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SIMBIO

SOCIAL INNOVATION MANAGEMENT FOR BIOPLASTICS

SEEING THE SYSTEM:

Findings from the first UK SIMBIO Social Innovation Lab

4th March 2021

Acknowledgements

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Glossary of terms and abbreviations

AD = Anaerobic digestion.

Autoclave = Autoclave is a process that utilises heat/steam under high pressure to 'clean' residual waste, and thus biodegradable materials, including paper and cards, can be broken down [1].

Biorefinery = According to the International Energy Agency (IEA), a biorefinery is defined as a plant in which occur the – "processing of biomass into a spectrum of marketable food and feed ingredients, bio-based products (chemicals, materials) and bioenergy (biofuels, power and/or heat)…" [2, p.2].

Compounder = Manufacturers that enhance the properties of the extant bioplastics materials.

Digestates = Digestate is a nutrient-rich substance produced by anaerobic digestion that can be used as a fertiliser.

Feedstock producers = In this report are farmers (e.g. corn).

IVC = In-vessel composting.

Landbank = An area of land utilised to spread digestate generated from AD processes.

PLA = Polylactic acid.

Standard Rule Permits = According to the Environment Agency, the standard rules define "the activities that an operator can carry out. They also specify necessary restrictions on those activities, such as emission limits or the types of waste or raw materials that can be accepted at the sites" [3, p.6]

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Executive Summary

Background

25.8 million tonnes of plastic are produced in Europe each year, however, less than 30% is collected for recycling, with millions of tonnes ending up in the ocean.

There is significant potential for bioplastic materials to replace hydrocarbon-based plastics. Such materials have the potential for a lower environmental impact, can facilitate circular production processes and present a valuable economic opportunity.

SIMBIO

SOCIAL INNOVATION MANAGEMENT FOR BIOPLASTICS

The SIMBIO project

SIMBIO (Social Innovation Management for Bioplastics) Research's overall aim is to develop social interventions to address the environmental and social challenges of bioplastic packaging throughout its entire supply chain from production to end-of-life management.

The project employs a 'Social Innovation Lab' method, which means working collaborative with actors across the supply chain using a whole system approach to map the current bioplastic packaging system, design solutions and prototype these solutions to achieve a positive change.

Seeing the system workshop

- This report details the first social innovation lab workshop entitled seeing the system. The aim of this workshop was to facilitate dialogue between stakeholders to obtain a consensus about what the current packaging supply chain looks like for bio-based biodegradable products, identify barriers and opportunities and discuss future possibilities.

- The workshop first featured presentations from Professor Benny Tjahjono and Dr Macarena Beltran, Centre for Business in Society, Coventry University, as well as David Newman, Director of Bio-Based and Biodegradable Industries Association (BBIA) and Emily Nichols, Technical Manager for the Association for Renewable Energy and Clean Technology (REA).

- Three breakout sessions took place (production, consumption and waste management) where participants were asked to complete three tasks via the online collaborative whiteboard platform Miro. These tasks involved identifying their position on a supply chain map, commenting on the system as visualised and putting forward barriers and opportunities for achieving growth.

- The participants spanned a broad range of private and public sector roles with actors across the three areas of production, consumption and waste management well represented.

Presenting the results from seeing the system breakout groups

- We presented a diagram of the bioplastic packaging supply chain and three further diagrams that give further detail of the actors and connections in the production, consumption, and waste management areas.

- In the **production breakout group,** participants noted the need for inclusion of further actors in the supply chain diagram, such as converters, packaging producers, printers and testing laboratories. The need for educational steps between the producing and consuming parties was also identified.

Further points made in the production breakout group included the fact that strategies to increase the use of compostable plastics focus on the consumer, the need to encourage greater competition through a product focus and discussions around cost and the current low scale of bioplastic production.

- In the **consumption breakout group,** participants indicated the need for further steps in the diagram related to informing consumers which biodegradable materials can be composted and how.

- Further points made in the consumption breakout group related to the difficulties of identifying and disposing of compostable and non-compostable plastics, as well as the inaccuracies between product labels and different local council collection systems.

- The **waste management breakout group** were shown diagrams representing “possible options” for the level of infrastructure that is needed in the UK. Participants agreed that the connections between AD digesters and composting sites don’t exist in the UK.

- Further points made in the waste management breakout group related to how bioplastics are not just one material but many, the need for greater capital investment, the importance of disposing of the right material and the right facility, existence of right waste management facilities, possible soil contamination from bioplastic recycling and issues with compostable plastic bags.

Five key emerging themes were identified during the workshop

1. Standardisation, labelling and its connection to competition and innovation

- There were mixed views on the need for standardisation, with this term meaning different things to different stakeholders.
- There is a wide range of labelling being utilised, resulting in confusion and packaging materials failing to reach the correct waste management route.
- Consumers face challenges in knowing whether bioplastic packaging can be placed in their local authority household collection.
- Certification standards were noted as potentially stifling competition.

However, there was a general agreement that stakeholders need to work together and share knowledge to grow the industry.

- The mandated segregation of food waste to be enforced in 2023 is an opportunity to bring waste management procedures for compostable plastics in line through a collective framework of efforts.

2. Bioplastic material limitations and potential

- Consensus that bioplastics are not as good as their hydrocarbon equivalents in terms of their properties as a packaging material. Shortcomings related to different barriers such as moisture resistance, gas barrier properties and compostability.
- Perception that the greater the ability of compostable plastics to match the properties of hydrocarbon-based plastics, the less likely the material is to be compostable plastics.
- Disconnection between the innovation in bioplastic material creation and consideration of how the waste management sector will process such materials.

3. Cost and scale of production

- The low scale of production and high cost of input materials means that bioplastic materials and subsequent packaging products created are higher in cost in comparison with hydrocarbon-based equivalents.
- There is a need to look further at how a steady supply of bioplastic material inputs can be more consistently supplied, for example, by waste.
- Utilising a life cycle cost analysis approach, bioplastic packaging could represent a cost-saving over conventional plastic packaging materials.

- Participants of the breakout sessions shared the vision that bioplastics would become more cost-effective with continued growth in the sector than traditional plastics.

- Participants highlighted that the sector is slow to change, with cost often the driving factor of packaging purchasing decisions.

4. Marketing, consumer knowledge and bioplastic waste management behaviours

- For end-users, the purpose, use and waste disposal procedure of bioplastic packaging materials are unclear.

- Bioplastic packaging materials that use the labelling, such as 'eco-friendly', mislead consumers when the product is only biodegradable via industrial processes.

- Comments suggest that there is not enough consumer interest in bioplastics to drive change through consumer choice or preferences reflected in purchasing decisions.

- Concerns expressed around the ability of consumers to separate and recycle bioplastics in domestic household waste collections.

