



Consortium¹

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Introduction

Social Innovation Management for Bioplastics (SIMBIO) is a Trans-Atlantic Platform-funded project with an objective to develop social interventions that will address the environmental and social challenges of bioplastic food packaging throughout its entire supply chain from production to end-of-life management. The scope of this project focused on bioplastic packaging made from bio-based polymers since it has a large potential impact on both food systems and waste management systems worldwide. Both biodegradable (including compostable) and non-biodegradable bio-based plastic packaging were considered.

A social innovation lab process was used to strategically bring participants together to develop a common understanding of a problem and work together on innovative solutions through iterations of information collection, analysis, creative engagement, and prototype development. It provided a whole systems approach with the intent of exploring solutions that result in a profound and permanent shift in the social system. The objective of the social innovation lab is to answer the following research question:

What are the social and environmental roles of bioplastic packaging in the global context of sustainable food production and consumption?

Project Progression

Each consortium member followed a similar social innovation lab process that involved key informant interviews to define the challenge of bioplastics and a series of three workshops to

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understand the problem in a systemic way, explore solutions, and prototype solutions (Figure 1). This process was customized for each country based on the local context, participants, and restrictions due to the COVID-19 pandemic. Dissemination activities occurred throughout the project through conferences, academic publications, media, and on the project's website. A description of how the project was implemented in each country and jointly is described in the sub-sections.

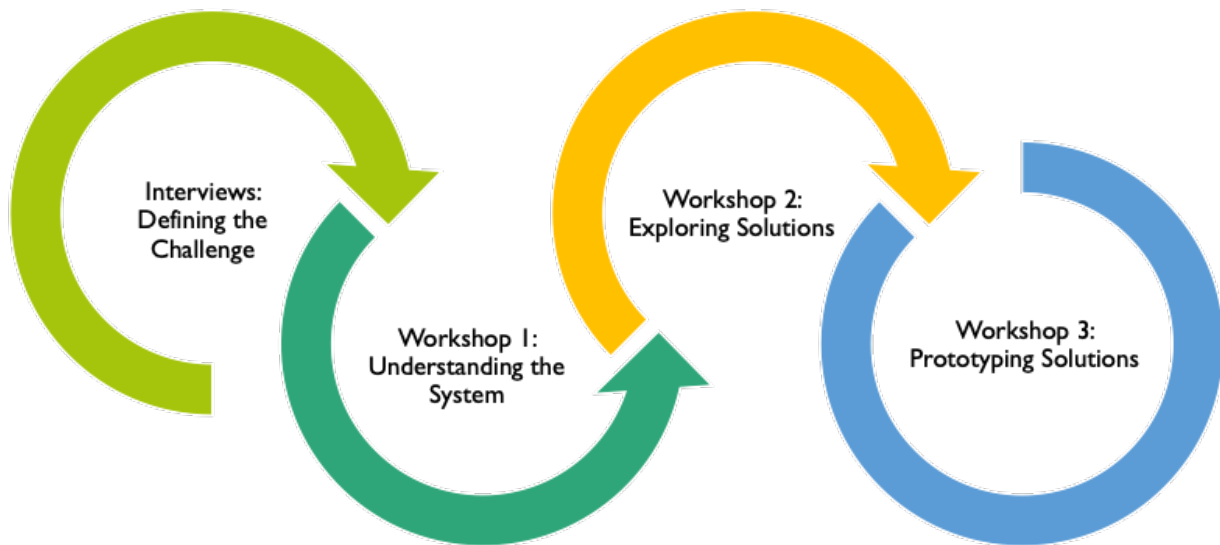


Figure 1: Social innovation lab process

Brazil

Defining the Challenge: Due to the COVID-19 pandemic, research activities began later in Brazil and commenced in June 2020. Twenty-seven semi-structured interviews were conducted with participants that included: companies producing raw materials, packaging companies/start-ups, food manufacturers, recyclers, solid waste pickers cooperatives, associations, researchers, consumers, and policy makers. Themes from the interviews included materials and alternatives that are already on the market, cost of new technologies in packaging, gaps in Brazilian legislation and regulations for biodegradables, lack of societal knowledge during consumption and correct disposal of different types of packaging, and concern in waste management and social impact for waste pickers cooperatives.

Understanding the System: The first workshop took place in July 2021 using Zoom. Participants analyzed the main challenges and barriers in the production, use and end-of-life management of bioplastic packaging. Participants discussed legislation, waste management and impact for cooperatives and waste pickers, production and consumption, and cost of bioplastics.

Exploring Solutions: The second workshop took place in December 2021 using Zoom. The objective of the event was to expand the discussion through possible solutions that challenge

the norms in bioplastic packaging, in addition to identifying promising prototypes. However, different stakeholders participated in Workshop 2 compared to Workshop 1. Despite the advancement of the discussion, we noticed the interest of some participants regarding the deep understanding and need for space to address the theme specifically in their expertise areas.

