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Stakeholder Interviews

Assessment of the Regulatory and Institutional Framework for Agricultural Gene Editing via CRISPR-based Technologies in Latin America and the Caribbean

RG-T3431

Sebastián Zarate, Ilaria Cimadori, Maria Mercedes Roca, Michael S. Jones, and Katie Barnhill-Dilling

Publication editing and design by Patti Mulligan

Genetic Engineering and Society Center, NC State University

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Introduction

Gene editing tools have promised tremendous opportunities in agriculture for the breeding of crops and livestock across the food supply chain. These new tools have the potential to address issues associated with a growing global population, sustainability concerns, and the effects of climate change (Kuiken, Barrangou, and Grieger 2021). These promises come along-side environmental, cultural, and socio-economic issues, including concerns that governance systems are not keeping pace with the technological developments and are ill-equipped, or not well suited to evaluate risks new genome editing tools may introduce. Understanding these complex, dynamic interactions across the Latin American and Caribbean (LAC) region is important to inform appropriate and acceptable governance and investment strategies for the region.

In order to understand these complex interactions, the project team conducted forty-one semi-structured interviews of subject matter experts and other stakeholders designed to provide in-depth information about the needs of the countries of interest with respect to gene editing for agriculture. The interviewees were chosen according to the following parameters:

- **Country of origin.** We aimed to get participation from representatives across the different regions including the Southern Cone, Andean, and Central America. The original countries identified in the project proposal included Argentina, Bolivia, Brazil, Colombia, Honduras, Mexico, Paraguay, Peru, and Uruguay. These countries were also chosen because of the variety of regulatory frameworks which provide comparative and nuanced analysis. The final list of countries represented in these interviews can be found in *Table 1*.

- **Occupation.** We aimed for perspectives from different sectors, including regulators, policymakers, researchers in public as well as private institutions, and representatives of environmental groups and farming communities. The forty-one participants represented the following sectors: **Academia and other publicly funded research** (31%), **Industry** (31%), **Government** (26%), and **Non-Profit or Advocacy** (12%).

- **Position toward gene editing.** Because gene editing perspectives can be complex, we sought to capture and reflect the different points of views in the region. As a result, the interviewees were either neutral, leaning pro or doubtful about the application of biotechnology and more specifically gene editing.

Stakeholder Interviews: Executive Summary

This section highlights the key points that we identified in the stakeholder interviews, and we describe each of these in greater detail in subsequent sections of this chapter. *Table 1* summarizes the key challenges, priorities, and suggestions for investment that the interviewees mentioned.

Challenges are the persisting issues that interviewees identified while asked about biotechnology development, patenting and licensing, risk assessment, outreach, perception, funding, political implications of biotech, markets, trade, training opportunities and regulation. **Priorities** are the issues that interviewees identified as urgent such as increasing the agility of procedures, strengthening and harmonization of regulatory frameworks, providing funding and resources, developing partnerships, reaching markets, providing training in risk assessment, and achieving social and environmental impact. Finally, interviewees also provided **suggestions for investment** such as investing in training, infrastructure, patenting procedures, licensing, public and private partnerships, reducing bureaucratic limitations, educating decision makers, communication expertise and public engagement. The difference between priorities and suggestions for investment is that suggestions expand more about specific support than the bank could provide.

Recurring topics included regulation, outreach, training, and perceptions of genetic engineering and biotechnology., Interviewees represent a variety of institutional affiliations, such as universities, industry, government, nonprofits, consultants, and applied research. At the same time, their collaborators are domestic, public, and private actors, as well as international. Countries such as Brazil had more experts from diverse backgrounds and provided a more in-depth understanding of their country's current regulatory, economic, political, and social landscape.

Of the eleven countries represented, interviewees from five countries (Brazil, Bolivia, Costa Rica, Peru, and Mexico) described the significant **regulatory hurdles, including enforcement and clarity**. Interviewees from Brazil, Bolivia, and Peru discussed a **lack of funding and resources** as another challenge. Interviewees from Costa Rica, Mexico, Paraguay, and Argentina described issues with **partisanship around biotechnology**. And interviewees from Brazil, Guatemala, and Honduras detailed additional issues around **outreach efforts, public perception and engagement, and transparency**.

We identified country-specific priorities during this project. Interviewees from Brazil, Peru, Bolivia, Argentina, and Paraguay mentioned that a key priority should be focusing on providing **funding, resources, and training**. Interviewees from Brazil, Bolivia, Costa Rica, Colombia, and Argentina prioritized the need for **biotech regulation, such as strengthening frameworks and harmonization**. It is important to note that in the case of priorities, many are expecting action will soon be taken to address the regulatory challenges identified previously. In the case of Peru and Mexico, the **political context may restrict actions oriented to harmonize regulation**. Interviewees from Bolivia, Honduras, Mexico, Paraguay, and Guatemala expressed the need for their countries to **develop new partnerships**. Finally, interviewees from Brazil, Colombia, and Guatemala prioritized **expanding and improving public perceptions of biotechnology**.

At the end of each interview, we asked participants about potential investments. While some reinforced the challenges and the priorities from *Table 1*, they then expanded on activities that target-specific goals such as **funding startups, investing in bioremediation research, and synchronization approvals**. A majority of interviewees expressed a need for the Inter-American Development Bank to **invest in training and capacity building**, including for decision-makers and risk analysts. Additionally, for **investments aimed at reducing bureaucratic limitations and increasing understanding of the patenting process**. Interviewees from Brazil, Costa Rica, and Honduras mentioned that the Bank should **invest in partnerships and collaborations**. Finally, interviewees from Peru, Panama, and Argentina felt that the Bank should **invest in regulatory instruments, simplification of regulatory processes, improvement, and strengthening of regulatory frameworks**. This does not mean that regulation is not a challenge or a priority in other countries. Instead, when asked about investment alternatives, interviewees from other countries focused more on training and capacity building.

