universidad Veracruzana have concluded that:

The main staple food crops for Mexican diets (white maize and beans) are mainly produced by large-scale farms. In contrast, the agricultural products that small farms most produce are "commercial" or "cash crops": coffee and cocoa, sugar cane, followed by animal products, fruits, animal feed, and white maize, with only 16% of white maize being produced by small-scale farms. (Ibarrola-Rivas et al., 2023, p.12)
Small farms' emphasis on commercial crops and the lesser contribution to staple food production underscores the transformative impact of factors like NAFTA and subsequent policies, shaping a food system where the sources and types of agricultural outputs have undergone significant change because of market forces. However, recent efforts highlight a shift towards supporting small farmers and enhancing food sovereignty.

Navigating the intricacies of Mexico's food supply, our exploration must consider both sourcing dynamics and the breakdown of crucial imports, particularly emphasizing the central role of maize, which plays a pivotal role in the country's dietary consumption, constituting 32% of the energetic content in the rural basic basket and 16% in the urban sector (CONEVAL, 2015). My subsequent exploration delves into an analysis of corn imports into Mexico.

d. Breakdown of Corn Imports into Mexico

In Mexico, maize is central to the country's dietary consumption. Its cultivation spans 47% of the agricultural surface and contributes 36% of the total agricultural production value (SIACON 2012). White maize is traditionally served and is a staple for human consumption, most notably in tortillas. Yellow maize is typically utilized for animal feed and a diverse range of industrial applications, resulting in various uses: dextrose for snacks and beverages, ethanol for industrial uses, and high-fructose syrup as a sugar substitute.

The Service of Agrifood and Fishing Information reports that in 2013, the white maize supply was 23.9 million tons, with 81% originating from national production. The allocation of white maize use estimates that 49.5% is for human consumption, and 50.5% is used for industrial purposes, including auto-consumption, surplus accumulation, and livestock feed. In contrast, yellow maize, totaling 11.7 million tons, relies heavily on imports (60%), with only 18% of the supply coming from national production. This yellow maize is primarily allocated to livestock...
use (54.5%), the starch industry (19.9%), surplus (19.4%), and a small portion for human consumption, auto-consumption, and waste (6.2%). Hence, Mexico produces enough white and yellow varieties of maize for human consumption; however, the country relies on maize imports to fulfill industrial purposes. However, despite this self-reliance, it is necessary to consider the interconnectedness of the Mexican economy. Food security extends beyond the ability to produce sufficient food for the population. The accessibility of food is a crucial component as well. The potential price rise for all maize importations would affect the broader Mexican economy by affecting large industries such as the auto or livestock industries. This impact on the overall Mexican economy is crucial when considering the historical congruities between growth in GDP and food security levels.

IV. Existing Research on the Effects of a GMO Ban

a. An Introduction to Literature Review

In the exploration of the intricate interplay between food security and GMOs in Mexico, a critical examination of various perspectives becomes imperative. Because GMOs are a relatively new topic, and Mexico's prohibition of GMO imports is even newer, at this point, there is very little existing research surrounding the impact of the ban on food security or Mexico in general. Nonetheless, this section embarks on a review and analysis of three sources, each offering unique insights on the topic through respective economic, legal, and cultural lenses.

b. Review of World Perspectives Inc. Report

"The Economic Impacts of a Mexican Ban on GM Corn Imports" provides a comprehensive analysis of the repercussions of Mexico's move to prohibit GM corn imports. Their estimates project a net negative economic impact, primarily affecting Mexican consumers.
Over the next decade, they expect Mexico to incur an additional cost of $5.6 billion, encompassing expenses related to securing non-GM corn, segregation of corn and intellectual property costs from the U.S. grain industry, and genetic testing. This financial burden, resulting from the ban, will likely translate into a 30% increase in tortilla prices in the first year and a staggering 42% increase in the second year. The rise in tortilla prices is modeled as a net reduction in household income, potentially leading to a decline in employment by 108,000 jobs, a decrease in total labor income by $972 million, and a contraction of $3.4 billion in GDP over the course of a decade. Additionally, the livestock feeding sector in Mexico is expected to face rising corn costs and lower availability of co-products, likely diminishing the efficiency of livestock operations, potentially leading to a decline in Mexico's meat and animal product output and increased reliance on imports.