5. Infrastructure required

- Concerns that compostable and biodegradable plastics bags available to consumers are not suitable to use in the existing AD processes/infrastructure in the UK.

- Waste management infrastructure can only maximise its effectiveness and efficiency in its role of recycling biodegradable materials by working with actors in the production and consumption part of the supply chain.

Recommendations

A number of potential next steps are highlighted to better connect the supply chain and forward the development and growth of the bioplastic packaging sector.

- Develop clear and consistent legally binding labelling for product guidance to help consumers identify compostable plastics products (for example, a product labelled “compostable” must be certified).
- Develop clear guidelines for processing compostable plastics waste for the waste management industry.
- Enforce current certification standards to ensure certainty about producers’ claims for their products and materials.
- Connect the current certification standards with a compatible labelling system and procedures for the waste management industry.
- Develop clear and consistent terminology to avoid current confusion. For example, bio-based biodegradable products can be renamed as industrially compostable plastics or home compostable plastics in coherence with labelling.
- Develop educational programmes for home composting biodegradable products.
- Dedicated use of compostable products for applications that are difficult to recycle.
- Develop infrastructure for disposing of compostable materials at industrial levels, such as a separated food waste collection bin and processing of composting packages in composting facilities and adequate AD plants.
- Research and development of other feedstocks, for example, from waste.
- Adopt consistent policies to support the use of compostable plastics.

1. Introduction

1.1 The SIMBIO project

1.1.1 Background and relevance

Advancements in packaging technologies have played a crucial role in extending the shelf life of fresh products, which impact on the reduction of food waste [4]. However, packaging technology relies mostly on the adoption of fossil-based plastics materials. It is estimated that 25.8 million tonnes of plastic waste are produced in Europe each year, and less than 30% of plastic waste is collected for recycling [4]. This has led to a significant economic and environmental impact; for instance, 5 to 13 million tonnes of plastic ends up in the oceans every year [5]. In response to plastic waste's environmental issues, several bio-based materials with biodegradability potential have emerged in the plastic packaging market.

A greater adoption of biodegradable packaging could provide economic benefits to the UK, equivalent to £267 million per year by 2025 [6]. However, the biodegradable packaging market is in its early stages and faces several challenges such as: the high costs of the biopolymers, confusion from consumers to distinguish and dispose of them compared to its plastic counterpart (resulting in possible contamination of waste streams), the lack of suitable outlets, potential environmental and social impact, etc. [7]. As such, the adoption of this product becomes a "wicked problem", as it is seemingly difficult to solve due to the numerous interdependent factors that simultaneously impact solutions. This research, therefore, addresses these challenges through its entire supply chain.

1.1.2 SIMBIO project overview

SIMBIO Research – Social Innovation Management for Bioplastics – is funded by the ESRC (grant number: ES/T015195/1) and organised by the Centre for Business in Society, Coventry University, in the UK, who are working in collaboration with researchers in Canada, Brazil and Poland. The aim of SIMBIO is to develop social interventions to address the environmental and social challenges of bioplastic packaging throughout its entire supply chain, from production to end-of-life management.

To achieve the aim of this research, objectives have been designed to:

- Identify the current understanding of bioplastic packaging for food from the perspectives of consumers and businesses.
- Identify under what circumstances is bioplastic packaging the best option for storing and transporting food.
- Identify alternative products with lower environmental footprint that can be used instead of bioplastic packaging.
- Evaluate how the resource extraction and industrial processing for producing bioplastic packaging affect food security, the ecosystem, and the well-being of those impacted.
- If the quantity of bioplastic packaging increases substantially, evaluate how these products impact the formal and informal recycling, composting, and waste management sector.

- If bioplastic packaging is the best option for certain scenarios, identify product design parameters, processes, policies, and supporting systems that need to be in place to manage a supply chain of these packaging materials that minimise negative environmental and social impacts.

1.1.3 The Social Innovation Lab methods

Social innovation lab is a methodology that facilitates working collaboratively to find and implement solutions to complex social problems. This methodology takes a whole systems approach and uses a data-oriented evidence base for testing hypotheses, rigorous tracking and analysis. There is no single agreed definition for social innovation; however, we follow the definition of a lab as a process by Westley *et al.* – "one that is intended to support multi-stakeholder groups in addressing a complex social problem" [8, p1].

We implement the social innovation lab method in this research over five phases (See Figure 1):

Phase 1: Research and preparation. This phase aimed to develop a better understanding of the different types of bioplastics, how they contribute to sustainable development, and their current production, use, and end-of-life management processes. Furthermore, it aimed to identify key stakeholders, enablers and inhibitors to the adoption of bioplastic packaging.

Phase 2: Seeing the system. This phase developed a common understanding of the key challenges and barriers in the production, use, and end-of-life management of bioplastic packaging.

Phase 3: Designing solutions. This phase defines the leverage points to unlock the bioplastics packaging supply chain. It also evaluates current innovations in bioplastic packaging, their successes and shortcomings, and expands thinking on possible social innovation solutions that challenge norms in bioplastic packaging.

Phase 4: Rapid prototyping potential solutions. This phase tests and prototype solutions within the social innovation lab "container", funding, and resources for field prototyping.

Phase 5: Report – research dissemination. This phase makes findings accessible to stakeholders across the supply chain and policymakers.

Figure 1. Projected timeline 2020-2021

1.2 Seeing the system lab – SIMBIO workshop held by Coventry University

The aim of the first workshop was to facilitate the dialogue between stakeholders to encourage a transition towards sustainable bio-based biodegradable packaging products.

Objectives:

- Obtain a consensus and clear understanding of the current packaging supply chain for bio-based biodegradable products (compostable products).
- Identify barriers and opportunities for achieving a more sustainable supply chain.
- Explore the future possibilities for a packaging supply chain for bio-based biodegradable products (compostable products).

The SIMBIO workshop was held online on the 4th of March, 2021. Because of the diverse backgrounds of attendees (i.e. academics, waste management representatives, consumers, bioplastic producers, NGOs, local governments and government agencies), the workshop started with an introduction of some of the critical concepts, articulating the magnitude of the fossil-based plastic problem and the challenges and opportunities for the bioplastics packaging industry.

The event featured presentations from Professor Benny Tjahjono from the Centre for Business in Society at Coventry University, David Newman, Director of Bio-based and Biodegradable Industries Association (BBIA), Emily Nichols, Technical Manager for the Association for Renewable Energy and Clean Technology (REA) and Dr Macarena Beltran from the Centre for Business in Society at Coventry University.

Professor Tjahjono introduced the project and explained the relevance of the research. David Newman reviewed the role of compostable plastics, drawing upon a case study of Italy to highlight the urgency of the plastic problem and the need to intervene before the 2023 food waste collections are mandated in the UK. Emily Nichols explored barriers and opportunities for industrially compostable plastic waste. Dr Beltran presented an overview of the bioplastics market obtained from empirical research undertaken previous to the workshop involving a range of industry stakeholders. Insights from this were utilised to develop the tasks and materials for the breakout sessions.

