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Setting Research Priorities for Effective Climate Change Management and Policymaking: A Delphi Study in Bolivia and Paraguay

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Abstract: Over the last few years, increased research has been carried out on climate change. Part of this research has been based on foresight methodologies to gain time in the fight against climate change and identify planning and development policies that may be effective in the future. However, more research is needed, and it is essential to continue working to determine the appropriate strategies to chart the right path in the fight against climate change. Particularly scarce attention has been given to Latin American countries and, more specifically, to collaboration between countries in identifying priority research lines in this area. In this context, this study is innovative in presenting an articulated and cooperative work between Bolivia and Paraguay in identifying strategic lines of investigation linked to the Sustainable Development Goals (SDGs) that might have a more significant impact on climate change management. The application of the Delphi technique within a group of experts allowed the consolidation of different perspectives and knowledge on climate change and allowed us to identify, within the SDGs, the priority lines that should be addressed to manage climate change impacts. The results identify specific priority research lines for Bolivia and Paraguay related to the genetic diversity of food crops (SDG 2), new or reemerging human viruses (SDG 3), sustainable freshwater extraction and supply (SDG 6), cleaner fossil fuel technology (SDG 7), sustainable transport (SDG 9), local impact of climate-related hazards and disasters (SDG 13), and terrestrial biodiversity (SDG 15). These research lines should not be seen as exclusive but as the priority research lines that might have the most significant impact and should be addressed in the short term.

Keywords: climate change; policymaking; foresight; sustainable development goals; research priorities; Delphi study

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1. Introduction

It is widely recognized that scientific research must be innovative, applicable, and relevant to social challenges. Considering the constraints of limited research funding and the necessity for funders to make informed choices, defining research directions becomes crucial in addressing societal challenges. Furthermore, these research areas should comprise the Sustainable Development Goals (SDGs) objectives [1]. Among the SDGs,

climate change is understood to be the most acute global challenge, requiring urgent solutions to combat its effects, and thus, it is the subject of SDG 13: Climate Action. In this context, Fuentes et al. [2] emphasized the importance of scientific research in understanding climate change issues and how they are interconnected with other SDGs, which will have implications for designing policies and strategies to address its negative impacts.

The world is attempting to respond to the SDGs objectives by reflecting them in national policies and developing new strategies and solutions. However, it is essential to consider regional and country contexts. Confraria et al. [1] found that research priorities are not aligned with the SDGs in low- and middle-income countries due to the significant inequalities in research capacity and funding across countries. Given their knowledge and awareness of local issues, decision power, and direct engagement with local communities, local governments play a crucial role in achieving the SDGs. However, ensuring long-term progress towards achieving the SDGs requires adequate planning and decision-making, which are integral to local governance [3]. Thus, cooperation between the scientific community and governments is essential to achieve SDGs based on the knowledge generated in each country's scientific knowledge system.

A critical aspect that requires attention is understanding specific challenges and vulnerabilities in different geographic contexts, which must be reflected in research priorities related to climate change within those regions. Given that, this study aims to identify and assess future global trends in climate change research based on the SDGs, focusing on hypothetical applications for development in the context of Bolivia and Paraguay and developing strategic recommendations to guide R&D policy development in Latin America. Therefore, the research question of this study is the following: Based on the SDGs, what are the key research priorities that might have more impact on climate change management and policymaking in Bolivia and Paraguay?

For this purpose, the Delphi technique was used, allowing reliable knowledge through the input of experts in this field. As previous studies have demonstrated, increasing scientific and applied research to address climate change issues is a priority for the national policies in both countries [4], and therefore, this study contributes to the achievement of those goals. Targeting research directions to address the regional pressing challenges can provide valuable insights for shaping policies and strategies and specific indicators for their achievement.

2. Climate Change Research and the Sustainable Development Goals (SDGs)

SDGs provide a comprehensive framework to guide countries in achieving sustainable development by 2030, consisting of 17 goals, 169 targets, and several indicators, which form a complex and interconnected global challenge [5]. Each nation must integrate these SDGs across all government levels to achieve sustainable development. Since climate change causes a set of impacts at the environmental level, as well as sociocultural and economic [6], it has a broad effect on achieving the SDGs, both directly and indirectly [7]. Also, from another perspective, achieving the SDGs might have significant impacts on climate change management. Therefore, the interrelation of the SDGs highlights the need for an integrated approach to climate change and sustainable development. As Miola et al. [8] (p. 28) stated, "the SDGs implementation cannot be treated in isolation, but it should be contextualized in the specific political context which integrates the SDGs priorities in a broader context of policy priorities".

The SDGs were formulated based on their multidimensionality, which means they cover the three main dimensions of sustainability (economy, society, and environment), and in this way, they "are cross-linked and form an interlinked interwoven network of goals and targets" [9] (p. 161), providing several synergies and complementarities between them [8]. It is possible to verify these synergies, for instance, concerning SDG 13, which is specifically related to climate action. It refers to the necessity of urgent efforts to combat climate change and strengthen resilience and adaptive capacity to climate-related hazards and natural disasters through integrating measures into national policies, strategies, and planning [10].

This includes, as an example, promoting sustainable natural resources management and education and awareness-raising while advancing other SGDs, such as life on land (SDG 15) and quality education (SDG 4). The same happens with SDG 7, which ensures access for all to affordable, reliable, sustainable, and clean energy. The transition to renewable energy sources, such as solar, wind, or thermal power, helps reduce greenhouse gas emissions, the main driver of climate change. By promoting energy efficiency and increasing access to clean energy, we simultaneously combat climate change (SDG 13); promote better health and well-being (SDG 3); and advance industry, innovation, and infrastructure (SDG 9). Therefore, climate action should be integrated into all levels of policies, planning, and decision-making processes. Collaboration among governments, businesses, civil society, academia, and individuals is crucial to achieving the SDGs while addressing climate change effectively. Academia and scientific knowledge systems should be seen as influencers of the governmental agenda to make them more oriented towards adapting to sustainable development [11].