Country	Challenges	Priorities	Suggested Investments
Argentina	Product Development, Partisanship of Biotechnology	Provide Training, Harmonization of Regulation	Invest in training and risk assessment, Strengthen regulatory framework and synchronization of approvals
Bolivia	Embroiled lack of Regulation/Anti GMO activists, Lack of Funding and Resources	Regulation of GE, Funding, Resources and Training, Partnerships	Training and research, Training and funding, Research, and engagement with farmers
Brazil	Patenting System, Lack of Funding and Resources, Embroiled Regulation, Understanding of Regulation, Outreach Efforts	Agility of Procedures, Reach Markets, Funding, resourc-es and training, Harmonization of Regulation, Risk Assessment, Public Perception	Training and facilities, Basic and public research, Infrastructure, procedures in patenting, Training in risk assessment, Training and "culture of patents", less expensive licenses and seeds, innovation in bioeconomy, Commercialization and simple regulations, Research and risk assessment, Public and private partner-ships, startups, public engagement.
Colombia	Proactive man-agement, Career Development, Strengthen Risk Assessment	Public Perception, Public Engagement, Harmonization of Regulation	Research of pathogens and plants, Educate decision makers, research and capacity building, financial mechanisms for bioeconomy, public and private invest-ment in research
Costa Rica	Partisanship of Biotechnology, Embroiled Regulation	Strengthen Regulatory Systems, Regulation of GE	South to South collaboration, Markets for cash crops
Guatemala	Anti GMO Activism, Public Engagement and Transparency	Public Perception, Partnerships	Research centers and technology devel-opment, Communication expertise and technical expertise
Honduras	Public percep-tion, Underutilized equipment	Agility of procedures, Partnerships	Partnerships and biotech companies, ca-pacity building, Training new generation of students, give them opportunities
Mexico	Embroiled Regulation, Partisanship of Biotechnology	Assistance and Social Impact, Access and Relevance of Research, Partnerships	Research and capacity building, Training and reduce bureaucratic limitations, and infrastructure, Invest in higher education and private companies.
Panama	Legal Vacuum	Socioeconomic and Risk Assessment	Research and improvement of regulation.
Paraguay	Partisanship of Biotechnology, Strengthen Risk Assessment	Funding, resourc-es and training, Partnerships	Protect science from a changing envi-ronment, Bioremediation, and biotech research
Peru	Enforcement of Regulation, Lack of funding and resources	Funding, resources, and training, Reach markets	Institution, regulatory instruments and perception, Simplification of regulatory process and importation, Education, and capacity building

TABLE 1. Challenges, Priorities, and Investment Suggestions

1.0 Regulation

Regulation plays a significant role in shaping biotechnology development, in particular gene editing. Countries that do not have well-developed regulatory frameworks seek to follow the steps of countries that have more experience in regulating biotechnologies. Even though the institutions such as the Convention on Biological Diversity (CBD) have developed international legislation on Living Modified Organisms (LMOs), each country faces their own implementation and compliance challenges. Each country has specific regulations, and some have ratified international agreements such as the Cartagena Protocol. However, those that did not ratify it are certainly aware of its existence and may therefore be influenced both by this agreement and by other countries' regulations. For instance, government ministries are likely to be aware of the international regulatory framework updates, such as the different legal definitions of genetically modified organisms (GMOs) in use in the different countries. The private sector and the universities are also aware of regulations since these impact the pace of product development, as well as market reach.

The majority of the interviewees are particularly familiar with regulatory topics, often referring to the regulations' nationwide and international influence. Some interviewees showed interest in creating partnerships and networks around regulatory issues, but also for expediting product development and research. For example, international organizations have already successfully developed partnerships and networks, such as the Inter-American Institute for Cooperation on Agriculture (IICA) in Central America. IICA has provided networking opportunities for countries of the region, seeking to support governments' policies regarding biotech and agriculture. The goal is to inform how the technology works, as well as to expedite decision making. Another example in South America is the Southern Common Market (MERCOSUR). According to one interviewee, MERCOSUR has a biotechnology table that facilitates dialogue between countries such as Colombia (an associated state), Argentina, and Brazil (member states). Finally, others focus on developing public and private sector partnerships as well as partnerships between countries. One of the interviewees from Peru mentions that national companies and startups are also interested in regulatory advances in their countries, since they may face challenges such as slow customs procedures, paperwork related to importation of supplies for their work.

The following subsections focus on the most frequently mentioned topics in connection with the keyword "*Regulation*" during the interview analysis: harmonization, politics, and product development.

1.1. Harmonization

One pattern that emerged from the analysis of the interviews is the concept of harmonization. Harmonization points to a desire among the interviewees to have a more consistent and agile regulatory system among Latin American Countries, retaining a certain degree of autonomy. For numerous interviewees, the lack of harmonization is a serious problem. As several affirmed, this lack of harmonization has a negative impact on the biotechnology sector at large, particularly on companies and research institutions:

> **The rules are not clear around the world yet. From the perspective of the biotech industry, this is a major restriction**. This is the **lack of understating of the regulatory framework**, the European Union is in a legal constraint. (Brazil)

Country	Regulation		
	Harmonization	Politics	Product development
Argentina	Harmonization of regulations is very difficult, there are high costs for regulatory delay. The country's regulations are in line with the Cartagena protocol.	The political situation of Argentina seems separated from the risk assessment.	Argentina has many local developments with public and private financing. The products that have come out, come out of alliances between universities and institutes.
Bolivia	Understanding that in other countries there are more advanced regulations; need to harmonize regulations	Relationship between farmers and the political position of the government. Drug trafficking is politically relevant	Limited opportunities for biotech experts. Entrepreneurship based on local products such as purple corn.
Brazil	Concern that the regulatory system is not clear around the world; major restrictions for the biotech industry; desire to harmonize the regulations with other countries that would promote a better environment to establish public/private partnerships.	The influence of Europe in terms of political power is declining. Need to "put scientific information on the table".	Products could be questioned by consumers. Concerns about trade barriers and regulation. Europe does not buy products and has different regulations.
Colombia	It is hard to have harmonized regulations. However, there is the need to look at other countries that have regulatory experience and learn from them.	Need to think in advance about the technology that's coming out and the regulatory landscape. Need support from authorities to develop biotechnology products.	CIAT develops tech for cocoa, supported by USDA, and the Compañía Nacional de Chocolate. Colombia has 90 percent adoption of cotton. Focus on adoption and not replacement, as well as demand driven products.
Costa Rica	It is hard to have harmonized policies, but countries should share a baseline for regulations, although they may deal with the problem differently.	Government authorities not familiar with agriculture, the current authority "comes from cattle," therefore not familiar with crops agriculture.	Awareness about approving products under the "GMO umbrella".
Guatemala	Guatemala is part of the Central American initiative in biotechnology, promoted by IICA	The approval of biotech regulation is linked to the Free Trade Agreement. The Ministry of Economy negotiates, and the ministries of agriculture carry out the technical proposals. The Presidency had a lot of power.	Guatemala approved a petunia and orange GMO for commercial use. Guatemala has approval for cultivation, but not for the grain to be food.

