Transgenic Plants and Food Security in Honduras: *Challenges of Climate Change*

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Honduras, like many other developing countries, faces several food security challenges. The country's agricultural production is vulnerable to the effects of climate change, including variations in rainfall, rising temperatures, and extreme weather events such as droughts and floods. These environmental changes negatively affect crop productivity, the availability of water for irrigation, and soil health, which in turn jeopardizes the generation of food available to the Honduran population. According to the Regional Overview of Food and Nutrition Security, from 2019 to 2021, food insecurity increased significantly in Mesoamerica, covering a wide region from Mexico to Costa Rica, and half of the population of Honduras also experienced it in a moderate or severe way, with an increase in prevalence of 8.3 percentage points.[1]

More recent data in the Acute Food Insecurity Analysis Report of the Integrated Food Security Phase Classification (CIF per its acronym in Spanish) mentions that, in a study conducted from December 2021 to August 2022, at least 2.2 million Hondurans (24% of the classified population) are in food crisis, with the departments with the highest severity being Francisco Morazán, Cortes, Yoro, Gracias a Dios, Lempira, and La Paz. The population of Honduras is affected by a sharp rise in the price of basic goods and fuels and a decrease in the production of basic grains such as corn and beans. Some growers registered losses up to 50% in the production of basic grains the first harvest of the year, especially corn and beans and in some cases the total loss of food reserves, recently observed with Hurricanes Eta and Iota.[2] This has sowed fear of crop losses and created uncertainty in the Honduran diet.

Climate change exacerbates food insecurity in Honduras, reflected in an increase in cases of chronic malnutrition, especially in children under five years of age. The adverse effects of climate change, such as reduced food production and agricultural jobs, are contributing to this food crisis.[3] According to the National Climate Change Strategy, developed by the Inter-Institutional Technical Committee on Climate Change, water scarcity in certain regions of the country also directly affects this food availability, since access to water is fundamental for agricultural production and the well-being of communities.[4] Projections of water deficit in Honduras for 2025 suggest that the availability of surface water will supply less than half of the current demand, so food security faces significant challenges due to climate change and the dependence on traditional crops such as corn, beans, rice and sorghum, which are vital to the national diet. These studies show us the need to develop resilient agricultural strategies. To improve food security, agriculture has been evolving since the 1960's Green Revolution which had a positive impact on global food supply, from generating high yield rates through extensive large-scale production, to what we now know as genetic engineering. This Green Revolution was based on the genetic selection of new crop varieties, and the massive use of chemical fertilizers, pesticides, herbicides, and heavy machinery,[5] especially increasing cereal production, and helping to combat hunger in many regions of the world. However, although these technologies contributed to that increase, their intensive use had negative effects on the environment, such as soil degradation, water pollution and the loss of biodiversity and pest resistance to pesticides.[6] Therefore, although the substances used were considered necessary to achieve the objectives of the Green Revolution, it is also necessary to rethink their use in the context of sustainability, and today's environmental health.

Advances in genetic improvement allowed the production of genetically modified organisms (GMOs) for crops. According to the United States Food and Drug Administration (FDA), a GMO is a plant, animal, or microorganism whose genetic material has been modified using technology that generally involves the specific modification of DNA, including the transfer of specific DNA from one organism to another.[7] Scientists often call this process genetic engineering, and when it is done in the plant world, they are known

as transgenic plants.

This technology provides researchers with the tools to select specific genes, such as those that confer resistance to herbicides, insects or drought tolerance, and precisely transfer them to plants. The motivations behind genetic modification today are the same as those of ancient times: improving agricultural yields, reducing crop losses, extending shelf life, improving aesthetic quality, optimizing nutritional composition, among others. With the use of traditional breeding methods, these results could take decades to be achieved, but only a few years with genetic engineering and genome editing and allow rapid development of new crop varieties that address emerging challenges with desirable characteristics.[8] In this context, transgenic plants represent a potential option to improve crop productivity and resistance to adverse climatic conditions.