Breakout Sessions:

Three breakout sessions took place following the presentations, which aimed to open up discussion in different parts of the bioplastic packaging supply chain: production, consumption, and waste management.

Each of the breakout sessions completed the following three tasks. Facilitators guided participants through these activities in an online environment provided by the collaborative whiteboard platform Miro.

Task 1: Identifying your place in the system

For the first task, participants were shown a supply chain diagram that covered the key activities in production, consumption and waste management. Participants were then tasked with identifying and giving explanations of where the remit of their activities was based. This also covered activities that spread across these areas, for example, roles related to regulation, certification, trade organisation, academic enquiry, non-governmental organisations and composting technology.

Task 2: Seeing the system

For this task, participants were shown a more detailed supply chain diagram specific to their breakout group area. This was a representation of what the SIMBIO research team thought was happening in this area in terms of the actors present and their connections. Participants were then asked to comment on how accurate this representation was, providing details of where additional links or actors were required.

Task 3: Barriers and opportunities for achieving growth

For this task, participants were asked to first think about and discuss what the barriers are to achieving growth in the biodegradable plastic packaging supply chain, followed by the opportunities.

Bonus task: Sustainable pathways

If there was remaining time, participants were asked to comment on what they think are the pathways for sustainability in the bioplastic packaging sector.

1.2.1 Participants

Table 1 below gives an overview of the background of the participants that took part in the workshops. This is broken down into each of the breakout groups. This report does not identify participants individually.

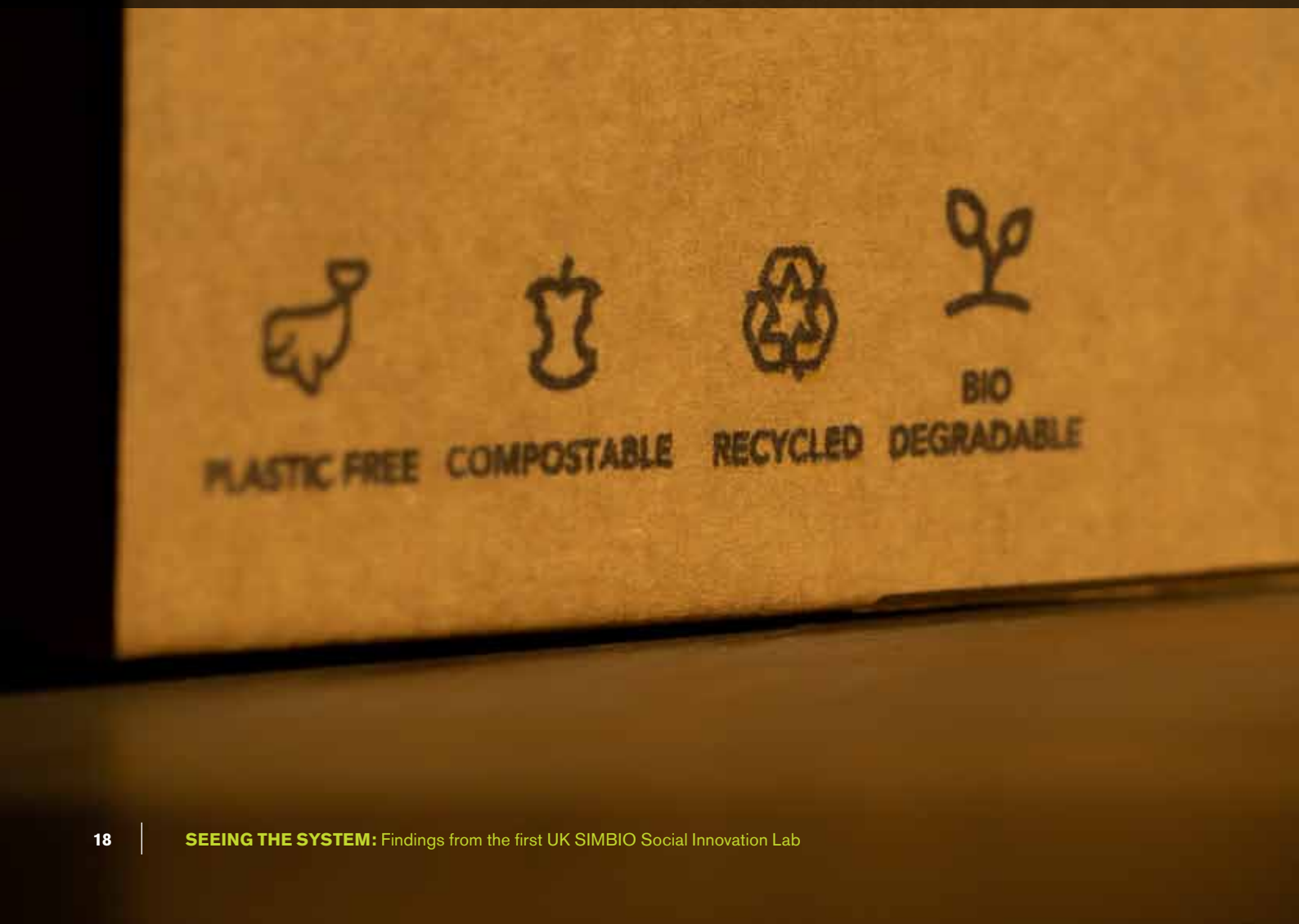
Table 1. Overview of the background of the participants that took part in the breakout sessions

Production breakout group	Consumption breakout group	Waste management breakout group
• A regulatory adviser (P31) • A technical consultant (P13) • A company director purchasing bioplastic packaging products (P11) • A producer of pellet compounders selling to an importer (P25) • A representative from a composting organisation (P14) • Two academics working in the area of bioplastic production (P17, P33) • Two workshop facilitators	• A representative of company providing equipment and guidance for commercial composting (P6) • An operations expert at an industrial composting facility (P12) • A composting waste reduction project co-ordinator representing councils providing education and recruits volunteers (P49) • A representative from a composting organisation also representing a county council (P10) • A volunteer from a composting organisation (P9) • An academic working in the area of bioplastics (P32) • Researcher and project manager looking into composting (P4) • Two workshop facilitators	• A bio-industry energy process engineer (P52) • A technical expert in clean waste technology (P16) • A sustainability manager of a company selling biodegradable film products (P5) • A local government environmental officer and composting expert (P8) • A community composting expert (P7) • Agroecology, water and resilience academic (P21) • An environmental scientist working for a public body (P1) • Two workshop facilitators

P (n): 'P' means participant, and 'n' is the ID number used to anonymise the participants.