However, apprehensions concern the report's precision and underlying bias, given its commissioning by CropLife, a biotech trade association. Furthermore, there is a critical omission of a nuanced distinction between white and yellow corn. This lack of distinction brings questions of reliability to many of the report's predictions, especially the estimation of the rise of price for tortillas price, which, as noted earlier, are traditionally only made from white corn. Moreover, the report's assumption that all Mexican corn imports will be non-GM is incorrect, dismissing the nuanced variations the prohibition allows for, including the continuation of importations for corn with industrial applications. These identified limitations question the report's reliability in accurately predicting the multifaceted impact on both economies and food security. Nonetheless, to date, this report provides one of the most thorough and analytical presentations of the impact of the GM ban in Mexico.

c. Review of The Monsanto Appeal
In consideration of existing literature on the intersection between legality, GMOs, and food security, Susan Burns demonstrates a second point of view in her presentation of a compelling case regarding the cultivation of GMO maize in Mexico. The discussion revolves around a critical legal case that unfolded in the Mexican Supreme Court of Justice of the Nation (SCJN), as outlined in Burns' publication in *The Year of Review: Mexico for 2017* by the American Bar Association. The case centers on an appeal by the agricultural giant Monsanto, challenging a ban on the commercial planting of GMO maize. The ban, implemented in 2013, raised concerns about environmental damage and unproven benefits of GMO maize.

Burns contends that the court's decision not only preserves Mexico's status as the center of origin for maize but crucially maintains food security, particularly for indigenous and peasant farmers. The argument against GMO maize cultivation centers on fears of genetic contamination, potentially forcing local farmers to buy patented seeds at controlled prices, affecting their ability to sustain traditional agricultural practices, and jeopardizing food security. The discussion also raises concerns about environmental impacts, health issues, and uncertainties regarding the nutritional value of food produced from GMO seeds, adding layers to the argument against widespread cultivation in Mexico.

Unlike the previously presented WPI report, this review does not provide specific estimates or predictions. Due to this fact, it is harder to make specific critiques of the argument. Furthermore, the argument presented by Burns largely aligns with that of my previous research review, with concerns about the legal liabilities, environmental impact, and health issues of GM seeds. This perspective holds local farmers and their ability to maintain sovereignty over their seeds as a central component of maintaining food security, presenting an interesting perspective that differs from that of the perspective of the WPI report.
d. Review of "Geopolitical Maize"

Lastly, in my third selected source for review, "Geopolitical Maize: Peasant Seeds, Everyday Practices, and Food Security in Mexico," author Emma Gaalaas Mullaney uses feminist perspectives from geopolitics and political ecology to explore the geopolitical implications of small-scale maize production in, emphasizing how the state's attempts to reshape agricultural systems align with nationalist and capitalist priorities.

Mullaney challenges the prevailing development narrative that links increased food crop production with addressing hunger, drawing on geographer David Nally's insights. The text argues that agricultural restructuring through industrialization, often touted as a solution to poverty and hunger, serves to increase resource inequality and food insecurity in the modern world (Mullaney, 2014; Nally, 2011). This perspective challenges the simplistic notion that technological interventions, such as hybrid maize varieties, alleviate inequalities and enhance food security. Importantly, the text emphasizes the detachment of the discourse around transgenic maize from the daily realities of local maize cultivators. While international debates primarily focus on the risks of transgenic maize and its implications for food sovereignty, the concerns and experiences of farmers in this region are inadequately represented. Mullaney's work invites a more nuanced understanding of the challenges faced by local communities in the context of global agricultural debates.

As with the previously presented report, this research does not present statistics or estimates. As presented in the text, the smaller scope of research, which is conducted through a small number of ethnographic studies, provides the research with both depth of study and limitations to the broader applications of the research. Nonetheless, the text provided unique
commentary on the distance between the political discourse surrounding GMOs and the farmers who are in the field.