Although the use of transgenic plants is perceived as a viable option to achieve food security in the face of climate change, this technology raises various questions. These questions are related to concerns about the environmental impact on biodiversity, the influence on food security and population health, the potential development of resistance to pests or herbicides, as well as the socioeconomic impact and sustainability of crops. The main concerns in this regard are listed below.

Impact of GMOs on the environment: According to Rodriguez, genetic contamination is the main concern for the environment when it comes to the use of transgenic crops.[9] Genetic contamination, and more than 100 incidents of contamination have been reported in nearly 40 countries related to the use of this technology. The greatest concern is the loss of biodiversity due to large-scale monocultures, due to the transfer of genes to other species, and its possible impact on the ecosystem.

However, humanity has already used traditional methods to modify crops and animals to adapt them to their needs and tastes for more than 10,000 years, producing monocultures, and altering the ecosystem. As mentioned by the FDA, crossbreeding, selective breeding, and mutation breeding are examples of traditional ways of making these changes.[10] These breeding methods often involve mixing all the genes from two different sources, and they are used to create common crops such as modern varieties of corn, and seedless watermelon. Modern technology now allows scientists to use genetic engineering to take just one beneficial gene from microorganisms, plants or animals, such as insect resistance or drought tolerance, and transfer it to a plant.

For this reason, plant breeders (scientists or professionals specialized in the genetic improvement of plants) produce new varieties of plants through genetic engineering and genome editing, accelerating the results.[11] This technology could solve food security problems in a shorter time, especially in those regions most affected by climate change.

Transgenic plants were introduced in Honduras in 1996, with the aim of controlling Sigatoka disease in banana crops, Later, transgenic corn began to be planted, standing out in Central America as the only country that had authorized this type of crops for both field trials, and commercial use. By 2009, studies had already been conducted out at the Universidad Nacional Autónoma de Honduras where traces of transgenic contamination were found in corn, and derived products.[12] This means that these types of crops had already become widespread in the country and were being consumed in the diet.

Health impacts of GMOs: Another concern related to foods derived from genetically modified crops is whether they cause allergies, or other conditions such as cancer. An allergy is an adverse reaction, mediated by the immune system, to one or more substances called allergens, which are substances that normally do not cause any symptoms in most of the population, and are caused by proteins that are naturally present in foods. Approximately 160 foods, and food-related substances are associated with the induction of allergic reactions. However, 90% of food allergies that occur worldwide are caused by only 8 foods: milk, eggs, soy, fish, peanuts, shellfish, nuts (walnuts, hazelnuts, almonds, etc.), wheat, and other cereals with gluten, as well as derivatives of these foods that retain the allergenic proteins.[13]

Genetically modified foods are regulated by several US agencies, including the Food and Drug Administration (FDA), the Environmental Protection Agency (EPA), the Department of Agriculture (USDA), and the International Council of Scientific Unions (ICSU). These agencies require extensive safety data for evaluation. These measures ensure that genetically modified products meet quality and safety standards before they are introduced to the market. The FDA ensures that genetically modified foods are as healthy and safe to eat as their non-GMO counterparts.[14] In fact, some genetically modified plants have even been modified to improve their nutritional value. According to organizations fighting cancer, so far, no studies indicate that genetically modified foods influence the risk of cancer or cause long-term health problems.[15] We must not forget that this same genome editing technology is used in the treatment of esophageal cancer, leukemia and other diseases such as HIV, and contributes to the health of individuals.[16]

The impact of GMOs on food security: In order to guarantee food security in developing countries, and according to the definition given by the Food and Agriculture Organization of the United Nations, the four dimensions that comprise it must be satisfied: a) the physical availability of food, b) economic and physical access to food, c) the use of food, d) the stability over time of the three previous dimensions.[17]