TABLE 2. Overview of Regulatory Issues

Country	Regulation		
	Harmonization	Politics	Product development
Honduras	Honduras is part of the Central American initiative in biotechnology, promoted by IICA	Government and private sector pushed for regulation. Biotechnology understood by politicians as a tool for economic development	Working on electronic applications. Need to increase the agility of procedures. Determined "case by case", depends on the type of modification.
Mexico	The interviewees did not mention harmonization of regulations.	The government is against biotechnology led by the Secretary of Science and Technology. Disputes between the Ministry of Environment and the Ministry of Agriculture.	Need to demonstrate the benefits of the products to the people (better grains and better seeds) in crops such as maize with a cultural importance for farmers.
Panama	The interviewees did not mention harmonization of regulations.	The Ministry of Environment developed a regulation in accordance with gene editing. Changes in government authorities stopped this process.	From 2014 onwards, Salmon was developed, including capacities in risk management, with Indigenous groups. Got out of proportion, USDA was involved.
Paraguay	It is a great challenge to understand the regulatory framework.	Political pressure to release seeds. Disputes between political parties of the government.	Cotton was released. Paraguay had issues with Argentina that had releases as well. Started to release transgenic events because there was less pressure from the media and from politics.
Peru	The interviewees did not mention harmonization of regulations.	Stakeholders involved in the moratorium included farmers and civil society. Technical recommendations were not considered.	Slow processes at universities that delays product development. Submit for approvals in countries such as Brazil and Colombia.

TABLE 2. Overview of Regulatory Issues, continued

According to another interviewee from Argentina, harmonization impacts the ability to spread progress within the region but also globally, which may severely impact peoples' lives. As the interviewee explained, having products available can help to address food insecurity:

> **Harmonization initiative to be developed, it is very difficult** [...] We have to realize that to be non-scientific may cost lives. **Harmonized regulatory framework, synchronization of approvals, very difficult questions**, rationally we can work on regional agreement [...] also **progress will be spread more easily and effectively**. Some efforts supporting harmonization initiatives will be very interesting. **This issue is important, there are lives depending on this**. (Argentina)

Other interviewees mentioned the differences between Central American regulation and the way in which Andean countries such as Colombia, Ecuador, Peru, and Bolivia develop their own regulation:

> It is very complicated to have a regulatory harmonization. The only country [in the Andean Community] that has experience [...] is Colombia. All the rest have a ban on genome editing that has been extended, except in Ecuador. In Central America [...] **what they have done is have a Central American regulation, where each country is autonomous, but they take into account the regulatory content.** (Colombia)

Because interviewees placed a high priority on regulatory harmonization, collaborations in this area could help to establish new partnerships between the public and the private sector:

> **Harmonize with other countries [...] the normative will give us a better environment,** to create public private partnerships, create a good environment with universities... (Brazil)

Even as many have hoped for regulatory harmonization, the previous quotes highlight the difficulty encountered in attempting to do so. However, as highlighted by one interviewee, the goal should be that of sharing the same baseline, thus approaching the problem in a comparable way:

> "…**it is impossible to have harmonized policies. Regulations with the same spirit with the same line. All these countries are asking to have a clear regulatory framework**, to have specific importance**, and to have a baseline to analyze the information in the same way**. We need to have predictability, [...] the baseline could be the same. Have a common star point. Have clarity, [...] **Mirror other countries and introduce something based on what neighbors have done. If that is working for you, then it could work for us**. (Costa Rica)

A harmonization attempt at the international level is represented by the Cartagena Protocol, whose goal is to "contribute to ensuring an adequate level of protection in the field of the safe transfer, handling and use of living modified organisms resulting from modern biotechnology that may have adverse effects on the conservation and sustainable use of biological diversity, taking also into account risks to human health, and specifically focusing on transboundary movement".[1] All countries that have ratified the Protocol should draft regulations that comply with the Protocol's requirements:

> We should look deeper, to our own legislation, harmonize with other legislation. [...] International treaties become more complicated to regulate. [...] **If we look at the products, we have yeast, animals, vegetables, they are coming fast to the process, to harmonize with international and domestic regulation, this will be a big mess.** (Brazil)

1.2 Politics

As articulated by interviewees, political pressures can play a significant role in interactions with lawmakers and regulators, as well as with researchers or companies involved in development and deployment of biotechnologies. Some described stakeholders in positions of power as being unable or unwilling to act. One interviewee from Costa Rica stated that it was difficult to convince the Minister of Agriculture of the importance of emerging technologies:

> **But the problem was a political problem. The Minister of Agriculture comes from cattle, not from farming. Difficult to make him understand**. It was not a priority; we

1 Article 1 of the Cartagena Protocol

have a political party (left) that doesn't want to approve new technologies. The procedures are waiting to be approved. (Costa Rica)

Ministries of the current governments in the region are actively reshaping the ways in which biotechnologies gain approval. Thus, the political interests of these public officials influence regulatory design and implementation:

> **The law does empower those interested in releasing biotechnology into the environment, but there are contradictions with the permits granted, which became more acute during this presidential term**. In previous ones, there has always been resistance from the government [...] **The real clash is between the Ministry of the Environment and the Ministry of Agricultural Production, there is a clash of vision**. Those in the Ministry of Environment have worked as hard as they can to ban biotechnology in agriculture. (Mexico)

