Project Proposal (Draft for GEF-9 Funding)

Title: Biosafety and Sustainability in Agricultural Systems: Monitoring of Transgenic Events and Pesticide Compounds in Maize Crops in Mexico.

Lead Institution:

National Laboratory for Agri-food Biosafety (LNC-BIOSAA)

Universidad Michoacana de San Nicolás de Hidalgo (UMSNH)

In coordination with SECIHTI and Executive Secretary of CIBIOGEM

Project Duration:

2026–2030

Estimated Budget:

USD 7–10 million (Preliminary estimate for national-scale implementation)

Geographic Scope:

National (with regional implementation sites in central, southern, and northern Mexico)

Introduction

Maize is the most important crop for Mexico in economic, cultural, and nutritional terms, occupying the largest cultivated area in the country (Ibarrola-Rivas et al. 2020). However, large-scale production has favored the emergence and prevalence of phytopathogens (insects, nematodes, bacteria, fungi, and viruses) that impact crop yield and health. Diagnosing some diseases based on visual observation can be challenging due to the similarity of symptoms, mixed infections, absence of vectors, or because the pathogen may be in a latent phase where the infection is not yet visible. Moreover, even when biochemical tests are used, there remains a risk of misdiagnosis, as many of these tests have low

sensitivity (Kumar et al., 2023). These factors can delay the timely design and implementation of phytosanitary management strategies.

The introduction of genetically modified (GM) maize into Mexico has commercial, agricultural, and biosafety implications, closely linked to the use of glyphosate, a herbicide classified as highly hazardous. The harmful effects of herbicides on human health and the environment are well-documented. Each year, ten million tons of maize are produced by industrialized agricultural systems, predominantly in northern Mexico, while another ten million tons are produced on smallholder farms. Approximately 17 million tons are imported, mainly from the United States, where a large proportion of the maize is genetically modified.

The use of molecular techniques such as PCR (Polymerase Chain Reaction) and its variants enables the accurate identification of phytopathogens by detecting nucleic acids (DNA and RNA). One of the main advantages of this tool is its ability to detect the causal agent in asymptomatic plant tissues and vectors (mainly insects) present in or around crop fields (Aslam et al. 2017; Kumar et al. 2013). However, technical laboratory work and research are required to standardize PCR protocols, taking into account several variables such as the type of tissue used for DNA extraction, the desired specificity level, and the number of samples.

Therefore, the proposal put forth by Laboratorio Nacional de Bioseguridad Agroalimentaria (LN-BIOSAA) is to develop molecular diagnostic methodologies for established or emerging diseases in maize crops using real-time PCR, to contribute to more effective phytosanitary surveillance and rapid management response to epidemic outbreaks, particularly in areas with high agricultural activity and rich native maize diversity. Furthermore, the diagnostic capabilities resulting from this proposal are expected to be transferable and applicable at the national level, enhancing phytosanitary monitoring systems and strengthening food security in Mexico.

Given the agroecological, socioeconomic, cultural, and public health significance, as well as the importance of agri-food heritage and biosafety policy in Mexico, monitoring for transgenes is essential. At LNC-BIOSAA, regional and national protocols will be implemented for the detection of transgenic sequences and herbicide residues in maize and food products, as well as for mitigating risks associated with genetically modified organisms (GMOs), to ensure food quality and safety.

Justification:

Mexico is the center of origin and diversification for maize and several other essential crops. Peasant and smallholder farming systems continue to maintain and evolve native maize varieties, playing a vital role in global agrobiodiversity conservation. However, the country

faces significant risks from the introduction and presence of GMOs, particularly GM maize, as well as the widespread use of hazardous herbicides such as glyphosate. In December 2023, the Universidad Michoacana de San Nicolás de Hidalgo was awarded recognition under the CONAHCYT National Laboratories initiative for a project focused on the sustainable monitoring of transgenes and pesticides in food systems. This project is now implemented through the National Laboratory for Agri-food Biosafety (LNC-BIOSAA), a key institution working under the Mexican biosafety framework and aligned with the Presidential Decree banning GM maize and glyphosate. Based on a thorough review of GEF's priority thematic areas, we propose a project for the GEF9 initiative, whose actions are strategically aligned with international frameworks**,** including the Kunming-Montreal Global Biodiversity Framework**,** the objectives of the Convention on Biological Diversity (CBD), and the Cartagena Protocol on Biosafety.

The project focuses on three key thematic areas: biodiversity conservation, chemical and waste management, and food security. The primary objectives involve developing strategies for detecting and identifying transgenic maize varieties through regional and national real-time analysis and monitoring, as well as rapid diagnosis of pesticides such as glyphosate in human consumption products, with a focus on sustainable and safe solutions for the national agri-food system. Additionally, to establish and implement a rapid and timely monitoring system for both established and emerging phytopathogens that threaten the sustainable cultivation of native and hybrid maize in Mexico. The aim is to contribute to the establishment of more effective phytosanitary surveillance and a rapid management response to epidemic outbreaks, particularly in areas with high agricultural activity and a rich diversity of native maize varieties. These actions will contribute to the development of sustainable and safe solutions for Mexico's agri-food system, with a particular focus on benefiting vulnerable populations, conserving agrobiodiversity, and enhancing the resilience of agroecosystems.

