Agroterrorism: Assessing the Growing Threat to Global Food Security and Economic Stability

ABSTRACT

Agroterrorism, the deliberate introduction of harmful agents into agriculture to cause disease and economic damage, poses a growing threat to global food security and economic stability. Motivated by deep-seated conflicts and often perpetrated by both state and non-state actors, agroterrorism targets livestock, crops and water supplies, aiming to destabilize economies and social systems. Historical incidents, such as the mercury contamination of Jaffa oranges and cyanide-tainted grapes, underscore its severe impact. Recent concerns, intensified by advancements in biotechnology and increasing global trade, highlight the vulnerability of agriculture to such attacks. The potential economic damage from a single agroterrorism incident could reach billions of dollars, exacerbating food shortages and undermining public trust. Effective prevention and preparedness require multi-sectoral cooperation involving law enforcement, agricultural and scientific communities. Strategies include enhancing detection methods, developing biosecurity measures and improving international trade regulations. The World Organization for Animal Health (WOAH) and related organizations advocate for a comprehensive approach to bolster global resilience against agro-crime and agro-terrorism, emphasizing the need for robust preparedness and inter-agency collaboration to mitigate this evolving threat.

Keywords: {Agroterrorism, Food Security, Biosecurity, Plant Pathogens, Economic Impact, Multi-Sectoral Cooperation and Global Trade Regulations.

1. INTRODUCTION

"Agroterrorism refers to the intentional release of harmful or pathogenic agents into livestock, crops, or water supplies to cause disease, death, economic damage, and social disruption" (Gill, 2015; Green *et al*., 2017). Such acts often arise from deep-seated social, political, economic, or religious conflicts (Alekseeva *et al*., 2017) and are of concern to both state and non-state actors (Jaspal & Khan, 2017). The introduction of bacterial, viral, fungal, or toxic agents into plants at any stage of the agricultural process can severely impact a nation's crucial economical infrastructure resource. The threat of agroterrorism is growing, given its potential to disrupt agricultural development, which constitutes about one-third of global GDP (World Bank, 2018). Historical incidents highlight the severity of this threat: In the 1970s,Israeli citrus exports dropped by 40% due to mercury contamination of Jaffa oranges and in 1989, Chile experienced a $200 million trade loss from cyanide-tainted grapes (Alekseeva *et al*., 2017). Projections suggest that a single agroterror attack on livestock could result in $10-30 billion in economic damage (Alekseeva *et al*., 2017).

Agro-crime encompasses a range of illegal activities affecting agriculture and food systems, including:

- **Falsification of products**: Misrepresentation or adulteration of agricultural goods.
- **Non-compliance with disease control measures**: Ignoring or violating protocols designed to control animal and plant diseases.
- **Animal cruelty and abuse**: Mistreatment of animals within agricultural settings.

- **Food fraud**: The deliberate misrepresentation of food products.
- **Smuggling of animals and animal products**: Illegal transport of animals and their products across borders.
- **Exploitation of wildlife**: Illegal capture and use of wildlife for profit.
- **Theft**: Stealing agricultural goods or equipment.
- **Deliberate release of biological agents**: Intentional introduction of harmful pathogens to cause disease or death.