Some see political influence as a national phenomenon, while in other cases as an external influence coming from Europe. An interviewee from Brazil argued that the influence of Europe is not as strong as it was 20 years ago. In Bolivia, one interviewee relayed an instance where the government reacted to the farmers' demands in the case of corn due to political pressure inside the government:

> So, these small farmers said, "Why did our government import corn from Argentina when we can produce our own corn in Bolivia, with our techniques, our tastes?" **This caused some movement inside the government, and this allowed an opening towards this discussion.** (Bolivia)

Additionally, there are conflicts of interest, since some representatives or government officials are aligned with agribusiness, and thus have more capability to directly influence regulation. As one interviewee from Honduras mentioned, the Ministry of Agriculture and the private sector pushed to include regulatory updates for gene editing in the country:

> **The Ministry of Agriculture and private entrepreneurs pushed for inclusion of regulatory updates for gene editing.** When they wanted to import new technology, they wouldn't have any problem with it. The Ministry of Agriculture has focused on this issue, but on suggestions from the private sector. (Honduras)

Guatemala had a similar experience around political influences on regulation. According to one interviewee, the ministry of agriculture and the ministry of economy cooperated to pass biotechnology regulations due to the Free Trade Agreement and the support of the private sector and the universities:

> The free trade agreement began to move biotechnology in the region. **The regulations would not have passed without the Free Trade Agreement [...]** It was fundamental, it would not have been possible if it had not been done under that premise, it allows the regulation to be maintained […] The Ministry of Economy negotiates the treaties. The Ministries of Agriculture carry out the technical proposals. There was support from business, the private sector, and the academic sector. (Guatemala)

Political leadership is often a factor in spearheading or blocking biotechnology regulation. One interviewee from Mexico mentioned that the current political position of the country against biotechnology as being represented by the actions taken by the Secretary of Science and Technology:

> **Mexico is having a position against biotechnology, led by the Secretary of Science and Technology** [...] This country is taking as an example to oppose biotechnology, a strong influence in central America. (Mexico)

Finally, in some countries, biotechnology may be perceived as an opportunity or as an obstacle in political terms. According to one interviewee in Bolivia, regulation is more complicated due to the issues regarding drug trafficking. In contrast, an interviewee from Honduras mentioned that the political actors view biotechnology as an opportunity for economic development:

> **The politicians understand that we are a big part of our economy, exportation of agriculture, they know that biotechnology is a tool to improve.** (Honduras)

1.3 Product Development

The development of genetically modified organisms is restricted by regulatory or bureaucratic impediments in some Latin American countries. An interviewee from Honduras mentioned that the agility of these procedures needs to increase and thus far they have been working to implement electronic applications. Importing supplies for product development has been identified as a problem by an interviewee from Peru, since supplies need to pass customs revisions, slowing down research and development:

> When you go to customs, they ask you for all the paperwork, they ask you for basically a permit from the university, so they don't have to charge you extra import taxes. **That took us close to four months because the university is also very slow. There are all these legal documents that you get asked in the process that just make the whole team very slow.** In the end it was like a year to get all the documentation. (Peru)

At the same time, it is important to be aware of the regulatory updates to develop products that are going to be approved and commercialized. One interviewee from Brazil argued that what they are regulating is the process, not the product itself, adding that once developed, the products could be questioned by consumers or NGOs:

> **We are trading the product, not trading the process** [...] **the products or the methods of production will be questioned because of some claim of consumers or the NGOs**. The other scenario depends on the concern of the **production methods.** (Brazil)

Companies are interested in regulation to develop products that reach different markets, and this involves dealing with what one interviewee from Costa Rica called the "GMO umbrella," which refers to the way the regulatory framework determines which products are GMO or not:

> We can have different traits, which mutation is the best, they will move into a DNA free method banana. **They have been approved under the regulatory framework, under the GMO umbrella [...] It is still a GMO. Once they get the data, they will use it to leverage a GM product.** (Costa Rica)

However, together with regulations, products may encounter other types of barriers, including consumer acceptance and trade barriers:

> **There is always the concern of trade barriers. We have experience with biotech products, consumer thoughts, and the regulatory process of biotech**. When it comes to products that are not the products themselves but usually products used in industrial processes. (Brazil)

Products can gain approval in multiple countries at the same time, based upon their regulatory framework. This is the case for countries that are part of the Free Trade Agreement in Central

America. As an interviewee from Guatemala mentioned, biotech products have been approved for commercial use in this country. However, according to the norm, these products are approved for cultivation, but not for food:

> In their mind there is a risk of biological safety. **In the norm they can't approve a GMO. They have approval for cultivation, but not for the grain to be food.** (Costa Rica)

Interviewees also mentioned that products gain approval on a case-by-case basis, based upon the agronomic characteristics of the product. This analysis allows some products to already be approved as non-GMO. One interviewee from Honduras highlighted the importance of identifying GMO products with molecular tools:

> In gene editing, the case-by-case scenario will have the same procedure, depending on the case of modification [...] **Determined case by case, the modification assumed it can be done, a simple one, something that can be regulated or recognized by molecular tools**, if we determined the modification was not to be a GMO, has to do the agronomic dimension. (Honduras)

Finally, it is challenging to know when or if regulators will deem export products as GMOs, as the countries importing them may have different rules and restrictions for these products. This is related to the trade barriers that make reaching markets difficult, even when regulations facilitate the development of biotech products. One interviewee from Brazil gives an example of this challenge:

> The EU considers all of the products as GMO, analyzing the process with the tech not the final product. **This is a very serious problem for Brazil because they buy many of our products—here in Brazil not considered transgenic but they do.** (Brazil)

1.4 Training and Capacity Building

Table 3 summarizes the main findings related to country-specific training and capacity building, based on the responses of interviewees. As shown below, this is a challenge shared by many countries. Some have similar issues, such as providing opportunities for students, and increasing their student talent pool and qualified workforce, as well as increasing risk and regulation experts. In contrast, countries like Argentina have provided training to other countries in topics such as regulation of biotechnology. Those like Bolivia seek partnerships with institutions inside and outside their country. Finally, countries such as Panama and Mexico have proposed directing investments in biotechnological entrepreneurship.