It is thus essential to promote collaboration between academia and governments to achieve global and national sustainable goals and targets based on the knowledge produced by the scientific and academic systems of each country. Fuentes et al. [2] (p. 2) have already stated that "scientific research contributes to the global understanding of complex and interdependent climate change issues. Such research can also inform the development of policies to alleviate or mitigate the climate emergency, but those studies have been limited".

Much has been discussed about the importance of the SDGs, especially in combating climate change and assisting with environmental issues, as the SDGs are a call to action [12–14]. In this context, foresight methods and, more specifically, the Delphi method have proven to be of great utility in debating climate change issues [15–17] and their relation to the SDGs [18–20]. Thus, it is important to develop further studies that identify and assess future global trends related to climate change, focusing on developing strategic recommendations to guide policymaking and integrating the decision-making and scientific knowledge systems.

3. Research Framework

3.1. Delphi Technique

The Delphi technique is a research tool characteristic of qualitative research methods [21–24]. It is based on the opinions and perspectives of experts in the field or topic under study. It aims to discuss complex and subjective problems or issues requiring significant knowledge and experience of the intervenient. These problems and issues are not easily addressed using conventional questionnaires or interviews [21,25].

With a flexible and predominantly exploratory content, its application presupposes the structured and systematized collection of the perspectives and opinions of specialists on the subject of study in a non-face-to-face and anonymous way through questionnaires that are answered in successive rounds, together with the sending of controlled feedback of the previous round's results. This will allow each expert to see previous answers and perspectives before answering the following round Of questions.

The interaction between experts (designated as the Delphi panel) is carried out virtually, preserving anonymity and allowing them to express their opinions on a given topic thoughtfully and without the pressure and spontaneous character other methodologies promote. The interaction takes place in successive rounds, in which it is possible, after knowing the initial round's general opinions, to rethink and reformulate the perspectives to reach a final consensus on the topic. The possibility for reformulation allows for obtaining potentially more reliable data.

As for consensus, although it is often mentioned that this is the main objective of this method—that is, to build an acceptable consensus around the topic under discussion [24–29]—its increasing application has often removed the restriction around consensus [30–33]. The Delphi technique can be seen as a controlled debate in which the reasons for extreme opinions are explicit, and feedback is presented neutrally, without the association of feelings

on the part of others [33]. Usually, expert groups move towards consensus, but even when such consensus does not occur, the reasons for taking distinct positions are clarified. The analyses and conclusions drawn by the coordinator are based not only on the reasons given by the expert group but also on their own knowledge and objectives. The value of the Delphi technique is thus transferred into the global set of ideas it generates, whether through consensus or not. Because the number of respondents is generally small, the Delphi technique does not produce or claim to produce statistically significant results. That is, the results obtained by any Delphi group do not predict the response of a larger population or even a different Delphi group. They represent the synthesis of the opinion of a particular group [33]. Although the number of rounds can vary, it is generally accepted that between two and three rounds is ideal [32,34]. This number will necessarily depend on the higher or lower degree of withdrawal of the participants between rounds, the degree of consensus, the stability of the responses at the end of each round, or even through a predefined number of rounds [25,34].

From the moment it was first introduced, this technique found immediate applications in forecasting, especially those related to technological or scientific advances and certain events. However, the Delphi technique has been used much more and goes beyond forecasting, proving to be particularly useful in planning and development policies. The literature shows that there are three different types of Delphi method applications [23]: the classic method, for the prediction of future events; the political method, oriented toward developing policies or public affairs; and the decision-making method, more suitable for decision-making on strategic measures. A combination of typologies can also be adopted, known as the hybrid method.

The technique is applied by a coordinator (or a coordinating team), which usually coincides with the researcher himself or a team member.

In global terms, there are no previously defined general criteria to structure the profile of individuals to integrate a Delphi panel [28]. However, some specific criteria have been identified and considered valid—namely, the fact that individuals have personal or professional experience in the subject of study; they can contribute with their perspectives to the construction of more solid knowledge about the research and are willing to review their initial or previous perspectives to try to obtain a global consensus perspective.

Once the specialists' profile has been defined, it is essential to work throughout the selection process of the members to be integrated from the universe of potential specialists who could be of interest to the study. In this context, different criteria can also be used, such as a geographical restriction of the members to integrate, choosing specialists who work or live in the geographical area of study; the accentuated specificity of the subject of study, which can lead to a bottleneck of individuals considered specialists in that subject; and the suggestion of new participants by the initial group, known as the snowball method [35]. As for the number of experts to integrate onto the panel, there is no clear limitation [28]. However, as studied by Garrod and Fyall [25], although successful studies are made up of panels ranging from 4 to 904 specialists, the ideal number would be between 40 and 50. Other authors, such as Yong et al. [36], have suggested a number between 15 and 20 would be sufficient. Delbecq et al. [37] argued that researchers should use as few specialists as possible, however, seeking to verify the results in subsequent research. For these authors, between 10 and 15 specialists will be sufficient if the group is homogeneous. If the group is heterogeneous from the beginning, more participants will be needed. Ludwig [38] noted that the number of specialists to be used in a Delphi study is generally determined by the minimum necessary to constitute a representative exchange of perspectives and by the information processing capacity of the coordinator or their team, considering that most Delphi studies involve between 15 and 20 participants.