V. Primary Research and Interviews

a. Methodology

While my primary question of investigation seemed, at first, to be merely metric-based, I went ahead and chose to collect qualitative research through a synthesis of literature review with a few in-depth interviews. Qualitative interviews provided me an opportunity to learn more about the side of food security that is not solely metric-based – elements of impact that could not be anticipated through economic models, researchers, or policymakers who are backed by the financial interests of industry lobbyists. In my interviews, I chose to talk to corn producers, experts who could speak about the crop beyond terms of yields, prices, and number-centric data. The participants I have chosen are all smallholder farmers in the state of Oaxaca, meaning they are small-scale farmers and pastoralists who maintain less than ten hectares of land (FAO, 2013). This choice is based on my own residence being in Oaxaca, a portion of the country where most farmers are smallholder farmers and where food security is cited to be at one of the highest levels in Mexico (Díaz-Carreño, Sánchez-León, & Díaz-Bustamente, 2016).

I have synthesized this data with metrics and quantifiable data I found through a literature review to come to my own findings through analysis of a combined data set. I focused my literature review on questions that came to me through my interview research process, in addition to research that asked similar or complementary questions about food security or the use of GMOs as my stated question of investigation. In this process of literature review, I found that quantitative datasets omit factors of food security I came to find very important in my interviews,
such as the hidden cost certain growing techniques take on the land, accessibility of the food supply, or the cost of the risk of lawsuits that the introduction of GM seeds has for small farmers.

It is the intent of learning and recognizing factors that cannot be conveyed through metrics that I chose to use interviews to conduct my research. However, my interview-based research has its limitations as well. Through these interviews, I was able to glean in-depth perspectives from a very limited number of viewpoints. I cannot stretch this data to represent the corn producers around the entire country, nor can I stretch this data to all smallholder corn producers in the state of Oaxaca. Instead, the data represents the opinions of a few experts. These opinions can be synthesized with other research to draw greater findings and to prompt further research.

b. Assistance and Acknowledgements

As stated above, a primary method through which I carried out my investigation was through interviews of smallholder farmers in Oaxaca, Mexico. I was able to orchestrate these interviews through the help and connections of my academic advisor, Omar Núñez, who helped me talk through my research ideas and ultimately connected me with my participants. Furthermore, I was able to carry out my interviews with the help of my academic coordinator, Paola Cruz, who helped facilitate the interviews and provided transportation for me to visit my interview participants in their communities in the Sierra Norte and the Mixteca of Oaxaca. Lastly, I could not have carried out my interviews without the help of my classmate Kevin Garcia-Galindo, who conducted one of my interviews for me in Sierra Norte, which I was not able to attend because I got dengue fever. Kevin carried out my interview for me with a written contextual explanation and a collection of interview questions I gave to him. Kevin then passed the interview recording to me, which I used for my analysis and conclusions. Lastly, my investigation would not have
been possible without the preparation and support of my professors, Jorge Valtierra, Jessica, Florence Weinberg, and Nancy García García. Ultimately, these contributions and support played a crucial role in the successful execution of my investigative work.

c. Positionality

In acknowledging the inherent influence of my own identity and positionality on the research process, it is crucial to recognize the multifaceted impact on the framing of my research question, methodological approach, and selection of interview questions. As a white US citizen studying math and economics and American culture studies whose sustenance for the vast duration of my life has been almost entirely sustained from grocery stores and the industrialized food system of the United, my background undoubtedly shaped the formulation of my research question, focusing on issues related to GMOs, trade, and food security. As I conducted my research, I became increasingly aware of just how much my Western education and conceptualization of terms such as food security were rooted in United States economic and political terminology.

Furthermore, being that I have never been food insecure myself serves as a bias that has influenced the way that I perceive, conceptualize, and try to quantify food security. This bias also prompted a methodological approach that prioritized interviewing advocates rather than people who identify as food insecure themselves, a decision rooted in ethical considerations and a concern for topic sensitivity.