Training is a vital component of building a domestic talent pool and developing basic skills, not only in agriculture, but also in industrial and health biotechnology. Funding opportunities, such as scholarships, are often scarce. The Brazilian Agricultural Research Corporation (EMBRAPA), a publicly funded research institution, view scholarships to study abroad as a strategy to increase domestic knowledge in emerging technologies. An interviewee from Brazil described a lack of risk analysts for gene edited animals. In recent years, as another interviewee from Brazil mentioned, there have been restrictions in funding:

> We are in a bad situation because all scholarships are crippled. **We do not have money for the government, because of the pandemic**. In EMBRAPA we train doctors and visiting scholars. **It is important to train, but do not have any funds to motivate scientists to go abroad.** (Brazil)

Country	Training and Capacity Building
Argentina	Interviewees stated that Argentina provides training for regulators related to industry. They also trained people for universities. They consider that they have an important population of scientists in the country.
Bolivia	Interviewees stated that few universities offer molecular biology programs, while others tend to be more theoretical. At the same time, professors that study this field are scarce due to limited funding. There are options to establish connections with other universities and provide knowledge useful for farmers.
Brazil	Interviewees mentioned that companies require experts on risk assessment. There seems to be a need for young scientists, however scholarships are limited, and students lack motivation. Researchers are trained but are unable to join the workforce. Investment in research has decreased.
Colombia	As interviewees mentioned, universities are providing training courses for students and researchers. Private universities are more welcoming to biotech. Uncertainty regarding jobs in Colombia, as some prefer to travel to the U.S. Conducting seminars online for universities and regions.
Guatemala	Interviewees mentioned that there was a big boom in public private participation projects. According to them, this is an opportunity to invest in capacity building.
Honduras	According to interviewees, people that leave the country think that they will be unable to secure a position after graduation in Honduras. Unlike other countries such as Peru and Bolivia, the issue is not equipment so much as the need for a critical mass of scientists.
Mexico	According to interviewees, there is a lack of regulators, and universities do not include applied science or entrepreneurship in their programs. Additionally, an interviewee mentioned that universities market biotechnology based on foreign universities markets. Also, opportunities outside academia seem scarce. Universities would benefit from a closer relationship with the productive sector.
Panama	Interviewee mentioned opportunities in entrepreneurship and startups.
Paraguay	Interviewees mentioned they felt uncertain about of finding stable work if they return to Paraguay. Universities provide limited training, and then only to graduate students. Some graduate level programs have been discontinued. Through collaboration, experienced people have been providing trainings on regulation and risk analysis.
Peru	Interviewees argued that there is a lack of mentorship from professors due to limited resources, and due to their availability (part-time).

TABLE 3. Overview of Training and Capacity Building

These limitations not only affect students, but also technicians and other professionals training in biotechnology-related risk analysis. In Mexico, one interviewee lamented a shrinking pool of regulators, as well as the need for practical training. Nevertheless, training opportunities are available in different countries of the region:

> In 2017, we went there, we trained them. […] I went to Guatemala to advise their officials and their academics. ***And with our advice and our training, they finally made their legislation and put it on the same level, in the same agreement, in the same terms as ours. Since then, we are an example of international cooperation in these regulation issues. And now we have heard that El Salvador wants to join***. (Honduras)

There is high demand for partnerships with other universities and institutions in other countries. This is the case in Bolivia. According to one interviewee, there are opportunities to establish partnerships with local and international universities:

> We have a different partnership with researchers at other research institutes. **They have the class on biotechnology, we help with the practice and connection with other universities and institutions**. Connections with other cities that have a biotechnology laboratory, and in La Paz. (Bolivia)

Some interviewees suggested that universities should incorporate entrepreneurial training into their programs. Universities in Mexico are unlikely to incorporate this component, according to one interviewee. Partnerships between universities, the government, and the private sector are uncommon, as one interviewee from Brazil responded. In Honduras, Zamorano University has developed partnerships with governments and specialists in the sector, thus increasing the career paths for students.

Finally, there are opportunities to incorporate a social approach to research that benefits both farmers and Indigenous communities in countries such as Bolivia and Brazil. Interviewees from those countries mentioned that universities and research institutions are already involved in collaborating alongside with farmers, attending their needs in production systems:

> The gene editing must attend to the farmer's needs. Must be used for small farmers, which is about 80 percent in agriculture [...] **EMBRAPA has a good social approach, for different types of research. Common beans have a great program to develop new cultivars, training different aspects in production systems to train small farmers to correct plants and treat disease.** (Brazil)

2.0 Social Dimensions

2.1. Activism

Our interviewees link environmental activism or anti-GMO movements to the political actions of organized groups that oppose genetic engineering and other forms of biotechnology in the region. Activist actions are associated with the influence that these groups have to question and oppose the deployment of biotechnology products. According to interviewees from Brazil and Mexico, activists have had an increasing presence in the media in recent years. Some do not see the release of transgenics as a viable alternative, since they consider that all biotechnologies are the same and will not benefit farmers or Indigenous communities in any way, as an interviewee from Mexico argued. Another interviewee from Paraguay mentioned that biotechnology cannot replace agroecology, in the sense that agroecological practices add cultural value to their seeds and food:

> So, we are always fighting to protect the environment and our seeds, that more and more we are losing native seeds, and this means **that the problem of food in the world is not solved by transgenic or with modification. This is not an alternative.** We need to value our ancestral knowledge. The people should choose what to eat according to their culture. (Paraguay)

Others are open to engage with universities and learn more about gene editing technologies, such as CRISPR, so long as precautions are taken. One interviewee from Paraguay mentioned that farmers in her country want to understand how technologies will benefit them, and thus need more information:

> Information on CRISPR, new technologies in agriculture, the modifications, who benefits. **This is all new for us, for our organization.** We hear the name, but we do not know if it is good or bad [...] At the basis of our nutrition there is the corn, and this is becoming transgenic. And we don't know if it is good for humans to eat transgenic foods. At least us, as an organization, we don't know. **We know it is produced by the agrotoxic** [a broad term that refers to synthetic pesticides], **and we are scared to eat transgenic.** (Paraguay)

As interviewees from Mexico and Brazil mentioned, activist groups are not anti-science. However, they believe that harm is cause by the use of biotechnologies, and thus question their development and deployment:

> **About biotechnology, we are not against, we are against this pack of biotechnology that kills us**. Biotechnology has a lot to offer to develop, but this can affect life. (Brazil)

Interviewees from Paraguay and Brazil expressed concerns of harm experiences in their communities due to the use of chemicals and pesticides, which are associated with the use of biotechnologies:

> Without defending biodiversity, we will not protect our life. **We know that many of our women are dying with cancer because their husbands work in the big production and they use poison, agrotoxic**, and these women wash their clothes that are contaminated. [...] This is violence for us. (Brazil)

Activist groups engage in social demands that congregate multiple groups not only in their country, but also in different countries of Latin America. *Table 4* shows the diversity of topics that these groups advocate around. While international organizations such as Via Campesina are represented, others are locally based organizations such as CONAMURI, which congregates rural and Indigenous women from Paraguay.

According to non-activist interviewees, activist groups may have ties with national governments, such as the Mexican government. Several argued that the influence of these groups have led to restrictions on the development and deployment of biotechnologies. One interviewee from Bolivia mentioned that in his country previous activists now hold positions in the current government, thus making visible the connection between activism and assuming political positions in the Bolivian government.

Others stated that the political influence of activists may come from international groups. As one interviewee from Peru mentions, the influence of foreign groups is not as strong as in other countries of Latin America. However, according to this interviewee, activism is "rooted in Peru". In contrast, another interviewee mentioned that "pressure" groups are capable of modifying donors' behavior. According to an interviewee from Costa Rica, European supermarkets are funding activists:

> [...] **It is based on very orchestrated stuff.** You can detect their language, it is the same as what they are saying in other parts of the world [...] **Connections with supermarkets in Europe**, there are some studies based on this. **Non-GMO is a big movement.** (Costa Rica)

According to an interviewee based in the U.S., activists use "pressure tactics" to coordinate with NGOs and farmers, women, and Indigenous populations. One interviewee from Colombia mentioned that activist groups talk in the media about the dangers of these products. Similarly, another interviewee from Brazil argued that NGOs were using examples of damages that will then question products as well as the methods of production. Other interviewees stated that farmers, students, and Indigenous communities are not represented by the claims made by NGOs:

> **Activist groups are always international [...] Very rarely we saw small farmers, or agriculture, or students, or connected with those movements**. It was not a spontaneous presence; it was organized internationally. The same issues were brought back, same questions were brought to other countries. (Brazil)

Country	Goals of Activist Groups in Latin America
Argentina	Human Activity and Nature
Bolivia	Sustainable Rural Development; Indigenous; Native and Peasant Population; Nature; Energy; Sustainability; Art; Agroecology; Biodiversity; Biotechnology; Political Incidence; Citizen Engagement
Brazil	Agro-Ecosystems; Social and Economic Viability of Small-Scale Farm; Critique of Green Economy; Defense Of Creole Seeds; Popular Power; Peasant Movements; Struggle And Organization Of Workers; Small & Medium-Sized Producers; Landless; Women; Indigenous People; Rural Youth; Defend Life; Against Women Violence
Colombia	Communication; Education; Environmental Action; Biological Diversity; Social Movements; Agrarian Struggle; Defense of Territory; Food Sovereignty; Peasant; Indigenous and Afro-Colombian Organizations; Defense of Seeds; Advocacy; Corporate Agriculture and Transgenic Crops.
Costa Rica	Peasant; Environmentalist; Women's and Academic Organizations; Ecologist Movement
Ecuador	Food Sovereignty; Seed Management; Access to Water; Ecological Debt; Permaculture
El Salvador	Sustainability; Environmental Programs; Projects and Actions
Mexico	Environmental Justice; Food Sovereignty; Organic Agriculture; Democratic Control of Technologies; Corporate Power; Oppression of Farmers; Climate and Nature; Environmental Risk and Genetic Manipulation; Pesticides; Transgenic Seeds; Worthy Science
Paraguay	Social Research; Social Movements; Gender; Defend the Working Class; Agroecology
Peru	Organic Family Farming; Food Security
Uruguay	Social Ecology; Ecological Crisis; Concentration of Resources

TABLE 4. Overview of Goals of Activist Groups in Latin America

Non-activist interviewees often complained that activist groups are "stuck in time" regarding the debates around the use of biotechnologies, such as a Honduran expert based in the U.S.:

> **Some of these issues are not explicit to modification, issues that have to do with agriculture in general, control of genetic resources, dependence on small farmers**, might be specific to the technology but not apply to a specific technology. **It has not caught up with the genome editing technology debate**[...] Genome editing has not entered the public discussion, but it is coming, as a tactic. (Honduran expert based in the U.S.)

One interviewee from Peru felt that activist groups appeal to emotional arguments to explain their positions, which then has an influence on legislators. Another interviewee from Bolivia says that "[activists] make a fuss" when someone speaks in favor of genetic modification, and that speakers that are "not from the area" are often the ones advocating against them. In the case of Peru, where there is currently a moratorium in place, the gastronomy sector, according to one interviewee, seems to play an important political role:

> **Gastronomic sector, strong boost to these active sectors.** Now some figures have not participated, unlike in 2012, such as Gaston Acurio. They were younger chefs, more linked to the ecological, natural wave. **They were behind the support for the moratorium.** (Peru)

2.2 Outreach and Perception

Our interviewees engaged in different outreach strategies depending on where they are located and which groups they are trying to reach, such as Indigenous communities, citizens, policy makers, and broader public audiences. Some strategies are designed to engage with the general public of a country, such as Brazil, that aim to increase the acceptance of sugar cane. Other countries, such as Mexico, implement strategies to reach out to specific populations such as Indigenous people that grow maize and cacao. Colombian experts reach out to journalists as well as providing training opportunities for farmers in these topics. Finally, in Argentina, the communication strategy includes a public consultation process. *Table 5* provides an overview of different outreach strategies and perceptions of biotechnology by country.