3.2. The Delphi Panel

This study is part of the INNOVA project "Promoting Research Management in Higher Education Institutions in Bolivia and Paraguay", funded by the Erasmus+/KA2

program Cooperation for Innovation and the Exchange of Good Practices—Development of Competencies in the Field of Higher Education. It is an exercise of incursion into the field of foresight methods, which aims to identify and evaluate future global trends of cutting-edge research in climate change, focusing on hypothetical applications for development within the context of Bolivia and Paraguay and the development of strategic recommendations to guide policy formulation in research and development (R&D) at the Higher Education level in Latin America.

Therefore, the main requirements for this study were the following: the Delphi panel should include at least three experts from each institution within the INNOVA consortium (3 experts × 11 institutions = 33 experts), the number of rounds should be a minimum of two, and the gender perspective and indigenous knowledge should be considered. More objectively, to integrate the panel, individuals should be regarded as experts in research management (1 per institution), with accredited experience in holding a research management position at the level of Higher Education, have conducted research work in Bolivia and/or Paraguay, and be familiar with the region (does not apply to EU partners) or experts in climate change (2 per institution), with experience accredited by participation in research projects or publications related to climate change, research work conducted in Bolivia and/or Paraguay, and familiarization with the region (does not apply to EU partners).

Each project partner institution identified three experts who met the criteria (Figure 1). Then, a formal invitation was sent to participate in this Delphi study. From this group of identified experts, 31 effectively participated in the study. These participants constituted what we consider the Delphi panel for this study. The panel was balanced, including representatives from all partner universities and countries.

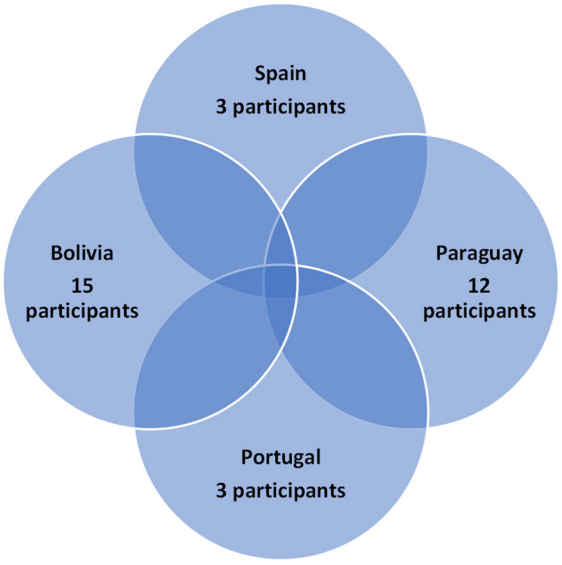


Figure 1. Initial Delphi panel proposal.

3.3. Delphi Rounds

The first questionnaire (first round applied between December 2021 and January 2022) was designed based on the report "UNESCO Science Report: the race against time for smarter development" [39]. This report identified a set of 56 lines of research to which greater attention has been given on a global scale and which are integrated into the following SGDs: SDG 2: Zero Hunger; SDG 3: Good Health and Well-being; SDG 6: Clean Water and Sanitation; SDG 7: Affordable and Clean Energy; SDG 9: Industry, Innovation, and Infrastructure; SDG 13: Climate Action; and SDG 15: Life on Land. From here, an analysis was conducted on the 56 lines of research to identify those that were most suited to the context of Bolivia and Paraguay, based on two criteria: the potential impact on the two countries and the level of priority regarding both country's research policies. This analysis, carried out by the coordinating researchers of the Delphi study, resulted in a final

list of 47 priority research lines. Then, experts were asked to indicate the degree of potential future impact (time horizon 2030) of each research line regarding climate change within the specific context of Bolivia and Paraguay (using a Likert scale where 0 represents a very low impact and 10 represents a very high impact). In the last section, experts could suggest additional priority research lines that they considered to potentially have an impact on climate change management and policymaking in Bolivia and Paraguay.

The second questionnaire (second round applied in February 2022) was based on the results collected and analyzed during the previous round. The aggregation of the individual assessments on the potential impact of each research line allowed the elaboration of a hierarchy, considering their priority. During the second round, experts were asked to indicate their level of agreement regarding the context of Latin America and the context of Bolivia and Paraguay. During both rounds, experts could always add new perspectives or comments about the topics under discussion. Figure 2 shows the framework for the application of the Delphi rounds.