Prototyping Solutions: The third workshop took place in June 2022 in a hybrid format with some participants online and others in person. This workshop was also open to the public. The initial objective was to prototype solutions and evaluate their feasibility and possible impacts for field prototyping. Instead, the format was changed to presentations by 13 stakeholders to explain their products already developed or under development in Brazil and pitch potential solutions that can be applied in the Brazilian reality. The event was presented in 4 sessions with the following themes: Legislation, Market, Waste Management and Research and Development. After each block of presentations, the Social Innovation Lab methodology was applied through interactive debates between the team, stakeholders, and general consumers.

Dissemination: Two scientific articles have been published. Two other journal articles are currently being prepared. Results from the project were presented at the 2022 Global Conference on Polymers, Plastics and Composites (PPC), held in Budapest, Hungary, in March 2022. Results were also disseminated at the Virtual Meetings on Materials and Science (e-Mat&Sci) – 2020 and 2021, held in Brazil. With the aim of expanding the project's visibility nationally, as well as disseminating information and awareness to the broad masses, some social networks were created for the SIMBIO Brazil team on Facebook, Instagram and LinkedIn platforms. Social media were created from the analysis of the interviews, since one of the key problems was the lack of knowledge and awareness of Brazilian. Posts were made about the study as well as general information about bioplastics, biopolymers, biodegradables, and recycling. Also, 12 media interviews were conducted through TV, radio, and electronic news agencies.

Canada

Defining the Challenge: Twenty-eight participants for interviews were recruited through contacts known by the researchers in industry networks in bioplastics, compostable bioplastic packaging, food production, food manufacturing, food retail, and waste management. A literature review was conducted to triangulate and supplement the information collected from the interviews. The literature review and key informant interviews took place from February to July 2020, with supplemental interviews in May and June 2021. A design brief based on the key informant interviews was prepared and formed the content for a webinar in August 2020. At this webinar, key findings were presented, and participants discussed these findings in break-out groups. These discussions formed the basis of developing a convening question for the social innovation lab.

Understanding the System: In the first workshop (Oct-Nov 2020), participants gathered to develop a common understanding of the key challenges and barriers in the production, use, and end-of-life management of bioplastic packaging. This workshop was divided into three

shorter sessions, spaced one week apart, and hosted online using Zoom. Activities included building group timelines, systems mapping, and identifying leverage points. From this workshop, a few areas of focus were identified: differentiating bioplastic products from each other, materials used to make bioplastics, role of bioplastics in packaging food, handling bioplastics from one stage to the next in the supply chain, and product design and the innovation process/pipeline.

Exploring Solutions: In the second workshop (Feb 2021), participants evaluated current systems in bioplastic packaging and discussed potential social innovation solutions that could be rapidly prototyped. This workshop was divided into two sessions, spaced one week apart. Gather.Town was used for the first session and Zoom was used for the second session. Participants explored some of the focus areas from the first workshop through a bricolage exercise and mapping out potential solutions on a business model canvas. The solutions explored in this workshop were: bioplastic durable packaging reuse cooperative/sharing system, ban on single-use bioplastics, and Extended Producer Responsibility for bioplastics.

Prototyping Solutions: In the third workshop (Apr 2021), participants prototyped potential solutions using a gamification approach to evaluate the feasibility, practicality, and potential impacts of solutions. The workshop was divided into two sessions, spaced one week apart, and hosted online using Zoom. One game was centred on a common theme participants raised throughout the project of needing to differentiate compostable plastics from others. Participants designed labels for different types of plastics (including compostable plastics) in groups and then tested how well these plastics were sorted by other groups through a quiz game on the Kahoot! platform. The key insight from this exercise was that just having standardized labels may not be adequate for differentiating compostable plastics from others. In the second game, the solution idea of banning single-use plastics was prototyped. Participants designed a retail system without single-use plastics in groups for a specific product which was then evaluated by another group for its feasibility. Key themes that emerged from this game was the importance of scale, localization, and equity when making changes to packaging systems.

Dissemination: Following the last workshop, a policy paper was written and distributed to interview and workshop participants in October 2021, which included multiple levels of government. A conference paper was accepted and presented to the IBIMA conference in May 2022. A journal article summarizing the social innovation lab findings from Canada was published in the Journal of Sustainable Production and Consumption in September 2022. In January 2023, a journal article about adapting a social innovation lab from in-person to online was published by the International Journal of Qualitative Methods. Insights from this project were quoted in articles in the National Observer (November 2020) and Chatelaine Magazine (November 2022).

Poland²

Defining the Challenge: The first phase of the project took place from September 2020 to April 2021. The starting point for carrying out the first phase of research was a systematic literature review on the circular economy and bio-packaging supply chains which included 98 scientific articles that were selected for final analysis. The results of the analysis were used to develop and conduct a qualitative study in the form of 29 in-depth interviews (IDIs) with representatives of internal stakeholders (e.g., suppliers of raw materials and bioplastics, packaging manufacturers, packaging distributors, consumers) and external stakeholders (e.g., organisations for standardisation and certification of materials and packaging, waste management entities, public administration institutions at central and local levels, non-governmental entities, scientific and research institutions) of bio-packaging supply chains. In addition to the interviews, two meetings were held online (Zoom, Microsoft Teams). The first meeting was aimed at presenting the project assumptions to the representatives of the stakeholders, getting to know the scope of activities and directions of development of cooperation in the project. The second meeting was a dialogue aiming at diagnosis including the identification of activators, supporting factors and barriers to the development of the market of bio-packaging (including compostable packaging) for food in Poland, based on the principles of circular economy.