Lastly, it is critical to recognize the limitations of my Spanish language proficiency and my lack of presence for two of my conducted interviews. My interviews were conducted in Spanish, the language my participants and I shared. However, my ability to speak fluidly in Spanish is limited, which undoubtedly affected the quality of the interviews and my ability to comprehend
the responses of my participants. This comprehension limitation is especially relevant considering one of my interviews was conducted by a classmate, the recordings of which were then passed to me for my analysis. Although I was very lucky that I was still able to complete these interviews, my absence must be acknowledged in recognition that my findings rely heavily on this collaboration and are based on recordings of the actual interviews.

d. Broader Limitations and Challenges

Expanding beyond individual and participant-specific limitations, my research confronts broader challenges inherent in the available data sources and the scope of the study. My reliance, and the reliance of scholars within my literature review, on federally produced data or corporation-produced research introduces inherent inaccuracies driven by the difficulties in gathering data for a nationally scaled population and for rural populations. Additionally, in my literature review, I found that the data referenced often came from datasets collected several years ago. In my research, I made an effort not to use or reference data sets that are more than ten years old. Nonetheless, given the rapidly changing nature of the food system and food security, my research must be contextualized with regard to the age of some of the datasets referenced, which may affect their reliability. To mitigate this challenge, I have tried to minimize my reliance on such datasets in the formulation of my conclusions, acknowledging the potential distortions or inaccuracies in the data.

VI. Findings

a. Mixteca Interview

As a part of my research, I had the opportunity to go to the Mixteca, a beautiful region with mountainous terrain that lies northwest of the city of Oaxaca. I went with my classmates
and professors to visit Eleazar's home, where, upon arriving, we enjoyed a homemade breakfast of memelitas and had the opportunity to try using a tortilla press to shape and then cook tortillas from the dough. After enjoying this breakfast, my classmates, professors, and I joined Eleazar to go to el campo (the field), where we walked around looking at different plants and seeds. Afterward, I had the opportunity to interview Eleazar about the local food system and the use of GM seeds.

In the community Eleazar lives in, there is no big market. Most families grow their own food, and what trade does happen takes place outside of a formal market. I learned that it has been a hard year for water, in line with a trend of decreasing yearly rainfall. This lack of water has negatively affected the yield. Although there has not been much evolution in agricultural practices in the past couple of generations, intentional efforts have been made through the Centro de Desarrollo Integral Campesino de la Mixteca (CEDICAM), which is an organization led by campesinos (small farmers and caretakers of the land), that supports several communities in Mixteca through the promotion of traditional agricultural techniques and ecological restoration. The range of techniques CEDICAM uses includes crop rotation, the use of granaries to store grains, and the use of some fertilizers.

When I asked Eleazar about the use of GM seeds, he was clear that he had no intentions to start using them himself. GM seeds need different conditions; they need different amounts of fertilizers and different amounts of rain. The seeds Eleazar currently has are dependable; he knows that they will produce, albeit production varies with rainfall. But GM seeds are riskier, and he does not know if they will be able to produce with the local soil and rainfall conditions. Furthermore, GM corn tastes different; it is dry and tastes superficial. His animals can taste the difference of GM corn, and they will not eat it. Besides, GM companies have many regulations
But beyond his own decision not to use GM corn, Eleazar recognizes that it is still a risk. If his neighbors start using GM seeds, it can easily cross-contaminate his corn through the wind and affect future generations of the plant.

Lastly, when I asked Eleazar if sustenance agriculture could be scaled to feed larger cities, such as the nearby Oaxaca City, he replied no. Yet he does believe that sustenance agriculture in communities can support communities and create food security within them, yet he could not imagine the notion of feeding a bigger city through smaller campesino agricultural production.

Overall, I was very fortunate to have the opportunity to interview Eleazar and learn his thoughtful insights while walking through el campo and the maiz plants themselves. As I reflected on my interview, I began to wonder if I had asked the right questions. This interview was early on in my investigation process, and I had not quite narrowed in on my focus yet. However, when I tried to parse through what I learned in my interview, I found that my conceptualization of food security was largely quantity-based. I was thinking of a calculation in terms of yields, caloric output, and necessity. But when I talked to Eleazar, he spoke of dependability, adaptability, and taste. He did not talk about maximizing yields or productivity. He did mention changing his production system, planting seeds that require less water, such as dragon fruit, and creating rainfall retention systems out in the field. However, he did not use words such as 'maximizing,' 'productivity,' or 'efficiency,' all of which have been drilled into the foundation of my own conceptualization of production-based activities through my extensive Western schooling and background studying economics.
Instead, Eleazar spoke with confidence in his seeds. He did not seem to be expecting any sort of yield or output from them. His approach seemed more in line with what seemed to me to be maintenance-focused. His concerns were about protecting his seeds from the possible cross-contamination of a neighbor using GMO seeds, protecting his independence against the major corporations and their IP rights, and the lawsuits that follow those rights.