The Growing Threat of Agroterrorism

Following the September 11 attacks and the anthrax scare of late 2001, there has been increased concern about non-state reasons such as terrorist groups like using unconventional methods to cause harm. These groups have become a significant concern in international security, particularly with advancements in biotechnology. While much attention has been given to the direct threat of bioterrorism to human health, there is less focus on the potential risks to agriculture. Agricultural production is highly vulnerable to bioterrorism because many nations rely on crops for both economic stability and food supply. Despite various scenarios outlining the potential impacts of a biological attack on crops, the risk to agriculture has often been underestimated. To address this, it is crucial to raise awareness about agroterrorism-biological attacks targeting crops and to develop effective prevention strategies. This involves understanding the indirect threats posed by these attacks and implementing measures to protect crops from plant pathogens. The aim of this review is to highlight the risks associated with agroterrorism, which may not be as well-known, and to propose preventive actions that can be taken by farmers, agricultural companies and scientists to safeguard crops from targeted biological attacks. The variety of potential agroterrorism threats complicates food defense efforts. Pathogens that can be used in attacks include bacteria, viruses, fungi, protozoa, insects, or non-native plant species (Green *et al*., 2017). Naturally, plant pathogens and pests already cause global yield losses of 20-40% (Das *et al*., 2019); thus, intentional infections could have catastrophic consequences. In addition to causing plant, animal or human mortality, agroterrorism can aim to destabilize social systems, create economic crises, and erode public confidence in government (Olson, 2012). While traditional bioterrorism has focused on human health through toxins and bacterial pathogens such as *Clostridium botulinum*, *Escherichia coli*, and *Salmonella enterica* in the food chain (Olson, 2012). This type of bioterrorism can affect not only domestic farming operations but also imported food products that may be contaminated with pathogens or pests before reaching a port of entry (Gill, 2015).

Threat Assessment

“The threat level of agroterrorism is closely tied to the goals of active terrorist organizations on the international stage. Groups aiming to destabilize nations for political or religious reasons might consider agroterrorism as a strategy, necessitating vigilant monitoring by scientific, agricultural and intelligence communities” [30]. Historically, agroterrorism has received less attention compared to more immediate threats like suicide bombings and mass shootings, which have long been favored by terrorist groups due to their direct impact on civilian safety. However, Gill (2015) emphasizes that the use of bioterror agents should not be underestimated. Biological agents, being naturally occurring or easily cultured with minimal microbiological expertise, are less detectable by conventional technologies compared to explosives. Moreover, their minimal infective doses and the potential for a delayed onset of symptoms allow terrorists to evade detection and responsibility (Gill, 2015; Alekseeva *et al*., 2017). Zamir (2016) highlights that phytosanitary inspections often rely on visual evaluations, which can be inadequate for detecting fungi producing spores that do not immediately cause visible symptoms. Additionally, pathogens that hitchhike on plants may find suitable environments in new locations, potentially affecting plants in unexpected ways.

With the rise in international trade of seeds and plants, these concerns are increasingly relevant.

The simplicity and cost-effectiveness of agroterrorism make it a dangerous threat, as it can cause significant harm with relatively low technical demands. In the late 1980s, concerns arose about Iraq's potential to use biological agents to destroy Iranian crops, including research into *Tilletiacaries*, *T. tritici*, and aflatoxin-producing strains of *Aspergillus* (Suffert*et al*., 2009). Groups such as al-Qaeda and the Taliban have also considered agroterrorism, including the weaponization of wheat rust, as a method to impact the U.S. economy (Suffert*et al*., 2009; Gill, 2015).

Agroterrorism can be employed alone or in conjunction with other forms of attacks, such as cyberterrorism or smaller bombings (Olson, 2012). The Federation of American Scientists (2011) identifies various risk factors for agroterrorism, including geographical concentration, insecure storage, reduced isolation, dependence on artificial pest control and lack of genetic diversity in crops. Historically, limited transportation and technical expertise restricted the threat of agroterrorism. However, the increasing accessibility of scientific knowledge and techniques has elevated its potential (Alekseeva *et al*., 2017). The emergence of genetically modified crops, for which vaccines or treatments might not yet exist, could serve as a force multiplier for terrorists. Adequately funded and knowledgeable terrorists could engineer resistant strains of plant pathogens or enhance their virulence, posing significant challenges for detection and response (Zamir, 2016). The majority of risk assessments focus on known threats, leaving novel and potentially more damaging pathogens underrepresented in global security strategies (Zamir, 2016).