In a review study, where articles from the last 20 years (2012-2022) were analyzed with data from Europe (35%), Africa (25%), the United States of America (20%), Asia (10%), and South America (10%), associating transgenic crops with

food security, it was found that 76% of the articles argue that food security is related to the increase or decrease of food products, supporting strategies that combine biotechnology with the use of conventional agriculture.[18] Several of the studies link food insecurity to sociopolitical factors, unfavorable climatic conditions (climate change) and/or negative agricultural factors (pests), which is why 81% of the articles defend the use, and development of genetically biofortified foods that increase the nutritional quality of the product and affirm that they do not pose a greater risk to human, and animal health than any conventional crop. This article concludes that, with transgenic crops, three of the 4 dimensions to guarantee food security can be achieved: physical availability, food use, and stability over time, making it necessary to combine them with other strategies to achieve economic stability. In contrast, different authors, and certain organizations, such as the NGO Greenpeace, refute this assertion, and attest that there are not enough studies, making it impossible to know what will happen in the long term to the environment, and to human and animal health, despite the fact that around three decades have passed since the introduction of transgenic crops.[19] More than two decades after the introduction of transgenic crops in Honduras, there are no studies that support environmental deterioration, or loss of biodiversity in the area where transgenic plants are grown. However, Honduran agricultural producers see some advantages in the possibility of increasing yields with less use of pesticides, improving the nutritional quality of crops, gradually increasing the Honduran economy in the medium term, and access to new technology that could benefit medium- and small-scale farmers.[20]

In a more recent study of agriculture in Honduras, 94% of producers indicated that transgenic corn provides sufficient pest control and that, due to this benefit, 97% of producers reported obtaining higher yields.[21] The study concludes that, according to the producer, transgenic technology continues to be economically beneficial with less use of pesticides, having a positive effect on the environment. They also assure that producing transgenic corn in Honduras requires a greater investment per hectare than conventional corn, however, the return on investment with the transgenic plant is considerably higher than that of the conventional plant.

Ethical concerns associated with transgenic plants: The emergence of genetic engineering has provided unprecedented technology that allows for the rapid and controlled redesign of adapted organisms. Biotechnology has managed to overcome barriers between species by operating directly on the genome, breaking boundaries previously considered insurmountable.

This has led to some ethical questions,[22] for which I will mention some of the basic principles of Beauchamp and Childress, and the Universal Declaration on Bioethics and Human Rights,[23] which apply very similarly to human health and environmental problems, to generate a reflection on the subject.

Autonomy: The Universal Declaration on Bioethics and Human Rights establishes that autonomy implies respect for the decisions made by people, assuming their responsibilities, and respecting the decisions of others. In this context, the right of farmers to decide the type of crop arises, also assuming the condition, and consequences arising from climate change, with the transgenic option being part of their resilience. It is equally important to consider how access to GM foods can help communities by providing them with more resilient and nutritious options, improving the conditions of farmers and consumers in regions affected by food shortages, giving them the opportunity to fight hunger despite inclement weather by using drought-resistant crops, especially in dry areas of cultivated valleys, and eliminating pests in times of high temperatures, where these insects tend to develop, and attack crops. We must also consider consumers. Labeling permits their know if the products they buy are GM and making informed decisions, respecting human dignity and rights.

Beneficence: The Declaration on Bioethics and Human Rights, UNESCO states that:

The benefits resulting from all scientific research and its applications should be shared with society, and within the international community, particularly with developing countries.

The patent system surrounding genetically modified products is a point of controversy, even when native plants are used, but it can also be argued that the benefits of these products could be shared more equitably through international policies and agreements. Biotechnology has the potential to improve agricultural production in vulnerable regions, thereby reducing hunger and increasing global food security.