2. Presenting the results from seeing the system breakout group tasks

This section of the report first lays out how we visualised the actors and stages in the compostable packaging supply chain. This first details how the complete picture from production to waste management was visualised. Next, this is broken down into the three workshop areas. Comments are made in each of these areas to elaborate on how we saw the system in the production, consumption and waste management areas in comparison to comments made in the breakout sessions by participants.



2.1 Seeing the whole system from Production to Waste Management

In preparation for the first workshop, we diagrammed the bioplastic packaging supply chain. However, to communicate this information with the different stakeholders we divided the supply chain into three main areas – production, consumption and waste management – visualising who the key actors are in each area as well as those actors that work across these areas. This can be seen in Figure 2 below:

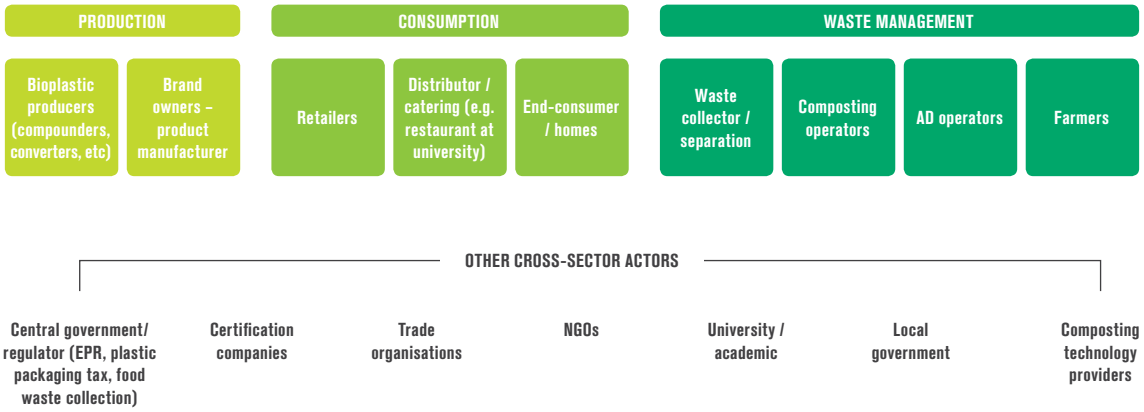


Figure 2. Diagram to show the bioplastic packaging supply chain

In visualising the production area, we included compostable producers (both compounders and converters), as well as other manufacturers that use compostable packaging in their processes. We acknowledge that the feedstock producers (e.g. biorefineries) are also part of the production supply chain, however, they are international actors that will be integrated into the supply chain by the other SIMBIO research partners.

Moving to the consumption area, this featured retailers, distributors, and organisations in the hospitality industry as well as end consumers or households. In the waste management area, this included firms that collect and separate waste, operators of composting facilities, anaerobic digestion operators (AD) and farmers who use the digestate outputs.

Other actors that operate across the sector included central government actors and regulatory powers, companies that certify bioplastic materials, trade organisations, non-governmental groups, academic researchers, local government groups, regulatory agencies and technology providers.

Participants were asked to place themselves on this diagram. The following Figures 3a, 3b, and 3c show the results of this. The colour stickie notes refer to responses made by participants during the breakout tasks. The figures show a good spread of participants across the supply chain represented in the three breakout groups. Overall, the composition of each of the breakout groups was successful in being made up of members with sufficient technological knowledge and insight but also involving participants with wider knowledge to help contextualise each group's position.