Building partnership relations with interview participants made it possible to invite them also to participate in the Social Innovation Lab workshops (SILs). At the same time, however, continuous search for new project stakeholders and their recruitment was carried out.

Understanding the System: This phase was implemented from February to November 2021, with the first workshop taking place in October 2021 using Microsoft Teams. The first Social Innovation Lab was aimed at recognition and understanding of problems and barriers to the development of supply chains of food bio-packaging (including compostable packaging) in Poland in accordance with the principles of the circular economy.

Exploring Solutions: This phase was implemented from July 2021 to March 2022. The second workshop took place in January 2022 using Microsoft Teams. Participants gathered to recognize and assess potential solutions dedicated to the causes of problems and barriers to the development of the bio-packaging market.

Prototyping Solutions: This phase was implemented from November 2021 to December 2023. The third workshop took place in April and June 2022 using Microsoft Teams. The last workshop was focused on rapid prototyping and testing three most urgent solutions, indicated by stakeholders as those with the greatest potential to stimulate the development of the compostable packaging market in Poland.

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Dissemination: After each project phase, a research report was written and distributed to Polish project stakeholders. Additionally, executive summaries in English were developed and made available to the international audience via the SIMBIO website. Project results were presented at nearly 30 conferences and seminars. Several articles have also been published in journals, such as Sustainability, Energies, European Journal of Sustainable Development and European Research Studies Journal. In September 2022, a stationary scientific seminar entitled "Compostable packaging - innovations for the development of the food packaging market" was hosted by the Polish team at SGH Warsaw School of Economics and attended by 38 participants. The seminar program consisted of three parts with the participation of special guests and stakeholders of the project. A paper was submitted to the International Journal of Emerging Markets in January 2023 and is under review. In February 2023, a paper written by the Polish and UK team was submitted to the Global Environmental Change. A paper has also been resubmitted to Industrial Marketing Management.

United Kingdom

Defining the Challenge: During this phase, the objective was to explore the different types of bioplastics, their contribution to sustainable development, and their current production, use, and end-of-life management processes. In addition, this phase aimed to identify key stakeholders, enablers, and inhibitors to adopting bioplastic packaging. This phase was accomplished by delivering an academic paper that describes the current status of biobased biodegradable plastics and by conducting 16 semi-structured interviews with stakeholders from the UK bioplastics industry.

Understanding the System: The objective was to develop a shared understanding of the challenges and barriers associated with the production, use, and end-of-life management of bioplastic packaging with stakeholders. The first lab workshop was held in March 2021 using Zoom. Considering the diversity of attendees (academics, waste management representatives, consumers, bioplastic producers, NGOs, local governments, and government agencies), the workshop began with a presentation of some of the key concepts, highlighting the importance of fossil-based plastics as well as the opportunities and challenges for bioplastics packaging. After the presentations, three break-out sessions focused on different aspects of the bioplastic packaging supply chain: production, consumption, and waste management. In each break-out session, participants completed three tasks: identifying their place within the system, seeing the system, and identifying barriers and opportunities for growth. Facilitators guided these activities using the collaborative whiteboard platform Miro. Ten important solutions emerged from the lab.

Exploring Solutions: The objective was to determine the leverage points that would unlock the bioplastic packaging supply chain, evaluate current innovations in bioplastic packaging, their successes and shortcomings, and develop ideas for social innovation solutions. The second workshop was held in June 2021 using Zoom. At the workshop, the main findings of the first lab were presented and the concept of 'System Thinking' was introduced to facilitate the selection of impactful solutions. Participants were asked to prioritise biobased biodegradable

(compostable) plastic packaging solutions from the first social innovation lab. The ten solutions were grouped into six clusters: communication with consumers, educational programmes, certification standards & guidelines, specific products and more feedstocks, end-of-life and policies. Mentimeter's online survey (menti.com) enabled real-time anonymous feedback; as a result, communication with consumers, certification standards & guidelines, and end-of-life received the most votes. After the survey, stakeholders were invited to identify the most 'infuriating' plastic packaging they encountered daily and explain how to improve it. To conclude, the participants were split into five break-out rooms to discuss the possible solutions (clusters) that were prioritised and prioritise solutions that will be implemented over the next ten years.