The key is to ensure that these benefits reach those who need them most through the development of regional, and national research, development and implementation programs for these technologies, as has been done by the Honduran Coffee Institute (IHCAFE per its acronym in Spanish) by helping the country's coffee growing community with improved coffee varieties, through a coalition between the government, private companies, and trade associations.[24]

Non-maleficence: Where the potential risks of these organisms must be analyzed before they are released, the precautionary principle, per the Cartagena Protocol,[25] directs governments to prevent any damage to biological diversity when living, modified organisms are transferred, manipulated or used, is essential to protect populations from possible harm, even when there is no scientific evidence of cause and effect. However, banning GMOs in the absence of conclusive evidence of harm could deprive hungry communities of solutions that could significantly improve their situation. It is important to balance potential risks with the opportunities that these crops offer to reduce hunger and improve

nutrition.

Justice: Where it is argued that the availability of GM foods does not reduce hunger if farmers cannot produce them themselves, or local people cannot buy them. Justice in the distribution and access to GM foods is a real challenge. However, it is possible to design policies that facilitate access to GM seeds at affordable prices for local farmers, promoting more efficient agricultural production. This could have a direct impact on reducing hunger, provided that equitable and sustainable access to these technologies is guaranteed, as mentioned above.

It should also be noted that the Declaration contemplates two principles applicable to this case:

Protection of the environment and the biosphere, in the sense that the interconnection between human beings and other forms of life is considered, the importance of appropriate access to biological and genetic resources, and their use, while always maintaining respect for traditional knowledge, and the role that human beings must play in the protection of the environment, the biosphere and biodiversity, but always considering future generations.

Conclusion

Although some researchers raise controversies about this, international regulatory organizations affirm that genetically modified foods available on the international market have undergone exhaustive safety evaluations, and that they are just as likely to cause health risks as their native counterparts, and further studies are still suggested to support the use of transgenic foods and their possible adverse effects. However, in the face of the ravages of climate change in agriculture, this technology could be one of the solutions to alleviate its effects on crops and, consequently, on food availability.

In the face of food insecurity, it is possible that people who are trapped in subsistence agriculture may have to take more risks than those who have certainty,[26] so it is essential to focus on the implementation of policies that promote their development, avoiding the monopoly of technology, and ensuring that small farmers do not depend on large corporations.

Now more than ever, it is necessary to transfer technologies to developing countries with the aim of saving human lives and meeting their basic needs, such as feeding a population. This implies promoting independent, and sustainable agriculture, which would allow developing countries not only to survive, but also to progress and improve in nutritional and socioeconomic terms. This long-term technological and financial sustainability is one of the main concerns of the use of transgenic plants from the point of view of equity.

In this context, and under ideal economic and technological circumstances, transgenic plants represent a potentially valuable tool to face the challenges associated with climate change in agriculture. These crops are designed to withstand adverse conditions such as droughts, nutrient-poor soils, and pests and diseases' attacks. For example, biotechnology has allowed the development of drought-resistant corn varieties, which could help Honduran farmers maintain the productivity of their crops in conditions of water scarcity, as projected in the national strategy for Climate Change in Honduras for the year 2025.[27] All this suggests that we must use more productive and resilient strategies such as transgenic crops, seeing it as a tool to ensure the food of the population in the context of climate change.

However, this also poses major challenges such as the acquisition of this technology, to avoid the scientific, and economic dependence that this would cause in developing countries. In short, although there are legitimate ethical dilemmas surrounding the use of transgenic plants, it is also true that, with adequate regulation, independent research, and an approach focused on social justice, as currently reflected in the Honduran National Policy on Long-Term Food and Nutritional Security (PSAN) and the National Strategy on Food and Nutritional Security (ENSAN): PyENSAN 2030,[28] the strategy seeks to align food and nutritional security actions with the Sustainable Development Goals and other national plans, such as the Country Vision (2010-2038) and the National Plan (2010-2022), with broad collaboration between the government, academia and the private sector, and the participation of new institutions each year in the Annual Operating Plans. Ultimately, food security in Honduras and around the world will require a collaborative and multidisciplinary approach. Science, ethics, culture, and sustainability must converge to ensure that decisions made today do not compromise the needs and rights of future generations.