Through the use of specific communication strategies, the goal is to inform different audiences about biotechnologies. One interviewee from Costa Rica mentioned that his organization aims to work with the governments of the region independently of the position they have towards biotechnology to provide advice to decision makers about emerging technologies as well as regulatory updates:

> **[We] wanted to show them, explain how the technology is, and determine how safe the technology is. Working with the countries even though they might be against technologies**, such as Peru moratorium (Costa Rica).

Another approach taken by an interviewee from Bolivia emphasizes fighting disinformation and explaining "all that biotechnology can offer''. An interviewee from Brazil mentioned that there is a need to "communicate more precisely" or "communicate the right way". One interviewee from Guatemala mentioned:

> **Part of our job is to explain the difference between GMOs and gene editing**. Bananas, a transgenic, are more dangerous than an edited product, both have scientific support […] **Particular things would have to be considered, in places where there is evidence, where the Indigenous people do not agree**, it is case by case, it cannot be generalized (Guatemala).

Country	Outreach and perception of biotechnologies
Argentina	Public consultation process, journalists were reporting. Ministry of Science and Ministry of Agriculture allies in providing help to agriculture innovation.
Bolivia	Interviewees mentioned that NGOs are involved in the approval and release of RR soy; farmers pushed for it.
Brazil	Focus on attending farmers' needs through agencies such as EMBRAPA. Cattle breeders are associated and are aware of biotechnology. Interviewees mentioned that the public does not understand the new technology. However, crops such as sugar cane suffered less from the public acceptance standpoint. Citizen assemblies were used to engage with the public. There is a need to invest in listening to the public and marginalized communities in decision making.
Colombia	Interviewees mentioned that some risks may not be real and that there is a void of knowledge about the use of biotechnologies. According to the interviewees, there is no distinction between GMOs and gene editing. To inform the public, experts are engaging with journalists. Some farmers may be eager to get trained, even though most of them are not professionals.
Guatemala	To reach wider audiences, experts use social networks and platforms to interact with grass root organizations. Interviewees mentioned that they were targeting communities that may be unaware of the biosafety framework.
Honduras	Interviewee argued that native resources and native communities should be treated with respect and discretion.
Mexico	Agroecology used by farmers as validating their work. Even though Indigenous people are considered to have cultural bonds with crops such as cacao and maize, the coming generation could be more open to technology. Reconciling interests as a challenge.
Panama	Interviewee stated that communication with other countries that have validated the gene editing was conducted.
Paraguay	Social and media pressure are instrumental to mobilize agendas. Some native people were organized without the government's help.
Peru	Interviewee mentioned that political decisions are not based on evidence and that more trust is required from the population.

TABLE 5. Overview of Outreach Activities and Perception of Biotechnologies

As one interviewee from Colombia stated, it is important to "make them understand" how biotechnology could be useful for their families. The goal is to show the opportunities that biotechnology could offer to the public, explained by an expert in the field. It is believed that sharing knowledge will increase the awareness of the importance of gene editing for these communities:

> **Make them understand it may be useful for you and your children […] have to have hands-on training for non-scientists […] teaching them what is gene editing and what it is that you can do** […] If you aren't in the (field), it's much more difficult to understand […] You have to be involved, otherwise it may end like Peru where you have this prohibition and no one wants to do any work on gene editing or GMOs […] **The public may not know how it's going to help you if you aren't aware of the problem**. (Colombia)

However, outreach can be considered a negotiation tool aimed at reaching other stakeholders holding different positions towards biotechnology. One interviewee from Guatemala mentioned that it is important to agree with the Indigenous communities even if their position is not scientific. In this way, it could be more effective to proceed case by case, targeting each community at a time, to provide information and negotiate with them.

According to an interviewee from Paraguay none of the Indigenous groups opposed technology, which aligns with the activist position of the same country that mentioned that was not entirely familiar with the technology:

> Participating organizations and the selection mechanism [public consultation] have always remained the same […] **None of the Indigenous groups opposed.** (Paraguay)

Finally, other interviewees mentioned that their focus is to find common grounds, bringing people with different perspectives and values together:

> **Find common grounds, listen to the counterpart, find those bridges, and speak the same language.** Find the same solutions to global challenges. Better dialogues. […] Just communicating, getting to know the context, getting their own opinion, people will need to demonstrate that this could provide them with better grains, better seeds, it is really an option. (Mexico)

3. Conclusion

Across the broad range of topics that our interview participants described, most of the issues share one fundamental premise: the need for meaningful in-person meetings and other events that will require funding. Examples include:

- **Harmonization of regulatory systems** would require meetings and/or workshops where high level officials can brainstorm about what kind of systems can be developed. The meetings would require officials with meaningful decision-making capacity and who will be able to officially represent the administration or agency for whom they work. ***This may mean sponsoring travel and providing funds to host a workshop***.

- **Training and capacity building** may require group trainings in-person with trainees from throughout the region. ***This may require paying for participants' travel, paying a trainer, and sponsoring the events themselves.***

- **Better understanding public perception** will require funders to sponsor social science research (e.g., interviews, surveys, focus groups) to conduct in-depth research on the different dimensions of perception and position.

- **Conducting stakeholder workshops** in order to facilitate dialogue amongst key constituencies would also be an important dimension: people tend to enjoy the face-to-face communication and deliberation, in-person workshops promote the humanization of people with different perspectives, and playing an active role in promoting perspectives on behalf of a constituency will help people feel like they have agency in decision-making. Again, ***this may require sponsoring travel and paying for the workshop itself.***

- **Workforce development** may require a program to be developed collaboratively, and the training activities themselves ***will likely require funding to support travel and sponsoring the events themselves.***

We imagine that other funding needs will emerge or become more clearly defined moving forward, but these stakeholder interviews provide important background information for understanding the capacity for developing gene edited crops in the region.