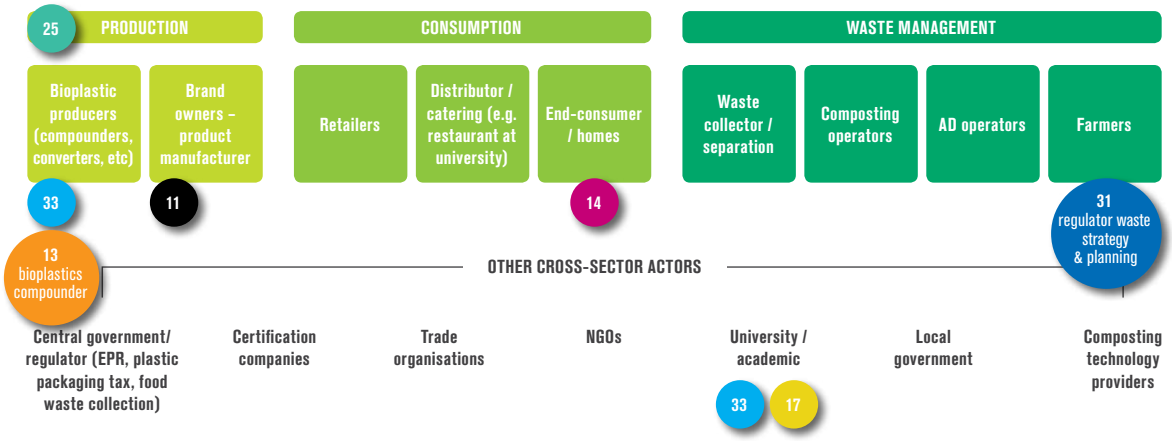


Figure 3a. Production breakout group identification task

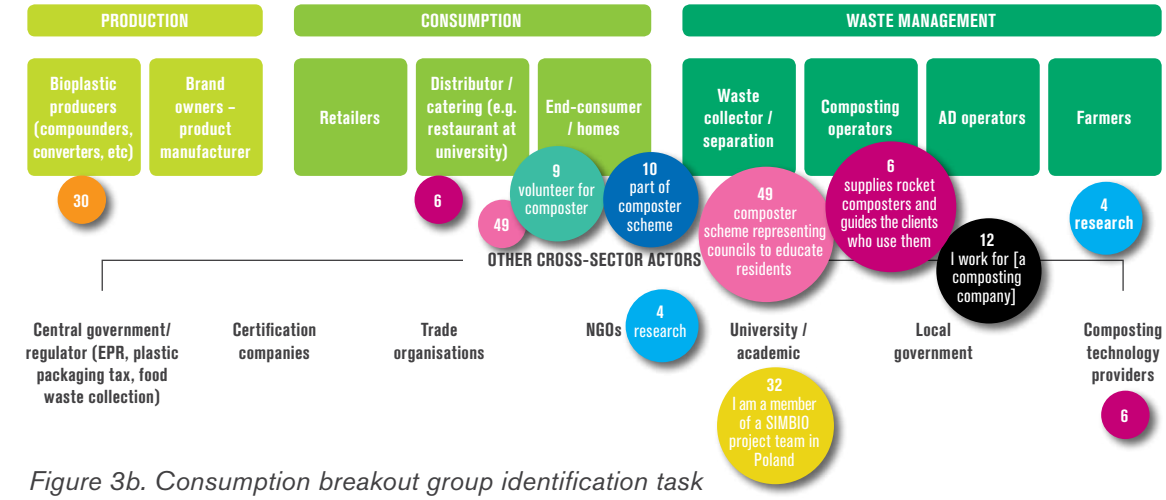


Figure 3b. Consumption breakout group identification task

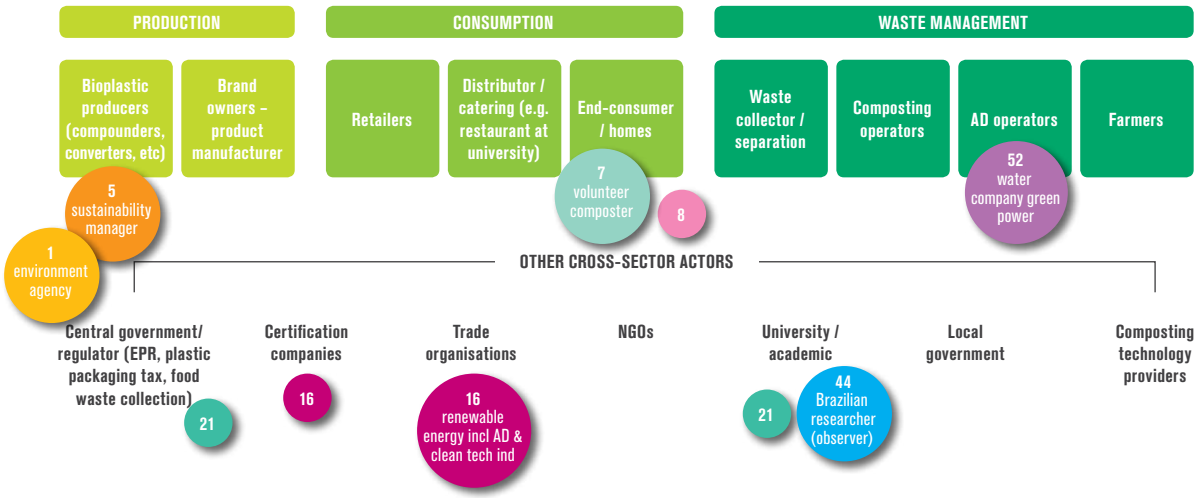


Figure 3c. Waste Management breakout group identification task

2.2 Production breakout group

Figure 4 shows the supply chain diagram developed by the research team for the production area. Over three stages, this first shows how the polymers for packaging, such as cellulose or resin, feed into packaging production. Biodegradable certification also connects into this actor. Packaging production is then connected to final production, typically by brand owners, which use the compostable packaging for their products (e.g. tea bags, coffee cups), which then links on to the next stage of the supply chain – consumption.

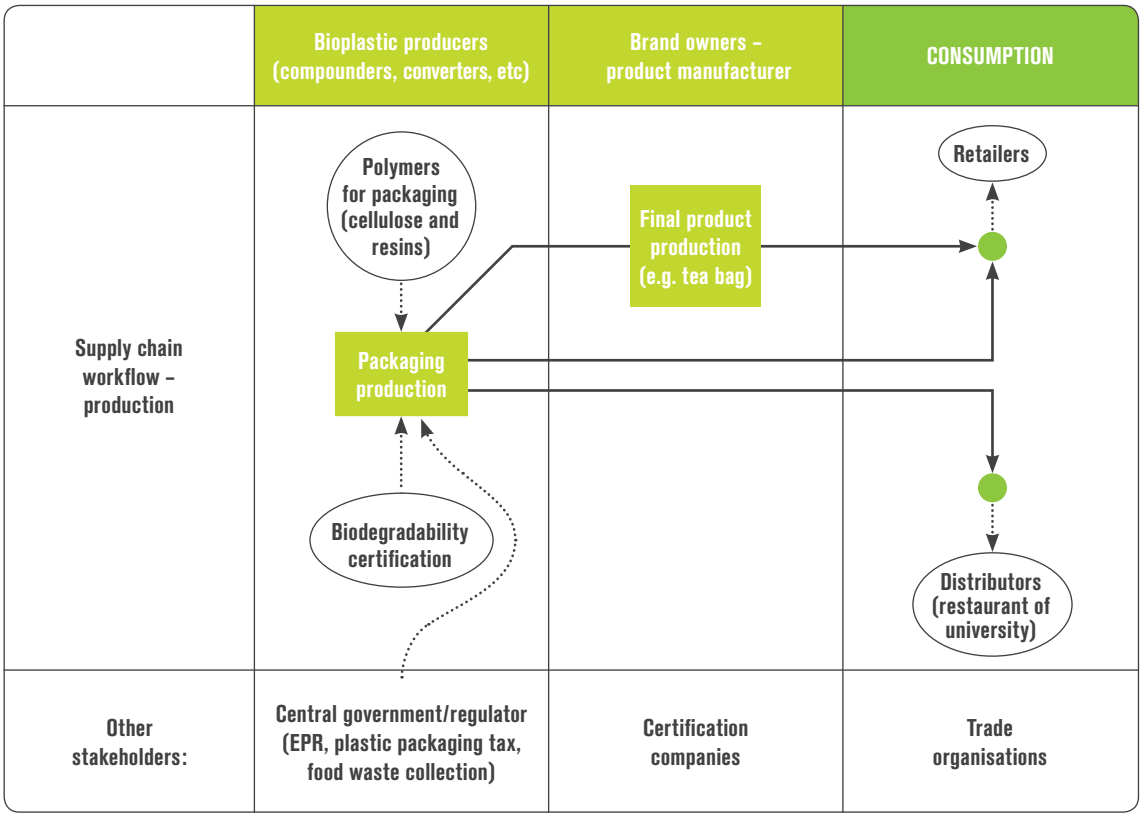


Figure 4. Supply chain diagram focusing on the production section

Figure 5 below shows the same supply chain diagram for production following the second workshop task. Here participants indicated the accuracy of the previous diagram and made relevant comments. In terms of the production supply chain, participants noted the need for further actors such as converters between packaging producers and the production of the final product. Other actors added included printing houses for packaging and testing laboratories. Participants also indicated the need to add educational steps between the producing and consuming parties to ensure that both retailers and individual consumers understand bioplastic packaging and its correct waste management processes.