References

1 . FAO, FIDA, OPS, WFP y UNICEF. 2023. Panorama regional de la seguridad alimentaria y nutricional - América Latina y el Caribe 2022: hacia una mejor asequibilidad de las dietas saludables. Santiago de Chile. https://doi.org/10.4060/cc3859es

2. CIF. Informe de Análisis de Inseguridad Alimentaria Aguda de la CIF Honduras Diciembre 2021 - Agosto 2022. (2022). Obtenido de https://www.sica.int/documentos/informe-del-analisis-de-inseguridad-alimentaria-aguda-de-la-cif-honduras-diciembre-2021-agosto-2022_1_129149.html

3. UNICEF, El Cambio climático en Honduras estudio 2016: La infancia en peligro, (2016): 39-73, tomado de https://www.unicef.org/honduras/media/501/file/El-Cambio-climático-en-Honduras-estudio-2016.pdf

4. Comité Técnico Interinstitucional del Cambio Climático, Estrategia Nacional de Cambio Climático, Honduras, (2011), recuperado de https://faolex.fao.org/docs/pdf/hon148589.pdf

5. Rodolfo Rodríguez Gómez. Organismos genéticamente modificados, seguridad alimentaria y salud: trascendiendo la epidemiología y la salud pública, *Revista Salud Bosque* 5 (2016), 67-78, https://www.researchgate.net/publication/304008008_Organismos_geneticamente_modificados_seguridad_alimentaria_y_salud_trascendiendo_la_epidemiologia_y_la_salud_publica