Prototyping Solutions: Social innovation lab solutions were tested and prototyped using the lab's "container". The third workshop was held in November 2021 as a hybrid of online and in-person. The third workshop consisted of three parts. Experts presented their expertise on each of the six solution areas. Participants then discussed each cluster solution in break-out group discussions in terms of its transformative potential. A prototyping game to test scenarios of implementing solutions for different packaging products was played. The break-out discussions posed three evaluative factors for participants to explore regarding solutions: feasibility, practicality and configurations for proposed innovations. Following the break-out discussion task, the third part of the workshop featured a scenario game to prototype feasible systemic solutions for specific biobased biodegradable plastic products.

Dissemination: A systematic literature review was published in Sustainability. Following the three workshops, industrial reports were published for the stakeholders. Researchers from the team attended workshops/conferences, including presentations with Garden Organic and Bioladies, as well as posted information in different social media.

Joint Activities

A team website, simbioresearch.com, was established at the outset of the project with a blog that is co-authored by consortium members to share updates as the project progressed.

Throughout the project, team members regularly participated in the social innovation lab workshops organized by other consortium members to promote cross-team learning. For example, teams that were less familiar with social innovation labs were able to see how different activities are facilitated and then used the newly acquired knowledge for their own labs.

In July 2022, a global webinar was hosted by the consortium to present key findings of the project. Project participants from the consortium were invited to attend this webinar, as well as other relevant contacts from the consortium. Highlights from each consortium member were presented at this webinar. Following all the presentations, there was a question-and-answer session with audience members. A total of 54 people attended this webinar.

In November 2022, consortium members attended the Trans-Atlantic Platform (T-AP) Conference "Social Innovation – Learning from Multinational Collaboration". The Project Leader

presented key findings from the project overall. Three of the Principal Investigators presented statements based on findings from their teams for breakout discussion groups.

Project Management

Overall coordination of the project for the consortium was done by the two research associates from the Canadian team. The research associates organized monthly meetings for the consortium during the first 2.5 years of the project (January 2020 to May 2022), and then meetings as needed afterwards. At these meetings, consortium members provided updates on project progress and collaborated on joint activities. Project management for each country is summarized below.

Brazil

The project was managed by a post-doctoral fellow who was responsible for coordinating project activities, liaising with partners in the consortium, and dissemination activities. Online meetings were held weekly with the PI and a research associate, which formed the core team.

Canada

The project was co-managed by the PI and two part-time research associates. The research associates were responsible for project administration, including coordinating project team members and participants, communication with participants, financial management, and implementation logistics. The PI was responsible for project oversight, decision-making, and liaising with co-PIs.

Poland

The project was co-managed by the PIs from SGH Warsaw School of Economics and University of Lodz and research associates. The PIs were responsible for project leadership, research design and implementation, research results dissemination, communication with project stakeholders, cooperation in the project team, budget planning, and implementation. The research associates were responsible for supporting research design and participating in its implementation as well as active research results dissemination.

UK

The project was organized by Coventry University's Centre for Business in Society in the UK. The research team consisted of the PI and three Co-Investigators. One of the Co-Investigators acted as the project coordinator. The PI was responsible for oversight of the project and administering the funding allocated. Research activities were led by the project coordinator who also was the main point of contact for the activities of the consortium. Internal communication was conducted by email exchanges and online meetings.

Lessons Learned

Virtual Adaptation

For all consortium members, adapting the social innovation lab process from an in-person to online experience brought both challenges and benefits. Almost all interviews, stakeholder workshops, and consortium interactions took place virtually using online platforms.

Additional time and resources were used to develop and test new methodologies to run social innovation labs in a virtual setting, as well as engage stakeholders across the supply chain for interviews and workshops. Adapting the social innovation lab model to a virtual format required flexibility and creativity. In Poland, the close and ongoing cooperation of researchers representing two universities using online tools was a key success factor in managing the research process because it allowed them to achieve and maintain flexibility in the selection of methods and the implementation of project tasks for the labs. The Canadian team held multiple online sessions for each of the three workshops with varied activities instead of one-day sessions following a well-defined methodology that had been used before. In Canada and the United Kingdom, gamification was added for rapid prototyping, which was a new approach that had not been used before by the consortium in a social innovation lab context. In addition to videoconferencing (Zoom, Microsoft Teams), different online platforms were employed to enhance different forms of interaction with participants, including Gather.Town, Kahoot!, Miro, and Mentimeter. While there is a steep learning curve for both researchers and participants, these tools proved to be very helpful to engage in activities that involved a lot of participant interaction and feedback in a more structured way. For example, Miro was used by multiple teams to visually organize ideas during discussions and help participants create a shared mental model.

One advantage of going online was that participants could be recruited from a broader geography and offer different perspectives. In Canada, which covers a wide geography across multiple time zones, stakeholders such as the federal government, international businesses, and international organizations were able to attend online workshops but would have likely not participated in-person due to the additional travel time and expense. In Poland, access to remote communication technology made it possible to attract attention of the highest-level representatives of stakeholders and to involve them into the SIMBIO project, regardless of location. Participation in the project became easily accessible online and open to stakeholders without any costs. While going online broadened the types of participants, it also created a barrier for some participants who are important to involve. In Brazil, waste pickers are responsible for collecting 90% of recyclables and dependent on the sale of these materials for their income and survival. However, most of them are still very vulnerable professionals, and therefore had difficulties accessing the online platforms, which limited their participation in the first workshop. In subsequent workshops, we involved waste pickers with support from the team for their virtual participation (in the second workshop) and in person (in the third workshop, which had a hybrid format).