b. Sierra Norte Interview

My next was with Jldefonso Sosa Pérez, a campesino living in the Sierra Norte of Oaxaca. The interview began with a question regarding what the concept of food security, or la seguridad alimentaria, means to Sosa Pérez. He told me that 'food security' is not a phrase he generally uses. He associates that phrase with the government, which often uses that phrase to talk about food that they do not care about the quality of. At La Unión de Organizaciones de la Sierra Juárez Oaxaca (UNOSJO), they prefer talking in terms of la soberanía alimentaria de la via campesino, food sovereignty of the campesino way. Food sovereignty, as he describes it, is more focused on the production and consumption of local foods that have a cultural belonging. This way of thinking focuses more on the consumption of whole foods and dishes rather than the consumption of junk foods, which has grown increasingly common among younger generations. It also emphasizes the use of simple, agroecological production methods, with the intention that those methods give back to the land rather than just taking.

Sosa Pérez believes that GM seeds do not support sovereignty in food production. They are not localized to the land where they are cultivated. Because they are not localized, they would take the place of native seeds that have cultural significance, and they would pose risks of lawsuits initiated by big companies. These changes, including possible lawsuits and the loss of native seeds, would come inevitably with the start of the use of GM seeds. It is with the intention
of protecting against those unwanted impacts that UNOSJO advocates against the use of GM seeds to protect la soberanía alimentaria de la via campesino.

This interview, once again, surprised me. While I was aware of the differences between food security and food sovereignty, I was surprised by the lack of attention to production amounts and yields that I often consider when I think about food security. Sosa Pérez, similarly to Eleazar, certainly saw GM seeds as a threat to personal sovereignty and the identity of the food he produces.

Ultimately, what I learned from this interview is that for a sustenance farmer such as Sosa Pérez, GM seeds are a threat to production because they are not conditioned for the local soil and because they come with many shoestrings attached to big corporations. In terms of food security, they pose a risk through lowering yields, reducing dependency, depleting the land, and increasing dependence on other companies.

Furthermore, even more so than a threat to food security, GM seeds are a threat to food sovereignty because they are unwanted, and they come with inevitable impacts such as cross-contamination. For Sosa Pérez, food sovereignty and the ability to grow and eat culturally belonging foods is more important than food security, a term he associates with political intentions.

c. Analysis

In my interviews, I found a consistent theme highlighting the profound impact of GM seeds on local food production and sovereignty. Both farmers express a strong preference for traditional seeds, emphasizing their dependability, taste, and cultural significance. The introduction of GM seeds was viewed as a threat to the essence of sustenance farming, as these seeds lack the qualities that make local produce integral to the community.
In contemplating the introduction of GM seeds, the interviews shed light on the broader consequences for agricultural systems. The inevitability of cross-contamination and the regulatory complexities associated with GM seeds pose tangible risks to local farming practices. The potential shift towards GM seeds threatens the well-established systems that sustenance farmers rely on, jeopardizing both food sovereignty and, consequently, food security. This intertwining of food security and food sovereignty underscores their inseparability, challenging conventional definitions and emphasizing the intricate connections between the two concepts.

Moreover, the interviews reveal that the concepts of food security and food sovereignty are often manipulated for various purposes, including political agendas. The specific scope of my own research about localized sustenance-based food systems reflects a need for more comprehensive research to fully grasp the implications of a GM seed ban for the broader population. Future studies should delve into how the GM ban might influence food prices in stores and how it might affect a greater, more representative collection of food pathways in Mexico.

d. Conclusions

On the matter of increased self-sufficiency in the Mexican food system, I believe that by prohibiting GM seeds and promoting reliance on national producers for corn, the ban lays the groundwork for enhanced food security in Mexico and protects the food sovereignty of local producers and campesinos. This viewpoint is grounded in the observation that Mexico's historical food security challenges have, in part, been exacerbated by dependence on international markets and fluctuating global prices. By prioritizing domestic production and reducing reliance on imported GM seeds, the nation is moving towards a more self-reliant food system, potentially fostering long-term stability and resilience in the face of external
uncertainties. However, ongoing monitoring and research will be crucial to assess the real implications and outcomes of this policy shift on the ground.
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