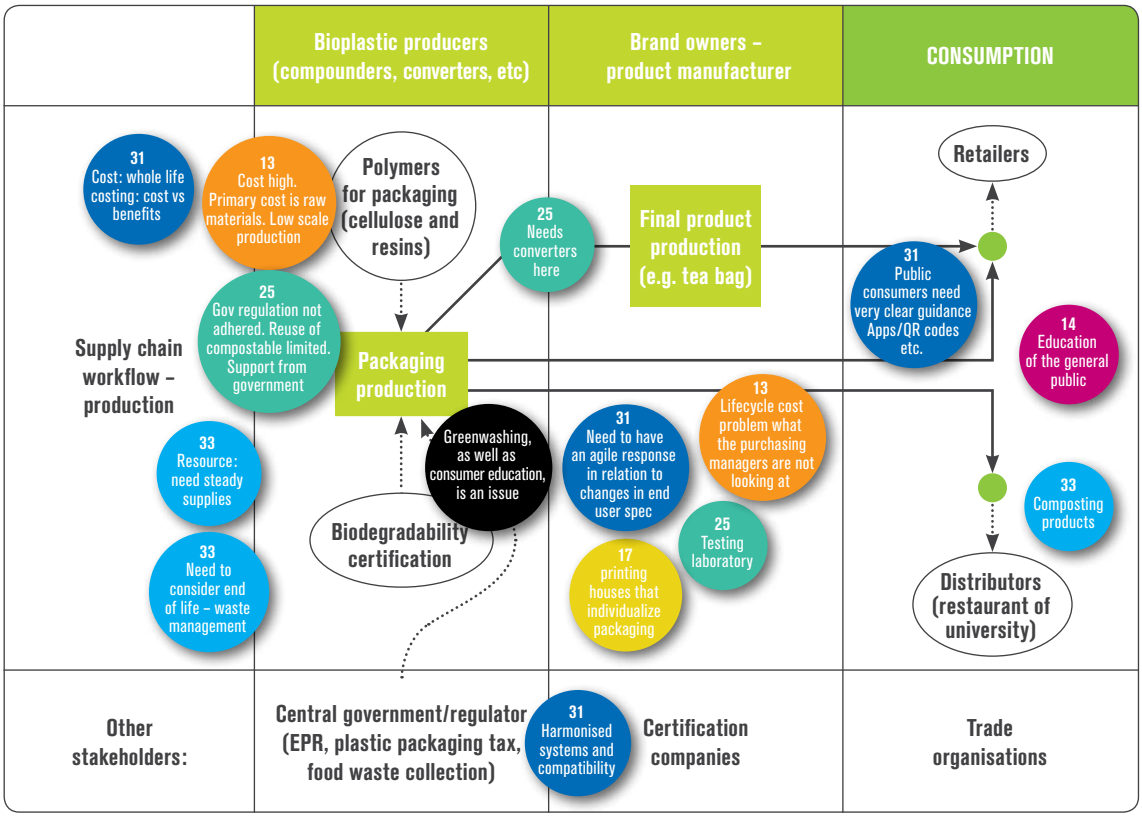


Figure 5. Production supply chain diagram following the second task of the workshop

Further issues raised by participants when completing this task of 'what the system looks like' for the production group included:

- Strategies to increase bioplastic use that focus on the consumer are problematic. For bioplastic packaging to become more mainstream *"it's really important to make it as easy for the customer as possible"*. Participants discussed how this meant moving away from eco-friendly claims that were in some cases seen as greenwashing, where products were only compostable under industrial conditions. Participants raised the point that companies selling bioplastic packaging products that are only industrially compostable are *"surfing on the back of the compostable description"*, giving the consumer a false sense of a product's biodegradability.

Participants in this group deliberated that the system would be better conceptualised by focusing on particular applications for compostable materials as defined products. This means delineating the journey of bioplastic packaging according to each product. Participants explain how this would provide greater clarity for bioplastic packaging purchasers in terms of understanding what they are purchasing and how the material can be best processed.

- Encouraging greater competition in the system through product focus. By reformulating how the system is understood around a specific application (e.g. tea bags), this would facilitate competition in bioplastic packaging production. This relates to differentiating how the supply chain is visualised and how this connects to further actors after bioplastic packaging is produced.

The cost was a further aspect discussed in the seeing the system task.

- Low scale production of bioplastic packaging products means their cost will stay high. Participants discussed the issue of cost. The view put forward was that whilst there are companies that are concerned about the environment, what will hold greater influence over shaping the supply chain to increase its capacity is a focus on cost. This bioplastic packaging sector was described as being in its infancy compared with conventional plastics in terms of unit production costs.

Taking into account the environmental impact of packaging products is one area where the stakeholders perceive that compostable plastics have an advantage, given the end result of a combustible, energy producing input material. The application of a life cycle analysis of bioplastic materials has provided evidence for this. However, often packaging purchasers will only look at cost price, which limits realising the benefits of compostable plastics.

2.3 Consumption breakout group

Figure 6 shows the supply chain diagram developed by the research team for activities related to consumption. Five stages feature in the consumption diagram, which connects producers through to retailers, distributors, end-users and the following waste management supply chain stage. Trade organisations and NGOs also play a role in this part of the supply chain in encouraging the use of bioplastic packaging. It was important in the consumption group to consider how the final product connects to the retailer in how the product is commercialised.

This part of the supply chain has two different inputs:

Input 1: The compostable products that can be commercialised by retailers to end consumers.

Input 2: The compostable products that can be commercialised by distributors to end consumers (e.g. catering industry, restaurant, etc.).

Therefore, this research defines two business models: business to consumers (retailers to end consumers) and business to business (distributors to end consumers). These business models are linked to different waste management routes. The business to business model, also called “closed-loop”, means that compostable packaging waste is collected as a separated waste stream and sent to an in-vessel composting facility. For instance, in a café, compostable packaging and food waste (e.g. tea bags, coffee cups) are disposed of in a separate bin and collected by a waste collector. The business to consumer model means that compostable packaging waste is disposed of and managed by the end-users (e.g. home composting, general waste bin, etc.).