Multi-Stakeholder Collaboration

This project demonstrated a need for multi-stakeholder collaboration to address the social and environmental challenges associated with bioplastic packaging. Collaborative approaches to social innovation can contribute to understanding and overcoming the challenges of bioplastic packaging since stakeholders have a variety of experiences, including production, certification, retail, and end-of-life.

Collaborative research requires engagement of diverse participants. It is not always possible to have representation across all sectors. Each consortium team faced different challenges in participant recruitment. In Brazil, it was difficult to recruit public authorities and government agencies. Two interviews with representatives of the local government were conducted, but there was no participation in the subsequent workshops. On the other hand, there was a lot of engagement of governments at multiple levels in Canada, but participation of the waste management sector was more limited. In Poland and in the UK, the start of the recruitment process was associated with the challenge of recognizing the market and developing a comprehensive list of its participants with organization names and addresses. Since no databases have been created to integrate external and internal stakeholders of food bio-packaging supply chains, this had to be created by the research team. Another challenge that was encountered by all teams is consistent participation throughout the different stages. This made it difficult to advance discussions if they drew on content from a previous workshop. Participation was voluntary and normally did not include a financial incentive (although in some cases a small honorarium was offered). Therefore, commitment of participants was mostly based on interest and availability. To bridge this gap, workshop summaries were prepared and circulated to participants and the opening presentations included a recap of the previous workshop.

A diversity of participants also comes with diverse opinions. One of the strengths of social innovation labs is that they are purposely designed to reveal divergences and convergences on a topic. Different opinions are expected, and the lab is intended to hold and explore those tensions. For example, some participants see bioplastic packaging as an innovation that should grow out of its niche to transform the packaging market towards a more environmentally friendly alternative. Other participants view bioplastic packaging as a continual problem even though it is promoted as being environmentally friendly because of the lack of facilities for proper processing or unwillingness of facilities to accept these items due to the high risk of contamination. Many stakeholders also had different ideas of what bioplastics are and how they are to be managed because the sector has not yet attained widespread standardization and regulation. Therefore, adopting selected common definitions of key terms for stakeholder dialogue and collaboration is important to generating more productive discussions. Stakeholders across the bioplastic packaging sector need to unite in terms of both the biodegradability of bioplastic materials and the strategies through which collaboration is possible.

We also identified that there is a fundamental need for increased awareness and accountability alongside collaboration in the bioplastic packaging sector. This must be bi-directional from producers to consumers, supported by educational programmes that tackle both the consumer bewilderment with bioplastic materials and their recycling procedures, as well as better policy integration. Collaboration in the development of bioplastic packaging products is also necessary such that products are created and then used and processed at the end-of-life in a completely closed cycle versus the current situation in most places where these products are disposed of as waste.

Through the broad and in-depth involvement of stakeholders in a social innovation lab process, we uncovered hidden and not yet realized potential for cooperation between stakeholders to close the life cycle of bioplastic packaging in accordance with the circular economy principles. We revealed that a concerted effort and multiple solutions are needed: communication with consumers, educational programs, certification standards, research and development for specific products and feedstocks, end-of-life management, and policies.

Indicators to Measure Success

The following table summarizes key metrics from the consortium related to stakeholder engagement, knowledge mobilization, and training. We consider this project a success in terms of being able to engage the number of stakeholders as expected, mobilizing knowledge through multiple avenues (academic publications, reports, conferences, media), and supporting training for students and early-career researchers.

Table 1: Key Metrics and Impacts

Team	Stakeholder Engagement	Knowledge Mobilization	Training
Brazil	<ul style="list-style-type: none"> ● 27 key-informant interviews ● 24 Workshop 1 participants ● 18 Workshop 2 participants ● 13 Workshop 3 participants + general public 	<ul style="list-style-type: none"> ● 2 journal articles published ● 2 journal articles being prepared ● 3 workshop summaries ● 3 conference presentations ● 13 media interviews ● 2 social media channels 	<ul style="list-style-type: none"> ● 1 post-doctoral fellow ● 1 undergraduate research assistant
Canada	<ul style="list-style-type: none"> ● 28 key-informant interviews ● 11 webinar participants ● 27 Workshop 1 participants ● 23 Workshop 2 participants 	<ul style="list-style-type: none"> ● 2 journal articles published ● 1 design brief ● 6 workshop summaries ● 1 policy paper ● 1 webinar ● 2 media interviews 	<ul style="list-style-type: none"> ● 7 undergraduate research assistants ● 2 Masters students