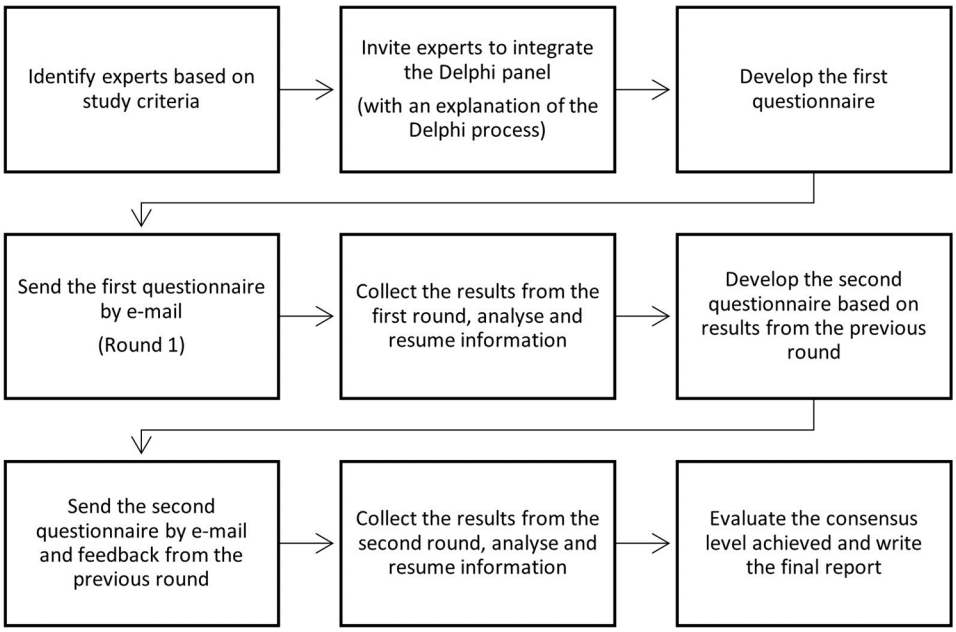


Figure 2. Delphi method framework.

4. Results and Discussion

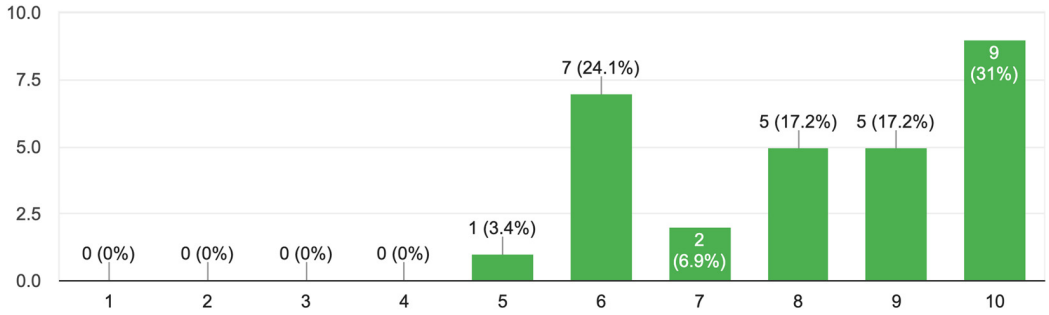
The results of the first round showed an overall positive assessment of the research lines presented to the experts. This was corroborated by calculating the median for each research line, with all research lines presenting a median of 6 or higher (out of 10). Likewise, the research lines with the best impact assessments had medians equal to or greater than 8, which demonstrated the high degree of consensus on the identification of which were considered the lines of most significant impact. Also, it was noted that all research lines presented many very positive evaluations (9 or 10). On the other hand, only 9 research lines (out of 47) obtained very negative evaluations (0 or 1). Thus, in none of these nine cases were there more than one or two experts giving very negative evaluations.

To elaborate the second round of questions, the mean and quartiles were calculated for each assessment of the previous round, allowing to establish a hierarchy according to two criteria: the value of the mean, which allows calculating the value of the scale that best represents the level of consensus among experts, and the percentiles value, which measures the dispersion between the experts' evaluations for each research line.

Based on these two values, a hierarchy was established between those lines that obtained the highest consensus in each SDG. Thus, the objective of the second Delphi round was to measure the level of agreement concerning the rankings obtained from the previous round's results. This level of agreement was related to the potential impact of the research

lines at both the regional (Latin American) and national levels (in the case of experts from Bolivia and Paraguay).

Analyzing the results more objectively, Scheme 1 shows a high degree of consensus regarding the priority lines of SDG 2: Zero Hunger (Table 1), with 31% of the experts showing total agreement (10) with the order resulting from the previous round. On the other hand, 24.1% of the responses showed a moderate level of agreement (6). Nevertheless, the most important research line of SDG 2 is related to maintaining the genetic diversity of food crops. This can be explained due to the region's heavy dependence on agriculture. Research in this area can help develop sustainable and resilient food systems that ensure food security and improve the capacity of the region's population in the face of ongoing environmental challenges.



Scheme 1. Level of agreement regarding research priorities for SGD 2 for South America (2nd round).

Table 1. Ranking of the research priorities for SDG 2: Zero Hunger (1st round).

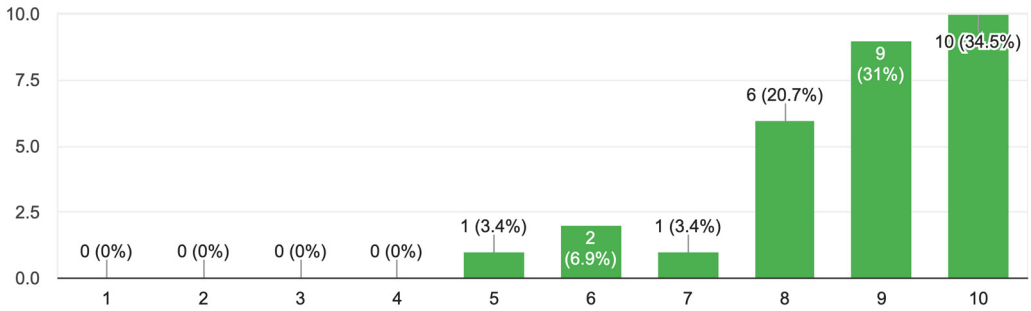
Rank	Specific Research Lines
1	Maintaining the genetic diversity of food crops
2	Agroecology
3	Aid to small-scale food producers
4	Traditional knowledge
5	Pest-resistant crops
6	Precision agriculture

In the additional comments, some experts considered that some research lines, such as agroecology or precision agriculture, can have a more significant potential impact on the Latin American region. Regarding the potential impact at the country level, the agreement level remained high but with a lower concentration. Two experts considered that this order does not correspond to the priorities of Paraguay.