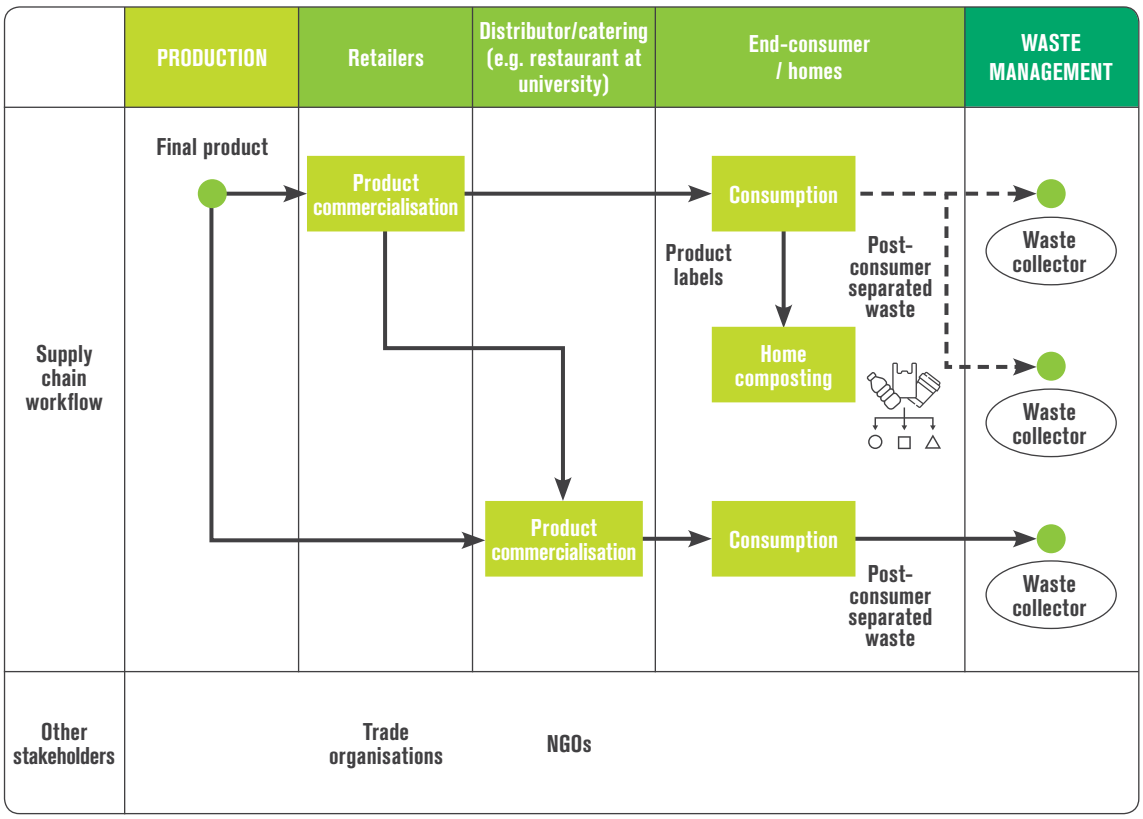


Figure 6. Supply chain diagram focusing on the consumption section

Figure 7 below shows the same supply chain diagram commented on by participants in this breakout group following the second task. Here, participants indicated steps in the supply chain related to informing consumers what biodegradable materials can be composted, as there is often poor communication of the correct waste management procedure. Participants identified the need for an identification or sorting action to aid segregation of waste between the consumption and waste collector actors. Participants explained the lack of clarity that consumers hold at the moment on what to do with bioplastic packaging, particular attention was given to the distinction between industrial and home compostable materials.

This has an influence on what the supply chain looks like as current pathways that connect consumption to waste management facilities are limited. If the circular nature of compostable applications is to be realised in the supply chain, it should better represent loops of materials being used and returned to feed back into the supply chain as inputs.

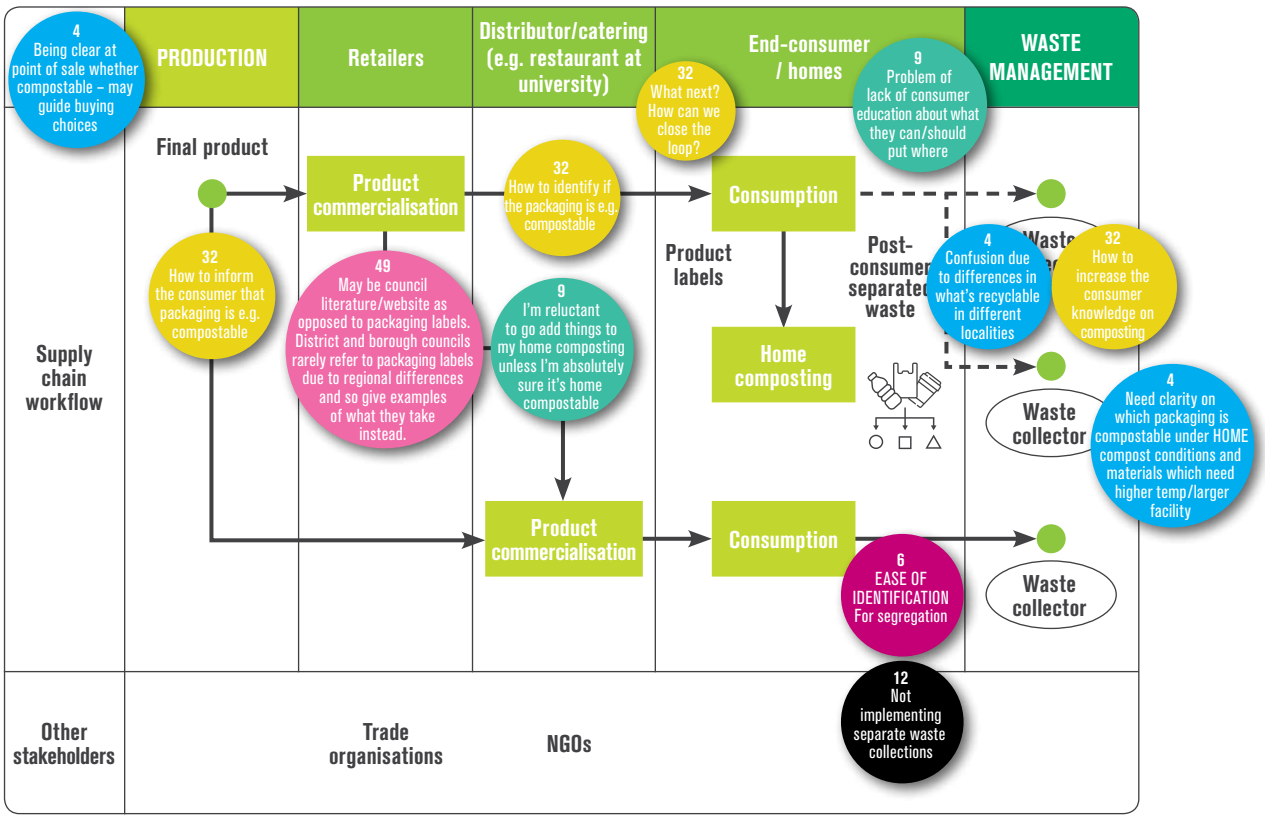


Figure 7. Consumption supply chain diagram following the second workshop task

Further issues raised by participants when completing this task of 'what the system looks like' for the consumption breakout session included:

- Difficulties of identifying and disposing of compostable and non-compostable plastics. Participants made comments on how the challenge of identifying the system is mirrored in the challenge of understanding which materials are compostable or not and their correct disposal.

- There are inaccuracies between product labels and local council collection systems. The way in which local councils list items that can be recycled in their facilities with examples and pictures often does not match with labelling standards; for instance, they may not refer to polymer types. However, the cost to standardise a recycling or waste collection system across the UK would be uneconomical. The variation in local waste collection schemes must be taken into account in seeing the system.