	<ul style="list-style-type: none"> ● 22 Workshop 3 participants 		
Poland	<ul style="list-style-type: none"> ● 29 key-informant interviews ● 22 Workshop 1 participants ● 26 Workshop 2 participants ● 28 Workshop 3 participants 	<ul style="list-style-type: none"> ● 6 journal articles published ● 3 journal articles submitted ● 2 journal articles being prepared ● 1 in-depth interview report ● 3 workshop summaries ● 4 executive summaries ● 33 conference and seminar presentations or posters ● 1 stationary scientific seminar ● 3 news articles 	<ul style="list-style-type: none"> ● 2 undergraduate research assistants ● 2 PhD students
United Kingdom	<ul style="list-style-type: none"> ● 16 key-informant interviews ● 21 Workshop 1 participants ● 25 Workshop 2 participants ● 49 Workshop 3 participants 	<ul style="list-style-type: none"> ● 1 journal article published ● 3 journal articles submitted/process of submission ● 3 industrial reports published ● 4 conference presentations ● 1 case study guideline ● 1 online training module 	<ul style="list-style-type: none"> ● 1 post-doctoral researcher ● 1 PhD student
All	<ul style="list-style-type: none"> ● 54 global webinar participants 	<ul style="list-style-type: none"> ● 1 conference (T-AP) ● 1 white paper ● 1 journal article being prepared 	

Success in Addressing the Project’s Research Question

The original research question of the project was about the social and environmental roles of bioplastic packaging in the global context of sustainable food production and consumption. Our general conclusion is that these roles are contested and context dependent. This finding was expected given that the consortium members represent different geographic, social, economic, and political contexts. We consider it a success that each consortium member arrived at slightly different answers to the research question so that together we have a broader perspective of bioplastic packaging as a global issue. Note that the scope of which bioplastics were considered

for each consortium member diverged, so the terminologies used are more specific. Canada focused on bio-based compostable packaging whereas Poland and the United Kingdom included bio-based biodegradable (including compostable) packaging and Brazil looked at bio-based packaging that was biodegradable and non-biodegradable.

In Brazil, this project surfaced polarized opinions on how bioplastic packaging has an environmental and social impact on society. On the one hand, stakeholders defended bioplastics as a disruptive solution, whether they are biobased and biodegradable/compostable, or even those that still need the recycling process. On the other hand, other stakeholders argued that regardless of the source, the disposal of these materials will continue to be a problem and impact both environmentally (since they depend on specific conditions to biodegrade, such as composting plants, which are practically non-existent in Brazil), and socially (reflecting directly on the work of the collectors, since many packages have a mixture of polymers and biopolymers, which contaminates the batch for recycling the already conventional ones). This project was successful in raising awareness of stakeholders on the impacts of bioplastics in Brazil, particularly in highlighting the realities of the informal waste management sector through including waste pickers in the social innovation lab process.

In Canada, there was some consensus that bio-based compostable packaging could be beneficial for specific use cases where plastics could not be reduced or reused, if it is fully compostable and raw materials are sourced responsibly. This would require many changes to both policy and infrastructure. While there wasn't a definitive answer on the role of bio-based compostable packaging in the food system, the main success of this project was using the social innovation lab methodology to convene diverse participants in conversations about their social and environmental impacts. The project enabled discourse that was not had before, linking different actors in the system that previously did not talk to each other. Awareness about bioplastics in general and their life cycle was increased for participants who were not as connected to the bioplastics industry. For example, participants became aware of the challenges faced by processors in having a variety of bioplastics contaminate their loads and that different types of bioplastics have different properties (not all are bio-based and compostable). These new insights can set the direction for further work on the application of bio-based compostable packaging in a way that is socially and environmentally sustainable.

In Poland, bio-based biodegradable (especially compostable) packaging is seen as the most environmentally desirable alternative to other food packaging types and there is a drive to stimulate its development. This project helped to identify problems and barriers hindering the development of this packaging market and solutions (social innovations) needed to solve or eliminate them. The project also raised awareness of the role of the bio-packaging market for food designed in accordance with the principles of the circular economy for stakeholders from the public sector, private sector, and consumers. The project provided new knowledge on the types of bio-packaging, paying particular attention to the need to focus on introducing compostable packaging that meets the requirements of international standards. Despite the widespread greenwashing in Poland, the stakeholders who joined the project were relatively

aware of the issues studied in the project. Lastly, the project contributed significantly to building relational capital between stakeholders, which may turn out to be a success factor for collaborative development of innovative projects in the future.

In the United Kingdom, the stakeholders identified communication with consumers, certification standards, and guidelines for waste management and end-of-life as the most promising solutions for reconfiguring the supply chain of bio-packaging. These solutions integrate educational programs, research and development for specific products and new feedstocks, and policy development and will have the greatest impact on specific biobased biodegradable products. The development of bio-based biodegradable plastics, for example, can be suitable to replace hard-to-recycle plastics or plastics prone to contamination and offer extra environmental benefits; however, it will only be achievable **if greater attention is paid to the product life cycle and its relation to circular systems**. Indeed, as a future route of development has the potential to be a compelling and powerful strategy in moving the sector forward, as long as the ways through which products are created and then used and processed at the end-of-life are considered. In other words, the blueprint of a future bioeconomy has successfully captured the attention of policymakers and industry; however, a niche must now be carved for bio-based biodegradable plastic packaging.