For the priority lines of SDG 3: Good Health and Well-being (Table 2), Scheme 2 shows a higher level of agreement when compared to the previous SDG. It is noted that 65.5% of the experts indicated total agreement (10) or very high (9). Experts who showed a more moderate degree of agreement based their position on the line related to the impact on the health of soil, freshwater, and air pollution. Also noted was the apparent influence that the COVID-19 pandemic has had on the experts' opinions, as the research line related to the need to research new or emerging viruses that can infect humans was placed as the highest priority. This research line is of foremost importance to Latin America, as this region is particularly vulnerable to vector-borne infectious diseases (transmitted through insects like mosquitoes) and changing climate patterns can expand the range of disease vectors, increasing the risk of outbreaks.

Table 2. Ranking of the research priorities for SDG 3: Good Health and Well-being (1st round).

Rank	Specific Research Lines
1	New or reemerging viruses that can infect humans
2	Impact on health of soil, freshwater, and air pollution
3	Tropical communicable diseases
4	Human resistance to antibiotics
5	Regenerative medicine
6	Reproductive health and neonatology
7	Type 2 diabetes
8	Drugs and vaccines for tuberculosis
9	Human immunodeficiency virus (HIV)



Scheme 2. Level of agreement regarding the research priorities for SGD 3 for South America (2nd round).

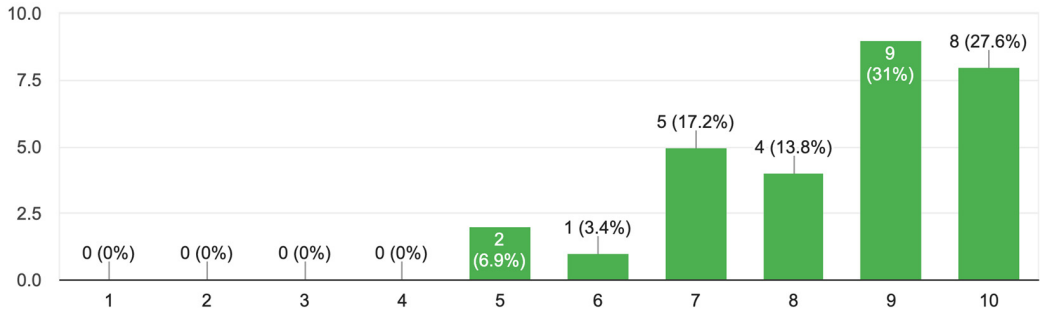
At the country level, there was a similar assessment of the impact of the lines linked to SDG 3. However, there was a more moderate degree of agreement than at the regional level.

Regarding SDG 6: Clean Water and Sanitation (Table 3), 58.6% of the experts indicated total agreement (10) or very high (9) (Scheme 3). In their additional comments, the experts highlighted the importance of these specific research lines linked to this SDG. However, local and national particularities can influence in which way these lines can have the most significant impact. Sustainable freshwater extraction and supply, placed as the main priority research line, can be particularly important for many rural and indigenous communities in Latin America that rely on local water sources for drinking, sanitation, and agriculture. Climate change can affect these water sources, disproportionately impacting vulnerable communities. Research in this field can assist in understanding the specific challenges these populations face and develop solutions to ensure access to clean water. At the national level, 62.9% of the experts indicated total agreement (10) or very high (9), with only one expert showing disagreement (4) and considering that this order does not entirely correspond to the context of Paraguay.

For SDG 7: Affordable and Clean Energy (Table 4), 55.5% of the experts indicated total agreement (10) or very high (9) regarding the ranking presented (Scheme 4). Cleaner fossil fuel technology is considered the most important research line, as Latin America is a significant contributor to global greenhouse gas emissions, primarily due to its reliance on fossil fuels for energy generation. Research within the context of SDG 7 can help identify and promote cleaner energy sources and technologies, such as renewables (solar, wind, hydrogen, and geothermal) and energy efficiency measures.

Table 3. Ranking of the research priorities for SDG 6: Clean Water and Sanitation (1st round).

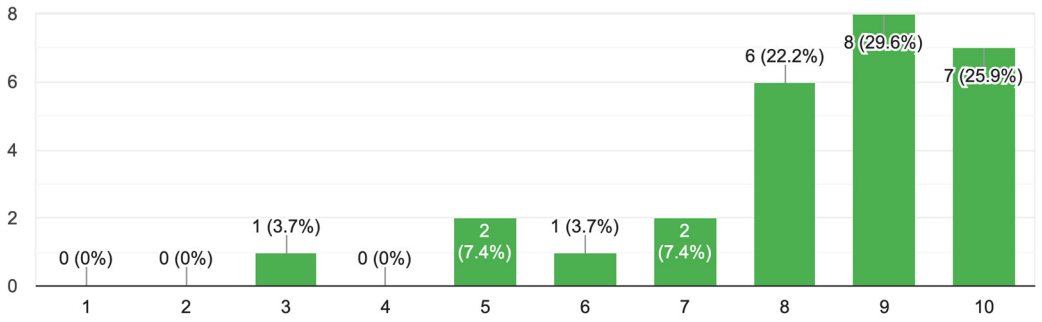
Rank	Specific Research Lines
1	Sustainable freshwater extraction and supply
2	Integrated national water resources management
3	Transboundary water resources management
4	Water collection
5	Wastewater treatment, recycling, and reuse



Scheme 3. Level of agreement regarding the research priorities for SGD 6 for South America (2nd round).