In addition, the diagnostic capacities derived from this proposal are expected to be transferable and applicable at the national level, improving phytosanitary monitoring systems and strengthening Mexico's food security. The project also aims to enhance national capacities in biosafety, food quality, and biodiversity conservation through the design and implementation of science-based, sustainable monitoring systems. This initiative will promote a culture of sustainability by facilitating the transfer and appropriation of knowledge derived from research findings. This project will be directed toward Indigenous Peoples, smallholder and large-scale producers, and the academic community, empowering stakeholders to shift from traditional intensive agricultural practices to environmentally responsible approaches.

In this context, we have identified national funding needs aligned with these priorities, which are detailed in the accompanying GEF-9 planned project proposals submission. Given the country's agroecological, cultural, and biosecurity importance, this project addresses urgent national needs and contributes to the implementation of the Kunming-Montreal Global Biodiversity Framework (GBF), particularly Goals A, B, and D, as well as Targets 4, 7, 17, and 18. In this context, we identify the following as key needs and priority challenges for capacity-building in the implementation of the Capacity-Building Action Plan: 1) The risk assessment of living modified organisms (LMOs) in the Mexican context, considering both environmental and socio-cultural aspects. 2) The risk management and analysis of LMOs, including long-term monitoring, contingency planning, and decision-making processes based on scientific, ethical, and precautionary principles. These priorities are aligned with target 17 of the Kunming-Montreal Global Biodiversity Framework, and National Targets 17.1 and 17.2, which emphasize the importance of biosafety, including the traceability and monitoring of LMO, as essential elements for safeguarding biodiversity and ensuring responsible biotechnology use. 3) Monitoring of established and emerging phytopathogens that threaten agriculture.

These priorities align with Target 4 by strengthening early detection and response mechanisms for potentially invasive or high-impact plant pathogens, thereby reducing the risk of their establishment and spread in agroecosystems.

Based on a thorough review and in line with Objective A8 of the Capacity-Building Action Plan, which calls for the creation and strengthening of LMO identification networks, the following priorities have been identified:

1. Financial support to strengthen infrastructure in national laboratories with the capacity to detect, identify, and quantify LMO.
2. Subsequent financial assistance to achieve accreditation and certification of these laboratories, ensuring they meet technical and quality standards for molecular analysis related to LMO monitoring.

The project will advance cutting-edge research to enable both controlled *in vitro* and *in situ* testing for the detection and validation of genetically modified organisms (GMOs) and pesticide residues, particularly glyphosate, in corn and its derivatives. It will also innovate in the development of low-cost, non-invasive, real-time diagnostics for glyphosate detection. Surveillance efforts will focus on differentiating transgenic sequences and herbicide residues in corn and processed food products, laying the groundwork for the development of regional protocols to assess potential transgene contamination across the

production chain. In parallel, the project will implement innovative computing and digital tools to generate a georeferenced inventory of glyphosate usage per production unit, creating the first decision-support prototype for use by public institutions, researchers, and organic producers.

A comprehensive spectral and biochemical reference library of data will be established to facilitate the identification of transgenic content in corn throughout Mexico. In addition, the project can promote sustainable production schemes using native and non-transgenic hybrid seeds, empowering local producers and communities through traditional knowledge and agroecological technology alternatives that help revitalize rural regions. This monitoring and diagnostic framework will be particularly relevant in Health and Environmental Emergency Regions (RESAs), where it will support early detection and response to contamination. The proposed actions will contribute to preventive and control strategies aimed at reducing food contamination and environmental degradation. The development of new bioformulations will help optimize agricultural production costs for the benefit of farmers and small-scale producers. The project aligns with the PRONACES agenda, reinforcing food sovereignty and public health, and fostering collaborations that address the climate crisis in Mexico. A key focus will be the transfer of knowledge and technology to rural communities, Indigenous peoples, and smallholder farmers, through training programs that promote sustainable agricultural practices. Technical guidance and capacity-building will also be provided to peasant cooperatives, producer groups, and local organizations, including those participating in programs such as Sembrando Vida (Sowing Life), to strengthen agroecological initiatives across targeted regions of the country. The project will help train a new generation of researchers with a humanistic and interdisciplinary perspective, equipped to address environmental health challenges, mitigate socio-environmental risks, and contribute to the protection of ecosystems, food systems, and public health. Talent development will emphasize a cross-cutting approach centered on biosecurity, food sovereignty, and technology transfer. In support of technological and intellectual sovereignty, the project will foster the generation, ownership, and dissemination of scientific knowledge, as well as the development of innovative technologies that benefit all economic, social, and environmental sectors. These technologies will contribute to Mexico's economic, democratic, and ecological advancement, while enabling local producers to obtain fairer compensation for their raw materials and transition toward agrochemical-free agroeconomic models.

Ultimately, the project will yield robust, science-based evidence to inform strategic decision-making at the municipal, state, and federal levels, with far-reaching implications for biodiversity conservation, human health, food security, environmental justice, and equity.