Researchers' Candid Opinions

Brazil

Lais Roncalho: As a Biopolymer Chemistry researcher, it was a great challenge to be at the forefront of the development of this project. Despite the difficulty with the commitment of stakeholders, as well as the support of a small number of researchers involved in the team in Brazil, I believe that we were able to address most of the initial objectives proposed in the work. Mainly with regard to waste pickers, we had a very positive return, since these professionals are so essential in the chain, and are still not inserted for discussion and decision-making in most projects and works focused on Social Innovation. As a SIMBIO Brazil team, we were able to break down barriers and include them in decision-making regarding realistic solutions for the Bioplastics packaging sector in our country. In general terms, the importance of developing the SIMBIO project for everyone involved in the chain was notorious, as well as the satisfactory return we obtained in the dissemination of our results in the media and in the academic environment. Contact with partner groups from different countries was essential for the development of the steps. Certainly, the development of this project will bring new opportunities for related research.

Sandra Cruz: The objectives of the Brazilian team were mainly focused on the social challenges and impacts of bioplastic packaging throughout the supply chain. One concern was to conduct an assessment especially with regard to waste infrastructure, informal waste pickers (waste collectors), plastic recycling companies, vendors, food producers, and policy makers in the State of São Paulo, Brazil. I believe the project was very successful with positive impacts associated with awakening in all stakeholders a reflection on the importance and impacts of bioplastics in

Brazil. Transversally to the central theme other aspects were also raised, such as the lack of a homogeneous and structured legislation in the country. There is no doubt that the Brazilian team created a framework to guide future research on this theme.

Rafaela Gutierrez: It was rewarding to bring a plural group of stakeholders with different perspectives to discuss the challenges and opportunities of bioplastic in Brazil. We were able to adapt the Social Innovation methodology to the Brazilian reality with informal waste management and include waste pickers in the reflections of the incipient bioplastic sector. The results of the Brazilian team to understand the social challenges and impacts of bioplastic packaging throughout the supply chain can pave the way to new research and methods to comprehend the bioplastic sector.

Canada

Tammara Soma: As Lead Principal Investigator on this project I had the opportunity to learn about the different priorities, contexts and experiences of the other colleagues. I am interested in identifying ways for countries, provinces and municipalities to be more circular and through this project, it is clear that bioplastics still have a long way to go. I remember growing up in Indonesia before plastics and plastic waste was ubiquitous. As a planner (food systems and waste management), it was shocking to see that within a system, so many of the upstream and downstream actors, along with those supposedly developing policies and regulations were not talking. There is a lot of potential in this approach to social innovation, of bringing diverse sectors and actors together. However, it requires more time, more funding, and more relationship building that can be quite difficult in the context of academia, and in our cases, in light of COVID-19. I often wonder how this project would have been different if we had been able to travel to the different labs and participate.

Belinda Li: As a process designer for this project, I was given the challenge of figuring out how to run a social innovation lab completely online. At the beginning, it felt overwhelming. Having been a participant and facilitator in other social innovation labs, I knew that these labs were meant to be highly interactive, dynamic, and messy. I was doubtful how well these activities that were meant for in-person experiences would be replicated online. After the first workshop session though, the enthusiasm and positive feedback from participants was encouraging. In fact, it pushed me to be more creative. In some ways, online facilitation opened new avenues of collaboration that I would not have imagined before. I never thought that I would be able to get a group of people in a professional setting wearing costumes, interacting as avatars, and playing games. Venturing into new ways of running social innovation labs did come with numerous difficulties, including navigating heated discussions, maintaining participant engagement and morale, and managing a distributed facilitation team. Overall, I think we managed very well considering the circumstances and the insights from the participants will be valuable to making bioplastic packaging more environmentally and socially responsible.

Poland

Beata Wieteska-Rosiak: Recognizing the problem of plastic pollution on a global scale is a great opportunity to face the challenges of the modern world dependent on non-renewable materials and widespread consumerism. As an economist and a consumer I notice today the increasing awareness of stakeholders in the designing and managing supply chains of food bio-packaging based on circular economy principles. The achievement of project goals was possible thanks to the involvement and integration of representatives of the food bio-packaging market. The cooperations with stakeholders during Social Innovation Labs was especially important to me because it accelerated the diffusion of professional knowledge throughout the bio-packaging supply chains. Further, the interdisciplinary discussions made it possible to understand multidimensional problems in the closed compostable packaging life cycle management as well as to jointly design tools supporting the development of the food bio-packaging market. Finally, the implementation of the project involved me in the dissemination of new knowledge in numerous research reports, publications and at international conferences. I supported the project team especially from the perspective of the public sector and its critical role in sustainable development and circular economy implementation. Being the person co-responsible for designing and carrying out the interviews, up to the workshops, I am grateful that the project gave me a chance to develop new competences and get a deeper understanding of the need to involve all key stakeholders in dynamizing the compostable packaging market niche in Poland.