Table 4. Ranking of the research priorities for SDG 7: Affordable and Clean Energy (1st round).

Rank	Specific Research Lines
1	Cleaner fossil fuel technology
2	Hydropower
3	Biofuels and biomass
4	Smart network technology
5	Photovoltaic
6	Nuclear fusion
7	Wind turbine technologies
8	Geothermal energy
9	Hydrogen energy



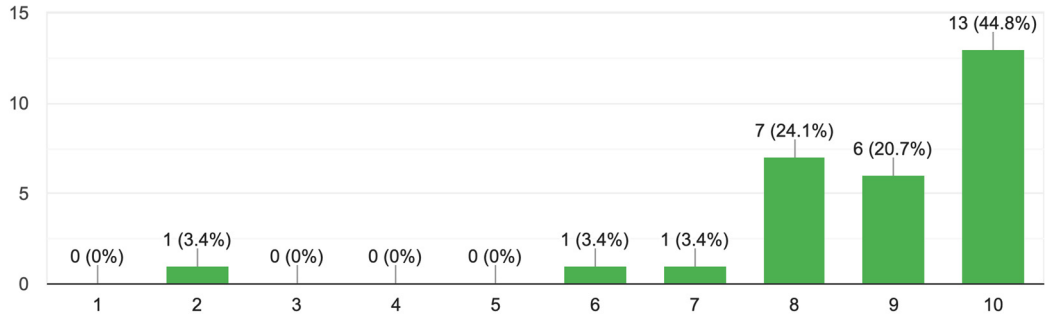
Scheme 4. Level of agreement regarding the research priorities for SGD 7 for South America (2nd round).

Other experts, who show a more moderate degree of agreement (or even disagreement, in one of the cases), considered that the impact of some of the research lines does not correspond to the region's reality, as is the case for smart network technologies or nuclear fusion. On the other hand, they considered that research on hydrogen energy should have greater prominence based on its potential impact on the region. The assessments obtained at the country level were similar to the regional level, although it was noted that the level of total agreement (10) was only 11.5%. At the national level, it is worth highlighting the case of photovoltaic energy, considered an energy source of enormous potential in Bolivia.

Focusing on SDG 9: Industry, Innovation, and Infrastructure (Table 5), the experts showed a very high degree of agreement on its potential impact on the region, with 65.5% of the experts indicating total agreement (10) or very high (9) (Scheme 5). A common observation among several experts was related to the importance of developing research in sustainable transport, which is considered the line of research with the most potential impact regarding this SDG. Transportation is a significant contributor to greenhouse gas emissions globally. Therefore, by investing in sustainable transportation infrastructure and policies, Latin American countries can make substantial progress towards achieving multiple SDGs while simultaneously combating climate change. The most noted discrepancy corresponds to the eco-construction materials, indicated by one of the experts as a research line of great potential in the region.

Table 5. Ranking of the research priorities for SDG 9: Industry, Innovation, and Infrastructure (1st round).

Rank	Specific Research Lines
1	Sustainable transport
2	Eco-industrial waste management
3	Increased battery efficiency
4	Eco construction materials
5	Carbon pricing



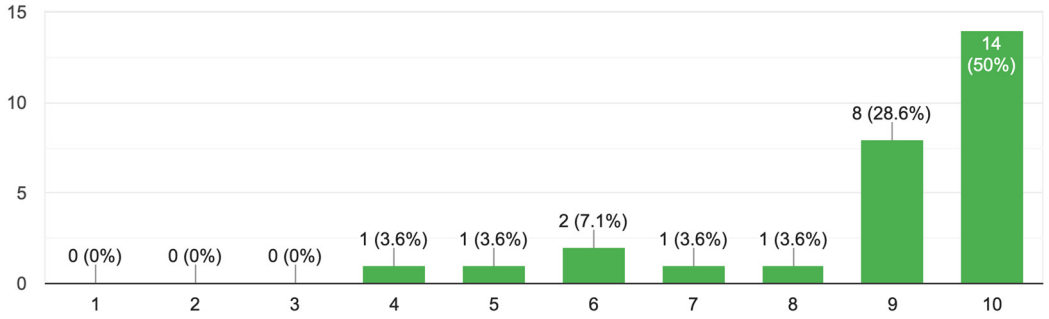
Scheme 5. Level of agreement regarding the research priorities for SGD 9 for South America (2nd round).

At the national level, the results reflect a similar global perspective of the panel. The experts pointed out the potential impact sustainable transport and more efficient batteries can have, especially for Bolivia. Battery efficiency is a critical factor in the transition to a low-carbon and sustainable energy future, enabling the effective use of renewable energy, reducing greenhouse gas emissions, enhancing grid resilience, and promoting cleaner transportation. The greater importance given to the research on eco-construction materials is also noted nationally.

The lines of research linked to SDG 13: Climate Action (Table 6) also had a high level of agreement regarding its impact at the regional level, with a level of total agreement (10) or very high (9) among 78.6% of the experts (Scheme 6). The main research priority is related to the local impact of climate-related hazards and disasters. Researching local impacts can help to identify regions and communities that are the most vulnerable to climate-related hazards and disasters. Therefore, understanding the specific vulnerabilities of these areas is crucial for targeting resources and assistance effectively. One expert considered that research on national and urban greenhouse gas emissions should be the most significant impact linked to this SDG. At the national level, there was a higher concentration in the distribution of responses, with none of the experts showing disagreement with the ranking. Likewise, at the national level, one expert considered the research on national and urban greenhouse gas emissions as the most important link to this SDG.