General Objective:

Develop standardized, transdisciplinary strategies for the rapid diagnosis of hazardous pesticides, such as glyphosate, in food products, as well as the detection and identification of genetically modified maize varieties through real-time analysis and monitoring at both regional and national levels. These actions will contribute to the development of sustainable and safe solutions for Mexico's agri-food system, with a particular focus on benefiting vulnerable populations. The project also aims to strengthen national capacities in biosafety, food quality, and biodiversity conservation through the design and implementation of science-based, sustainable monitoring systems. In addition, the initiative will promote a culture of sustainability by facilitating the transfer and appropriation of knowledge derived from research findings. This will be directed toward Indigenous Peoples, smallholder and large-scale producers, and the academic community, empowering stakeholders to shift from traditional intensive agricultural practices to environmentally responsible approaches.

Develop and standardize methodologies based on molecular techniques to strengthen the rapid and timely monitoring of established and emerging phytopathogens that threaten the agriculture of native and hybrid maize in Mexico.

Particular Objectives:

1. To implement and validate national and regional protocols for detecting transgenic sequences and glyphosate residues in maize and processed food products.
2. To contribute to the risk mitigation of GMOs through biosurveillance, early warning systems, and regulatory capacity-building.
3. To generate real-time biodiversity monitoring data to support policy decisions and inform the public, ensuring transparency and traceability in food production systems.
4. To foster inter-institutional and community-based capacity building for biosafety governance and agroecological transition.
5. To prioritize the main maize phytopathogens in Mexico based on their agricultural relevance.
6. To design DNA extraction protocols for the selected phytopathogens from plant tissue or vector samples.
7. To standardize the parameters of conventional PCR and qPCR for the detection of specific phytopathogens.
8. To develop a technical manual with optimized protocols and recommendations for their implementation in phytosanitary laboratories.
9. To validate and certify the standardized protocols with safety authorities.

Alignment with the Kunming-Montreal GBF:

This project contributes to:

Goal A: Reducing threats to biodiversity, especially from pollution and invasive species.

Goal B: Ensuring sustainable use of biodiversity for food systems.

Goal D: Enhancing capacity-building and access to knowledge and technologies.

Target 7: Reducing pollution risks from pesticides and harmful chemicals.

Target 17: Strengthening biosafety frameworks.

Target 18: Fostering access to biotechnology and innovation for biodiversity-friendly agriculture.

Expected Outcomes:

- A national system for detecting transgenes and pesticides is operational across key agricultural regions.
- A toolkit of validated, eco-friendly nanoagroinputs available for pilot use.
- Open-access biosafety and biodiversity data for use in national policy and public awareness.
- Improved institutional coordination in biosafety and biodiversity monitoring at national and subnational levels.
- Enhanced capacity in laboratories, research centers, and local communities to implement biosafety protocols and practices.

Sustainability and Impact:

The project is designed to deliver long-term, sustainable solutions to strengthen biosafety, food quality, and biodiversity conservation in Mexico. By establishing standardized, science-based monitoring systems, it will ensure the early detection and control of genetically modified organisms (GMOs) and hazardous pesticide residues, particularly glyphosate, across the national agri-food chain.

The initiative will develop and validate low-cost, non-invasive technologies for real-time diagnostics, enabling both regional and national actors to respond proactively to environmental and public health risks. The creation of a spectral and biochemical reference

library for identifying transgenic sequences in maize, along with a georeferenced inventory of glyphosate use per production unit, will serve as essential tools for evidence-based decision-making by local governments, national authorities, research institutions, and producer networks.

These efforts will directly contribute to the implementation of agroecological alternatives, particularly in Health and Environmental Emergency Regions (RESAs), where environmental degradation and contamination disproportionately affect vulnerable populations. By supporting transitions away from intensive agrochemical-dependent agriculture, the project will help promote more resilient and regenerative agricultural practices rooted in traditional knowledge, territorial identity, and climate adaptation.

Notably, the project includes a strong component of capacity-building and knowledge transfer, targeting Indigenous Peoples, smallholder and large-scale farmers, local cooperatives, and youth researchers. Through training programs, participatory research, and applied fieldwork, it will foster a culture of sustainability and innovation that transcends academic circles and empowers rural communities.

In alignment with national strategies such as PRONACES and programs like Sembrando Vida, this project will support the co-construction of territorial solutions for food security, environmental health, and rural development. The approach also contributes to Mexico's international commitments under the Kunming-Montreal Global Biodiversity Framework, particularly in meeting goals related to biosafety (Target 17), pollution reduction (Target 7), traditional knowledge (Target 20), and resource mobilization (Target 19).

Lastly, the project fosters technological and intellectual sovereignty by promoting the generation, ownership, and application of national innovations. It strengthens the scientific and technical infrastructure needed to address current and future biosafety challenges, while promoting fairer market conditions for local producers and reducing reliance on imported, high-risk agricultural technologies. The resulting impacts are expected to extend across ecological, socioeconomic, and policy dimensions, enhancing environmental justice, health equity, and food sovereignty in Mexico.

References

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