Appendices

Appendix 1. Methodology used to analyze the interviews

For the analysis of the interviews three rounds of coding have been conducted. The first one focused on reviewing the notes taken while interviewing to come up with preliminary code words. It was also critical to identify the keywords for the interview coding, which reflected the many topics that emerged from this initial analysis. The second round of coding focused on checking the consistency of the preliminary codes to expand on complementary information. To make the analysis useful for the project's goals, this stage allowed to understand and single out what the interviewees perceived as the challenges and the priorities in the region concerning biotechnology, and more specifically the gene editing technology. A complete list of those challenges and priorities, followed by an extensive explanation, is included in the results overview section. This division into challenges and priorities was used to guide the coding process, particularly to decide which quotes were relevant and which ones were not. Finally, the last round of coding focused on reviewing the audio and video of the interviews to increase the accuracy of the quotes selected for this report. The complete list of keywords and their meaning is displayed in *Appendix 1*.

Taguette software was chosen to code interview notes (or transcripts scripts) with the keywords referenced above. This qualitative research tool allowed the team to work collaboratively on the analysis of the interviews. A systematic analysis of the sections of the interviews that mentioned the topics of interest was also carried out. Since some keywords were modified and changed based on recordings and the notes taken, the original meaning of the keywords was updated according to the results of the analysis and new interpretation. Consistency was also thoroughly checked by performing multiple rounds of interviews analysis. We grouped the above mentioned challenges and priorities into well-defined themes (*Appendix 2*) to allow for an easier analysis.

Keywords used to analyze interview data in Taguette software	
Access	Access to patents and to biotech products as well as availability of technology for research purposes.
Activism	Anti-GMO networks and organizations that focus on biotech, genetic engineering.
Funding	Investing in the product, human resources, in the innovation system. Whole funding "stream".
Impact	Importance of biotech for society, benefits for people, for who it is relevant and in which contexts is important (not only economic relevance)
Infrastructure	Physical infrastructure such as research labs, equipment, libraries, student spaces and research facilities.
Legal	Precise mention of laws and norms used by the interviewees (Cartagena Protocol, domestic biotech laws). Also, legislation or normatives that are related to biotech and activities against it (illegal, etc.).
Management	Administration of human resources, infrastructure as well as organizational processes and style.
Markets	Economic and political factors of biotech commercialization, product development and patents (ex. Brazilian markets, European markets etc.)

Keywords used to analyze interview data in Taguette software	
Outreach	Activities intended to make connections with the local communities as well as public outreach tasks (public engagement, communication of biotech)
Partnership	Networking and collaborations facilitated by stakeholders in the biotech sector (public-private partnerships, universities and private sector research)
Patents	Specific patents currently developed or in process of development in the near future (pipeline). Also the patenting process as well.
Perception	Ideas/notions of biotech shared by the general public, if the regulation or the decision making is transparent or not (accountability), as well as effective communication strategies.
Policy	Government public policies: "politica publica." Intention of the government, which is not necessarily a regulation. Government trying to improve certain aspects of the field they operate (e.g., agriculture).
Politics	Decision-making. Power dynamics between different stakeholders involved in biotech. Interaction between the different subjects (like university and government)
Product	Output of biotech research (GMO/GE products such as corn, salmon, etc.)
Regulation	Enforcement and use of laws, norms, and internal policies, as well as bureaucratic processes inside government institutions. How the actual regulation works.
Risk	Activities and expertise on risk analysis, risk assessment, as well as training in this field.
Training	Education, training, investment in capacity building as well as career development opportunities.

Appendix 1. Keywords used to analyze interview data in Taguette software, continued

Appendix 2[2]. Themes that emerged from analysis of interviews based on selected keywords

Theme	Definition	Keywords
Access and Relevance of Research	Importance of biotech research for the public, as well as its accessibility/availability to other researchers, farmers and other communities interested in biotech (paywalls, restrictions, customs issues, accountability)	Access; Impact (Relevance)
Anti-GMO Activism	Anti-GMO networks and organizations that focus on biotech, genetic engineering	Activism
Enforcement and Interpretation of Regulation and Laws	Actions taken to directly create, enforce, block, or facilitate the implementation of regulations, laws and normatives (international as well as domestic)	Regulation (Policy, Legal Politics)
Funding, Resources, and Career Development	Human and physical resources for conducting research, as well as investment in training and opportunities for students and researchers	Funding; Infrastructure; Training
Partisanship Between Biotechnologists and Decision-Makers	Political divides between governmental policymakers involved in the regulation and governance of biotechnologies (agriculture, environment, development)	Politics (Policy, Regulation)
Partnerships	Connections and networking related to biotech development, as well as the ties between different sectors or organizations with the intention to reach markets (public private partnerships)	Partnership; Market
Patenting System	The patents and the patenting process of products of biotech and their repercussions on domestic/international markets	Market; Patent
Proactive Management	Proactive role of administration of human resources, infrastructure as well as organizational processes and style.	Management
Product Development	The output and the process of biotech research (GMO/GE products such as corn, salmon, etc.)	Product
Public Engagement, Outreach Efforts, and Impact	Actions and activities designed to engage and communicate biotech to the public or to a specific demographic (Indigenous communities).	Outreach; Impact (Relevance)
Public Perception	Ideas/notions of biotech shared by the general public, if the regulation or the decision making is transparent or not (accountability), as well as effective communication strategies	Perception
Reach Markets	The capacity of biotech products to reach domestic or international markets (acceptance) once developed.	Market; Product
Risk Assessment	Expertise on risk assessment as well as capacity building and training opportunities for students and researchers in this field.	Risk; Training

2 The reason why under the column "keywords" next to a definition multiple keywords have been listed is because it has been observed that occasionally one quote connected to a theme was better represented if multiple keywords were used. For example, in some quotes, when discussing regulations, references to political problems appear in the same quote as well as policy actions or references to specific laws (which is captured by the keyword legal).