Survey of Plant Pathogens

Among the plant pathogens of greatest concern for agroterrorism are several fungal diseases, including wheat smut, rice blast, brown stripe mildew (affecting corn), and Karnal bunt (affecting wheat). Fungal spores, which are naturally dispersed through the air, pose a significant threat because they can incubate for extended periods without detection by on-ground workers (FAS, 2011). Bioaerosols such as rust spores can travel vast distances, potentially moving kilometers into the atmosphere and across continents, with wind and rain enhancing their spread (Kim *et al*., 2019). This natural dispersal capability makes fungal pathogens a historically effective tool for biological warfare. For example, during the Iran-Iraq War in the 1980s, Saddam Hussein used canisters to release wheat smut spores over Iranian fields (FAS, 2011).

In addition to direct plant damage, fungal toxins that contaminate crops can have severe implications for public health. Aflatoxins, produced by fungi such as *Aspergillus flavus* and *Aspergillus parasiticus*, are particularly concerning due to their carcinogenic properties and their ability to bind with DNA and proteins, leading to long-term health risks (Anderson, 2012). This makes aflatoxins a potent bioweapon that could cause widespread public panic due to their chronic health effects.

Plant virology also plays a critical role in the study of agroterrorism. Plant virus infectious clones are particularly dangerous due to their natural pathogenicity and the potential impact of genetic modifications (Brewer *et al*., 2018).

Bacterial plant pathogens such as *Ralstoniasolanacearum*, *Agrobacterium tumefaciens*, *Xanthomonasoryzae*pv. *oryzae* and *Xylella fastidiosa* are also significant threats to staple crops. When evaluating these biological agents, it is essential to consider factors such as virulence, incubation period, available treatments and pathogen resistance.

The Risk Evaluation Scheme (RES) developed by Suffert*et al*. (2009) identifies thirty-five fungal, nine bacterial and six viral agents as potential candidates for agroterrorism. The scheme highlights that thirty-two of these agents could cause direct damage to staple food crops, forest trees, industrial and market crops, and orchards.

Impacts and Challenges

Agro-crime and agro-terrorism pose severe risks to public health, economic stability, and food security. For instance, deliberate outbreaks of animal diseases can have cascading effects:

Economic and Social Impact by Agroterrorism

Understanding the potential economic and social impacts of an agroterrorism attack is crucial for developing effective preparedness strategies. Historically, plant diseases have caused significant ecological and social harm, including high mortality rates and population displacement (Velasquez *et al*., 2018). A prominent example is the Irish potato famine of the 1840s, driven by the pathogen *Phytophthorainfestans*. This disaster led to over a million deaths from starvation and disease due to the collapse of Ireland's primary food source (DoChara, 2008). Given that one in six jobs in the United States is tied to agriculture (Olson, 2012), an agroterror attack would not only impact those directly involved in farming but would also have cascading effects throughout the economy, depending on the pathogen involved.

Recent concerns have expanded beyond traditional extremist groups like al-Qaeda to include economic opportunists, domestic terrorists (such as lone actors and disgruntled employees), and militant animal rights groups (Gill, 2015). The Federal Bureau of Investigation (FBI) highlights the potential economic and social repercussions of an agroterrorism attack on the U.S., including direct losses from containment measures like stop-movement orders (SMOs), indirect costs such as compensation for destroyed commodities and broader economic impacts from trade embargoes. Additionally, such attacks could undermine public trust in government, create social panic, and pose national and global health risks (Olson, 2012).

The Korean beef riots of summer 2008 illustrate how even minor food issues can lead to substantial economic and social upheaval. Demonstrations against U.S. beef imports mobilized thousands of people and contributed to the downfall of South Korea's newly elected administration (Green *et al*., 2017). In urban areas, where supermarkets typically stock only a week's worth of food, a disruption in the food supply could lead to severe panic and rioting (Olson, 2012). The potential for extensive, long-term damage from a major agroterror attack is significant, with effects potentially lasting longer than those from more conventional tactics like suicide bombings. Therefore, agricultural losses are viewed as a critical threat to global food security, given their lasting impact on food production and supply (Velasquez *et al*., 2018). Unlike a biological toxin or chemical contaminant that can be quickly isolated and removed, plant infections can affect crop growth and harvesting, posing a persistent risk to food security.

Public health risks: Potential for zoonotic diseases, which can spread from animals to humans, such as avian flu, COVID-19, and Ebola (WOAH, 2020).