6. Willett, W. et al. Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. *Lancet* 2019; 393: 447–92. DOI: https://doi.org/10.1016/S0140-6736(18)31788-4. Revisado en agosto 2024
7. US Food and Drug Administration website. Agricultural biotechnology. Feed your mind. www.fda.gov/food/consumers/agricultural-biotechnology. Revisada en abril 2024.
8. US Food and Drug Administration website. Understanding new plant varieties. www.fda.gov/food/food-new-plant-varieties/consumer-info-about-food-genetically-engineered-plants. Updated May 12, 2023. Accessed February 7, 2024.
9. Rodolfo Rodríguez Gómez. Organismos genéticamente modificados, seguridad alimentaria y salud: trascendiendo la epidemiología y la salud pública, *Revista Salud Bosque* 5 (2016), 67-78, https://www.researchgate.net/publication/304008008_Organismos_geneticamente_modificados_seguridad_alimentaria_y_salud_trascendiendo_la_epidemiologia_y_la_salud_publica
10. FDA, Agricultural Biotechnology. Tomado de https://www.fda.gov/food/consumers/agricultural-biotechnology. Updated April 19, 2023. Accessed February 7, 2024.
11. FDA, US Food and Drug Administration website. Understanding new plant varieties. www.fda.gov/food/food-new-plant-varieties/consumer-info-about-food-genetically-engineered-plants. Updated May 12, 2023. Accessed February 7, 2024.
12. María Isabel Manzur, María Isabel Cárcamo, eds., América Latina, La transgénesis de un continente: Visión crítica de una expansión descontrolada. (2015), 129-133, Recuperado de https://www.biodiversidadla.org/Documentos/America_Latina_La_transgenesis_de_un_continente._Vision_critica_de_una_expansion_descontrolada#:~:text=Am%C3%A9rica%20Latina%3A%20La%20transg%C3%A9nesis%20de%20un%20continente.%20Visi%C3%B3n,del%20mismo%20nombre%20publicada%20en%20el%20a%C3%B1o%202009.
13. ArgenBio, Consejo argentino para la información y Desarrollo de la Biotecnología. Alergias alimentarias, transgénicos y un mito difícil de derribar, (2020), https://www.argenbio.org/actualidad/87-mas-novedades/mas-temas-de-interes/12558-alergias-alimentarias-transgenicos-y-un-mito-dificil-de-derribar
14. FDA, Agricultural Biotechnology… https://www.fda.gov/food/consumers/agricultural-biotechnology
15. Brestcancer.org, Alimentos transgénicos. (2022), tomado de: https://www.breastcancer.org/es/organizar-la-vida/dieta-nutricion/reduccion-riesgo-cancer-mama/produccion-seguridad-alimentos/produccion/ogm-geneticamente-modificado
16. Lucía Gómez-Tatay, Justo Aznar, CRISPR-CAS9. El mayor avance en técnicas de edición genética requiere una reflexión ética, Cuadernos de Bioética 30(99), (2019), 171-185 DOI: 10.30444/CB.31
17. Organización de las Naciones Unidas para la Alimentación y la agricultura. Guía Práctica FAO. La Seguridad Alimentaria: información para la toma de decisiones [Internet]. Roma: FAO; 2011. Available from: https://www.fao.org/3/al936s/al936s00.pdf
18. María Luisa García Fernández y Teresa Hernández García, Alimentos transgénicos y seguridad alimentaria ¿son la solución contra el hambre y la desnutrición en los países en desarrollo? RIECS: *Revista de Investigación y Educación en Ciencias de la Salud* 8, (2023), 105-112ISSN-e 2530-2787
19. Greenpeace. Ámsterdam: Greenpeace; Respuesta ante la carta de premios Nobel sobre transgénicos. (2016), Available from: https://es.greenpeace.org/es/sala-de-prensa/comunicados/respuesta-de-greenpeace-ante-la-carta-de-los-premios-nobel-sobre-los-transgenicos/
20. Allyn Didier Del Cid Gutiérrez, Opiniones del sector agrícola hondureño sobre la introducción de cultivos transgénicos, (2000), 65.
21 . Diego Maximiliano Macall, Carlos Rogelio Trabanino, Alejandro Hernández Soto, Stuart J. Smyth, Genetically modified maize impacts in Honduras: production and social issues. Transgenic Res. (2020), 12, https://doi.org/10.1007/s11248-020-00221-y
22. Yunta E. R. Reflexión bioética sobre el uso de organismos genéticamente modificados. *Bioethikos,* 4(2), (2010), 222–227. Tomado de: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3173775/
23. UNESCO. Declaración Universal sobre Bioética y Derechos Humanos. (2005). Recuperado de https://unesdoc.unesco.org/ark:/48223/pf0000146180_spa
24. Instituto Hondureño del Café, IHCAFE. Tomado del sitio web: https://www.ihcafe.hn/investigacion-y-desarrollo/
25. Unión Europea, UE. Protocolo de Cartagena sobre seguridad de la biotecnología del convenio sobre la diversidad biológica, Tomado de: https://eur-lex.europa.eu/ES/legal-content/summary/convention-on-biological-diversity-cartagena-protocol-on-biosafety.html#:~:text=El%20Protocolo%20de%20Cartagena%20del,(Reglamento%20(CE)%20n.
26. FAO. La biotecnología agrícola: ¿una respuesta a las necesidades de los pobres?, tomado de: https://www.fao.org/3/Y5160s/y5160s06.htm#TopOfPage
27. Comité Técnico Interinstitucional del Cambio Climático. ESTRATEGIA NACIONAL DE CAMBIO CLIMÁTICO HONDURAS: ENCC HND. Recuperado de https://mnigrhonduras.org/download/estrategia-nacional-de-cambio-climatico-honduras/
28. Secretaría de Coordinación General de Gobierno. *Política Nacional de Seguridad Alimentaria y Nutricional de Largo Plazo (PSAN) y Estrategia Nacional de Seguridad Alimentaria y Nutricional (ENSAN): PyENSAN* 2030. (2019). Tegucigalpa, M.D.C., Francisco Morazán, Honduras. Tomado de: https://foprideh.org/wp-content/uploads/2020/10/BORRADOR-PYENSAN-2030-18012019-EC-SL-RM-3-editado-FINAL.pdf

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