Table 6. Ranking of the research priorities for SDG 13: Climate Action (1st round).

Rank	Specific Research Lines
1	Local impact of climate-related hazards and disasters
2	Local disaster risk reduction strategies
3	New technologies to protect against climate-related hazards
4	Climate-ready crops
5	National and urban greenhouse gas emissions
6	Carbon capture and storage

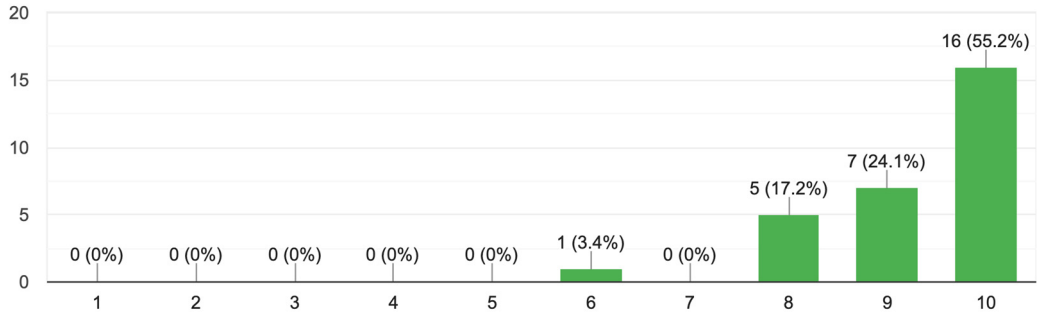


Scheme 6. Level of agreement regarding the research priorities for SGD 13 for South America (2nd round).

Considering the research lines linked to SDG 15: Life on Land (Table 7), there was a higher level of agreement, with 79.3% of experts indicating a total (10) or very high (9) agreement (Scheme 7). The top priority research line is related to the state of terrestrial biodiversity, contributing to evaluating the effectiveness of conservation and restoration efforts and adjusting strategies as needed.

Table 7. Ranking of the research priorities for SDG 15: Life on Land (1st round).

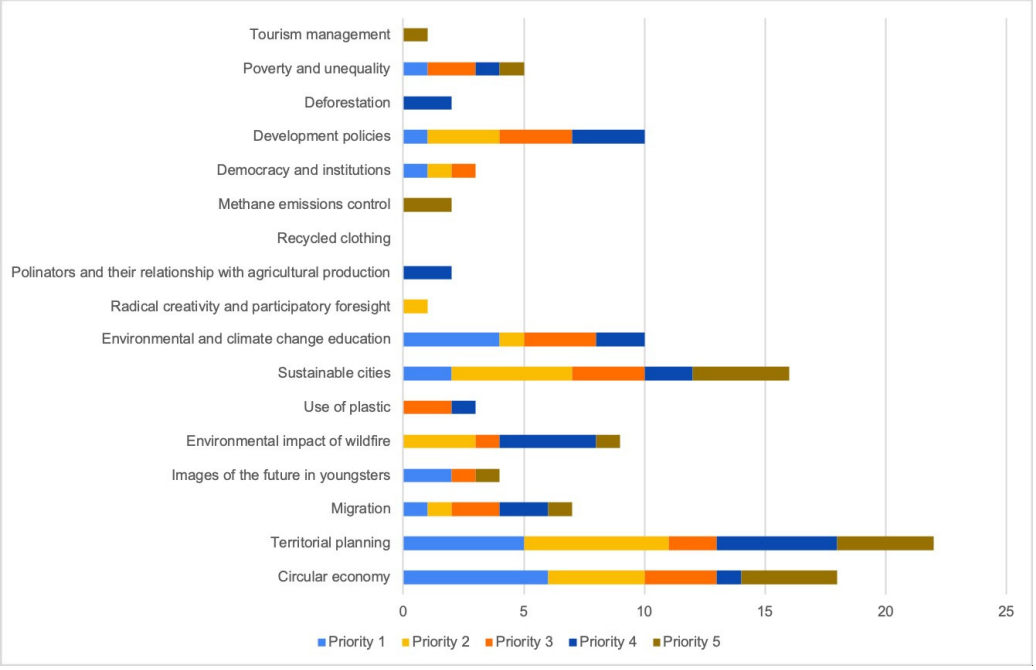
Rank	Specific Research Lines
1	State of terrestrial biodiversity
2	Sustainable use of terrestrial ecosystems
3	Extension of water-related ecosystems
4	Socioecological impact of terrestrial protected areas
5	Use of ecosystem-based approaches in terrestrial protected areas
6	Minimize poaching and trafficking of protected species
7	Addressing invasive alien species



Scheme 7. Level of agreement regarding the research priorities for SGD 15 for South America (2nd round).

At the country level, there is a very similar agreement level. Nevertheless, some of the experts considered that specific research on ecosystems in terrestrial protected areas and on the sustainable use of terrestrial ecosystems would have the most significant potential mpact.

Finally, the experts were asked to rank the other research lines identified in the first round (1 being the highest priority and 5 being the lowest priority) (Scheme 8). The research lines about territorial planning and organization, the development of the circular economy, and sustainable cities stand out as the highest priorities, with the first two being valued as priority 1 or 2 by more experts. Overall, these lines of research seem interconnected and contribute to an integrated approach to climate change mitigation and adaptation, especially in urban areas, where the impact of emissions can be more evident.



Scheme 8. Level of priority for the additional research lines proposed by the panel.