Organized crime groups can exploit animal disease outbreaks similarly to how they leveraged the COVID-19 pandemic by trading in fraudulent medical products. Such exploitation can exacerbate the spread of diseases and complicate response efforts (Green *et al*., 2021).

Prevention and Preparedness Measures

Olson (2012) emphasizes "the critical role of law enforcement in countering agroterrorism, noting that early warning signs, such as the theft of vaccines, medicines, and agricultural equipment, could indicate a potential attack. Effective threat mitigation requires collaboration not only among law enforcement and intelligence agencies but also with the agricultural and

scientific communities". "This cooperation should involve timely incident reporting by farm workers, first responders, and professionals such as veterinarians, phytologists, police officers, extension agents, and local planners" (Green *et al*., 2017).

"In the United States, pre-emptive legislation relies heavily on the cooperation of multiple agencies, including the Department of Health, the Department of Agriculture (USDA), the Federal Bureau of Investigation (FBI), and the Department of Health and Human Services" (Hunter, 2015). A significant challenge faced by agencies like the Food and Drug Administration (FDA) is shifting from a focus on food safety-preventing contamination-to food defense, which involves proactive measures to protect food and animal feed ingredients from deliberate attacks (Gill, 2015). Differentiating between accidental and intentional attacks is crucial and scenario-based training exercises have proven effective in streamlining responses. These exercises help coordinate efforts between the USDA, which handles containment and restoration and law enforcement, which focuses on investigation and evidence collection. Classical epidemiological methods and forensic science are vital in providing evidence for legal violations (Suffert*et al*., 2009). Research facilities, which could be potential targets, also face security challenges due to conflicts between research freedom and national security concerns (Suffert*et al*., 2009). To address these challenges, recommendations include employing molecular detection strategies for early identification of plant pathogens and establishing nationwide diagnostic networks (Suffert*et al*., 2009).

The United Kingdom's strategy of diversifying international trade links to alternative food sources is another counter-agroterrorism measure, aimed at mitigating food shortages during crises (Green *et al*., 2017). "While this approach can be valuable for developing nations, it may not be sufficient for major food producers like the United States. Efforts to achieve crop biosecurity have involved quarantine and phytosanitary regulations by organizations such as the International Plant Protection Convention (IPPC), which works to prevent the introduction of exotic plant pests" (Suffert*et al*., 2009). "Establishing biosecurity checkpoints to counter illegal plant product transportation is also critical" (Jaspal and Khan, 2017).

"In October 2019, the U.S. House of Representatives introduced the Protecting America's Food and Agriculture Act to enhance national food supply protection. The act underscores the need for adequate resources at borders to inspect incoming food and agricultural goods and proposes increasing Customs and Border Protection (CBP) Agriculture Specialists and support staff. Additionally, preventative measures such as Norway's Stella Polaris exercise, which involves local, regional, and national units in a multi-day training event, highlight the importance of crisis communication, including media management" (Wahl *et al*., 2015). The exercise demonstrated that personnel often felt unprepared for media-related aspects of emergency response. Research indicates that a lack of public awareness, especially within academia, remains a significant barrier to effective food defense. Jaspal and Khan (2017) suggest enhancing plant biosecurity education within life science curricula to address this gap.

The Importance of Multi-Sectoral Preparedness

The international community faces a significant threat due to insufficient awareness and gaps in strategies to prevent and address agro-crime and agro-terrorism. This lack of preparedness poses serious risks to animal and human health and safety (WOAH, 2021). The World Organisation for Animal Health (WOAH), formerly known as the Office International des Epizooties (OIE), advocates for the integration of preparedness for these threats into existing animal health emergency management plans. They emphasize the need for raising awareness among stakeholders and improving readiness (WOAH, 2021).