Jolanta Turek: I deeply value the experience of teamwork as a member of SIMBIO project in Poland. For the first time, I had the opportunity to participate in creating social innovations. The project in Poland has become a forum integrating representatives of internal and external stakeholders in the supply chain of compostable food packaging. Our Team invited stakeholders to co-develop a market diagnosis and ideate solutions that break barriers holding back compostable packaging market development. Furthermore, they were involved in rapid prototyping of urgent solutions: strategy for the compostable food packaging market, industry organization and B2B technology platform. I feel grateful for their involvement in the project and that they dared to implement one of the prototype solutions - they are in the process of building an industry organization. I found it valuable and fulfilling to see how the work of a team takes on an institutional framework and has a real impact on the development of the market.

Marta Raźniewska: A move towards more biodegradable packaging market orientation and integration in the Polish food sector between the various supply chain entities is noticeable and very much appreciated. The results of the project contribute to this development, which gives a sense of agency and encourages deep exploration of the topic. Participating in SIMBIO has brought me, as an early career researcher, multiple opportunities for learning and professional development. Firstly, I was responsible for the Social Innovation Labs preparation, assistance, and facilitation to make the working environment of research engaging, collaborative, and

people centred. The best practices analysis conducted on the global level has been an inspiration for future directions of problem solving and further research in the subject. Then, prototyping well selected potential solutions was in my opinion the most interesting part of the project due to the emphasis on possible project environmental impact. Secondly, the project results dissemination during conferences gave me the opportunity to discuss the topic also outside the Consortium. I must admit that the collaboration both on national and international levels has been a cornerstone of SIMBIO project and once again thank you SIMBIO Team for the opportunity to work with you.

Barbara Ocicka: Results of the SIMBIO project revealed the high upscaling potential of innovations aiming at developing bio-packaging market and supply chains in circular economy. Considering the multi-solution approach in the SIMBIO project, we have prototyped such exemplary social innovations as national strategy, industry organization and multi-sided B2B technology platform as triggers of the bio-packaging market growth. High importance of the research findings in the context of sustainable development can successfully enhance the initiated potential. Variety and multiple levels of the innovations development and implementation (strategic, tactic and operational on the one hand, or international, national and local on the other hand) advance the upscaling potential of social innovations. Moreover, the current crisis circumstances increase the significance of circular solutions in industries and supply chains. In my opinion, the SIMBIO project created a unique chance to reveal the power of stakeholder collaboration and could be a great starting point for their joint journey towards building sustainable resilience of economies.

UK

Macarena Beltran: The social innovation labs were a wonderful opportunity to talk about the future of plastic and potential alternatives such as bioplastics. The project goals were achieved thanks to the generous involvement and cooperation of bioplastic packaging industry stakeholders. This included the support of industry associations including BBIA, REA, ADBA, Bioladies network, and consumer associations like Garden Organics. During the last workshop, their representatives were also present in person. COVID and the need to involve high-level stakeholders were potentially among the most challenging aspects of the project. However, this also led to innovations in methods that can be applied online and to a broad range of audiences in the UK and abroad. In my opinion, inter-disciplinary and international discussions enabled us and stakeholders to better understand the multi-faceted problems associated with the life cycle management of bio-packaging.

Jordon Lazell: This project really opened my eyes to the important role that academics have in bringing together stakeholders. Through drawing upon the Social Innovation Lab model, the workshops were highly successful in encouraging different parts of a supply chain, here those working across the bioplastics sector, to come together and have conversations that would not normally occur. Further to this the innovative workshop engagement exercises utilised, such as

the use of online whiteboard platform Miro and the use of a board game, highlighted our important role as researchers to design methods that best bring out important, and sometimes challenging conversations, from research participants. This project was hugely successful at not only uncovering the barriers to change and issues facing different stakeholders, but how different stakeholders perceive each other in this sector. The need to transition towards bioplastics being a greater part of a future where plastics derived from fossil fuels are obsolete will only happen if parties across bioplastics creation through to its waste management are all on the same page of how to move forward. What we showed through this project's success is an equitable approach to appreciating the different viewpoints and concerns of each stakeholder group is critical for the success of this transition.

Benny Tjahjono: It has been a wonderful learning experience to collaborate with colleagues from Canada, Poland, Brazil, and the UK on the SIMBIO project. Working with enthusiastic people and brilliant minds from academia, industry partners, and policymakers during this project has shown me the incredible power of global collaboration. We all shared the common vision of driving sustainable change by developing innovative approaches to the management of bioplastics. I was particularly amazed by the variety of viewpoints that the team members contributed, which pushed the boundaries of knowledge beyond our normal comfort zones. Zoom and virtual meetings were introduced to us during the COVID-19 pandemic, and they helped us carry on with our job despite the physical restrictions. Overall, I am grateful for being part of the journey. In addition to deepening my understanding of social innovation, I have developed close relationships with remarkable individuals from four different countries. I just hope that the project can pave the way for a future with bioplastics that are more environmentally friendly. Well done, team!