It should also be noted that four experts considered education on the environment as the research line that deserves a higher priority. Although this perspective had less consensus among the experts, research on environmental education can be a powerful tool for building a more informed, engaged, and environmentally responsible society. By promoting climate literacy, sustainable behaviors, and active citizenship, environmental education can contribute significantly to the global effort to manage climate change in Latin America.

This study was based on identifying and evaluating future global trends of innovative research in the field of climate change, focusing on potential applications for development within Bolivia and Paraguay. It orients public administration and financing entities toward the lines of research that show the most significant potential to generate a greater impact on climate change at the national and regional levels. Also, it guides researchers toward the research lines that can allow the creation of networks or research centers aimed at developing research that may be key to the region's development and the fight against climate change.

5. Conclusions

For SDG 2: Zero Hunger, the priority research line at the regional level is related to maintaining the genetic diversity of food crops, followed in order of importance by agroecology, aid to small scale-food producers, traditional knowledge, pest-resistant crops, and precision agriculture. This strategic alignment had a high consensus for Latin America. Regarding the potential impact at the country level, the level of the agreement remained high. However, the concentration of results was low, considering some experts said that this order did not correspond to the priorities in Paraguay.

In the case of SDG 3: Good Health and Well-being, the main research line at the regional level is related to new or reemerging viruses that can infect humans, followed by the impact on health of soil, freshwater, and air pollution; tropical communicable diseases; human resistance to antibiotics; regenerative medicine; reproductive health and neonatology; type 2 diabetes; drugs and vaccines for tuberculosis; and human immunodeficiency virus (HIV). The participants showed a high level of agreement, and the emergence of COVID-19 eventually impacted this assessment. As for countries, we observed a similar assessment, although showing a more moderate level of agreement than at the regional level.

For SDG 6: Clean Water and Sanitation, the priority research line refers to sustainable freshwater extraction and supply, followed by integrated national water resources management, transboundary water resources management, water collection and wastewater treatment, recycling, and reuse. This ranking had a high level of agreement at the regional level. The results at the national level also showed a high level of agreement, with only one expert demonstrating disagreement regarding the context of Paraguay.

For SDG 7: Affordable and Clean Energy, the priority research line is cleaner fossil fuel technology, hydropower, biofuels and biomass, smart network technology, photovoltaics, nuclear fusion, wind turbine technologies, geothermal energy, and hydrogen energy. The results showed a high level of agreement by most experts; however, some experts considered that the impact of some of the research lines did not correspond to the region's reality, as was the case for smart network technologies or nuclear fusion. On the other hand, research on hydrogen energy should have a more significant role, depending on its potential impact on the region. At the country level, the assessments were similar to the regional level. Among the observations on the research lines of most significant impact at the national level, it is worth highlighting photovoltaic energy, considered an energy source of great potential in Bolivia.

Regarding SDG 9: Industry, Innovation and Infrastructure, the priority research line refers to sustainable transport, followed by eco-industrial waste management, increased battery efficiency, eco-construction materials, and carbon pricing. The experts showed a high agreement on its potential impact on the region. The most notable discrepancy concerning the ranking corresponded to the position of the research line eco-construction materials, indicated by one of the experts as a line of great potential in the region. At the national level, the results reflected a similar perspective, with Bolivian experts indicating the higher potential impact of the combined research lines of sustainable transport and higher battery efficiency. The research line of eco-construction materials was also noted as important at the national level.

For SDG 13: Climate Action, the priority research line refers to the local impact of climate-related hazards and disasters, following local disaster risk reduction strategies, new technologies to protect from climate-related risks, climate-ready crops, national and urban greenhouse gas emissions, and carbon capture and storage. These research lines were highly valued at the regional level. However, there was a minor disagreement regarding research on national and urban greenhouse gas emissions, which should be considered the most significant impact of this SDG. At the national level, there was a greater concentration in the distribution of responses, with none of the experts showing disagreement.

For SDG 15: Life on Land, the priority research line is the state of terrestrial biodiversity, followed by sustainable use of terrestrial ecosystems, extension of water-related ecosystems, the socioecological impact of terrestrial protected areas, use of ecosystem-based approaches in terrestrial protected areas, minimizing the poaching and trafficking of protected species, and addressing invasive alien species. These research lines had a higher agreement concerning their impact at the regional level. At the country level, the results also reflected agreement among the experts. However, at the national level, some experts considered research on biodiversity to have the most significant potential impact, specifically on ecosystems in protected terrestrial areas, in addition to research on the sustainable use of terrestrial resources.

Finally, the experts identified other priority research lines that should have been added to the SDGs initially discussed, namely territorial planning and organization, development of the circular economy, sustainable cities, and environmental education.

The contribution of this work can be beneficial for Bolivia and Paraguay in four specific contexts: it contributes to the academic environment by identifying the priority research lines to which academics should pay more urgent attention and presenting a methodological approach (based on the Delphi method) that can be answered; it shows the private sector which themes will be more impactful and, therefore, provide guidelines that enable and support decision-making; it gives indications to the government sector

about which research lines are a priority and how public policies can be adjusted; and finally, it presents guidelines for society and, more specifically, for local communities about sustainable pressing issues that can impact climate change.

As for the limitations of the study, it is considered that the identification of only two case studies (Bolivia and Paraguay) may be limiting for a Latin American context, and as such, more studies with more territorial coverage will be necessary to understand more comprehensively the future scenario regarding research on sustainability and its impacts on climate change in Latin America. Also, the fact that each Delphi panel is unique and valid on its own could be seen as a limitation. The same study applied to different experts may present different results. As such, more studies are needed to better support these results.

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