Investing in multi-sectoral preparedness can be more cost-effective than dealing with the socio-economic, health, and political repercussions of agro-crime and agro-terrorism. Since

many pathogens considered for use in bioterrorism are of animal origin or zoonotic (transmissible between animals and humans), the animal health and security sectors play a crucial role in mitigating these threats. Effective collaboration between Veterinary Services and Law Enforcement agencies is essential for planning, preparing, and responding to animal disease outbreaks on national, regional, and international levels (FAO, 2018).

To enhance preparedness and response capabilities it is critical to implement best practices and foster improved cooperation between sectors. This includes conducting joint threat assessments, developing comprehensive contingency plans and establishing multi-sectoral surveillance systems (FAO, 2018). By strengthening these areas, the potential impact of agro-terrorism and related threats can be significantly reduced, ensuring a more robust defense against deliberate biological attacks.

WOAH-FAO-INTERPOL Joint Initiative: Strengthening Global Security

"In a strategic collaboration, the World Organization for Animal Health (WOAH), the Food and Agriculture Organization of the United Nations (FAO) and the International Criminal Police Organization (INTERPOL) have launched a global project titled Building Resilience Against Agro-Crime and Agro-Terrorism. This initiative, which began in October 2018 with backing from the Weapons Threat Reduction Programme of Global Affairs Canada under the Global Partnership against the Spread of Weapons and Materials of Mass Destruction, aims to enhance global resilience to animal health emergencies driven by agro-crime and agro-terrorism" (WOAH, 2018). "The project seeks to foster improved collaboration and mutual understanding between the animal health and security sectors through a dynamic, interdisciplinary approach. It involves assessing the current global emergency management landscape for agro-crime and agro-terrorism, and developing capacity-building strategies based on these findings" (FAO, 2019). "To highlight the importance of multi-sectoral cooperation, a significant international simulation exercise will be conducted by the end of 2022. This exercise will recreate an agro-terrorism scenario, requiring coordinated responses from Law Enforcement and Veterinary Services. The project will culminate in a Global Conference on Emergency Management, showcasing the outcomes to a broad audience" (INTERPOL, 2022)."Recognizing animal health and welfare as a shared responsibility, the initiative aims to empower the global community to adopt an all-hazards approach to animal health emergencies, including those posed by agro-crime and agro-terrorism. The project also seeks to elevate the role of Veterinary Services in high-level forums and cross-government frameworks, and to build a stronger international emergency management network capable of responding to diverse emergencies" (WOAH, 2018). "The Building Resilience Against Agro-Crime and Agro-Terrorism project operates in conjunction with WOAH's sustainable laboratories initiative, which supports improvements in biosafety and biosecurity in laboratory settings" (FAO, 2019).

Agro-terrorism is a subset of agro-crime, involving deliberate attacks against crops and livestock to disrupt economies and food supplies, with the intent to coerce or intimidate (WOAH, 2019).

Motivational Aspects of Agro-Terrorism

Although agro-terrorism may not always align with high-profile terrorist tactics, its potential for economic disruption and psychological impact makes it a viable threat. With the relative ease of executing biological attacks and the low cost compared to other forms of terrorism, agro-terrorism presents a significant risk that requires ongoing vigilance and preparedness (Chalk, 2004).

4. CONCLUSION

Agroterrorism represents a significant and evolving threat to global food security and economic stability. Its potential to cause widespread damage to agriculture, disrupt economies and undermine public trust underscores the need for comprehensive preventive measures. Historical examples and recent concerns highlight the severe impacts that deliberate agricultural attacks can have, from economic losses to public health risks. Effective countermeasures require robust multi-sectoral cooperation among law enforcement, agricultural experts, and international organizations. Enhanced detection methods, biosecurity measures, and global trade regulations are crucial to mitigating the threat. The World Organization for Animal Health (WOAH), FAO and INTERPOL's joint initiatives exemplify the collaborative effort needed to build resilience against agro-crime and agro-terrorism. By investing in preparedness and fostering international cooperation, the global community can better safeguard against this insidious threat and protect essential agricultural resources from deliberate harm.

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DEFINITIONS, ACRONYMS, ABBREVIATIONS

Here is the Definitions section. This is an optional section.

Term: Definition for the term