2.4 Waste Management breakout group

Figure 8 displays the supply chain diagram developed by the research team for activities concerning waste management. Five stages feature in this diagram. The current supply chain for compostable products lacks a suitable outlet. Thus, this diagram visualises the potential options of waste management. **The majority of these processes do not exist at the moment in the UK** (only processes (squares) in green exist). Some of them have been implemented in other countries in Europe.

This part of the supply chain could have three different inputs:

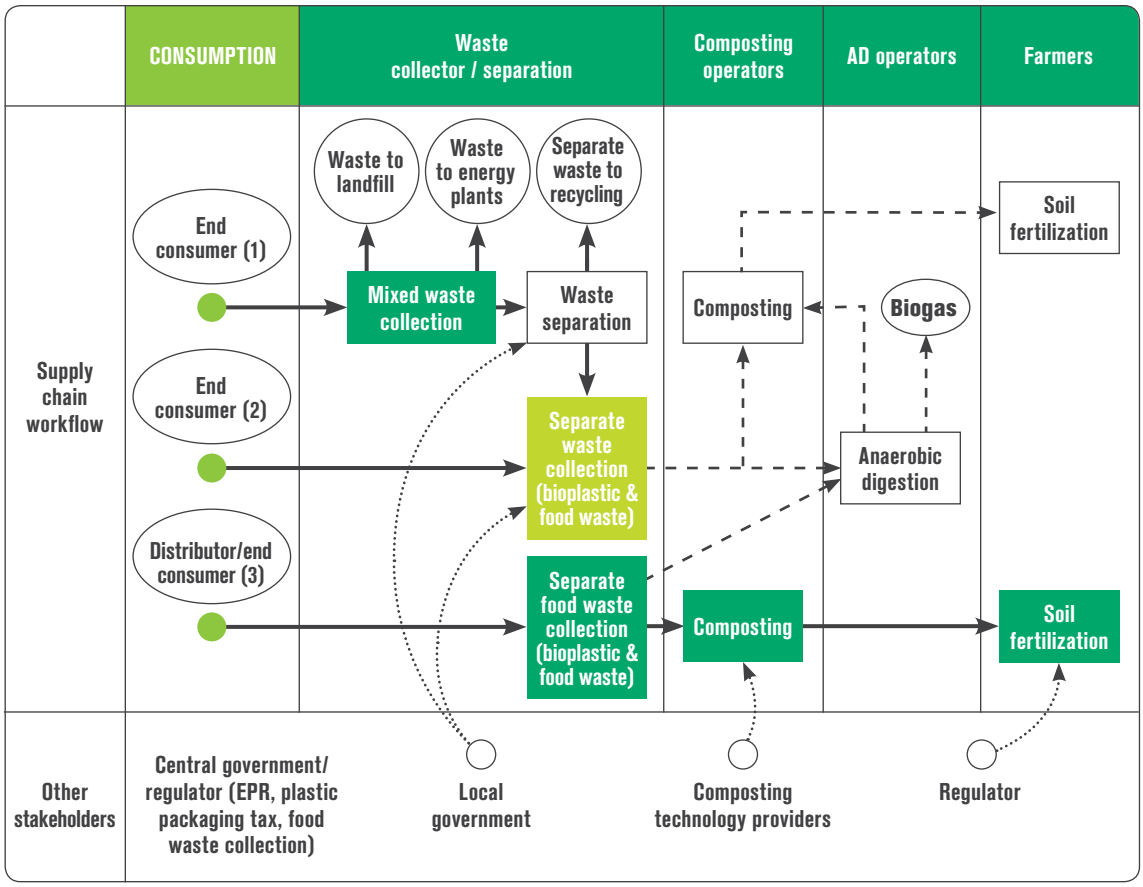
- Input 1 begins with the links to the previous consumption stage of the end consumer to a waste collector. The end consumer disposes of the compostable items on a mixed waste bin, with other general waste, the waste collector separates the waste. Four outputs (waste exits from the current supply chain) of this process can be expected: waste to landfill, waste to energy plants, waste to recycling centres and compostable waste separated from the other waste streams.

- Input 2 begins with the links to the previous consumption stage of the end consumer to a waste collector. Compostable packaging waste and food waste are collected by the waste collector as a separated stream waste and sent to a composting facility or suitable AD plant or composting plant. One of the outputs of this process is biogas.

- Input 3 begins with the links to the previous consumption stage of the distributor to a waste collector. Compostable packaging waste and food waste are collected by a dedicated waste collector as a separate waste stream; the waste collector cleans the waste to eliminate any other plastic material and sends the waste to an in-vessel composting facility. The alternative technical option is to send the separated waste stream to a suitable AD plant.

The final line that connects the supply chain with the farmers is the distribution of digestates for soil fertilisation

The waste management sector holds stronger connections with composting and AD technology providers and regulators, which oversee standards that dictate the quality of soil and the level of plastic contamination of soil, amongst other factors. Other actors in this diagram include the influence of local government in the operation of waste collection facilities in each of the three pathways.



Green : existent processes
Green : process in discussion in the U.K.
White : processes that don't exist in the U.K.

: current material flow.
: proposed material flow
: information flow

Figure 8. Supply chain diagram focusing on the waste management section

Figure 9 below shows the same supply chain diagram commented on by participants in this breakout group following the second task. It is important to note that whilst this figure displays less inputs from participants in the form of stickie notes (due to technical problems to access Miro) than the other breakout groups, there was considerable discussion by participants captured.

The participants indicated the diverse barriers in the UK to connect and unlock the supply chain, such as investment capital and the available technology. It is important to note; this infrastructure is not present at the moment in the UK as one participant explained: *"There is no site that goes from digesters to composting … we keep our digestate completely separate, so they're not linked on that chart".*

One key actor highlighted that a process missing from the supply chain diagram for waste management was a pre-AD thermal process. One participant explained the risks of not using a pre-AD thermal process: *"you cannot just put a load of plastics into a digester and an autoclave to make it digest. It doesn't work … it nearly broke the machine…[with] the sticky residue nature of these plastics, they basically got stuck to one side of the machine".* This process is critical to allow compostable plastics

to be processed in conventional AD plants with the same participant going as far as stating that *"we find none of the compostable plastics compost".* Another technical expert mentioned that there are alternative options to unlock the waste management supply chain:

1) Wet-AD facilities that do not have a front-end autoclave could remove compostable liners/bags and feed them into IVC (In-Vessel Composting), especially where they have IVC within their businesses and proximate their wet-AD processes.

2) The revision of End of Waste rules for anaerobic digestate, which allow further processing of digestates (beyond separation into liquid and solid fractions and aerobic maturation of the digested solids). This would help to grow the markets for digestates and digestate-derivatives.

3) Changes to new Standard Rules Permits (SRP) will allow SRP composting processes to accept digested material (where made from inputs allowed under the SRP), so this is another option for further biodegrading fibre digestates if they contain partially biodegraded compostable plastics.

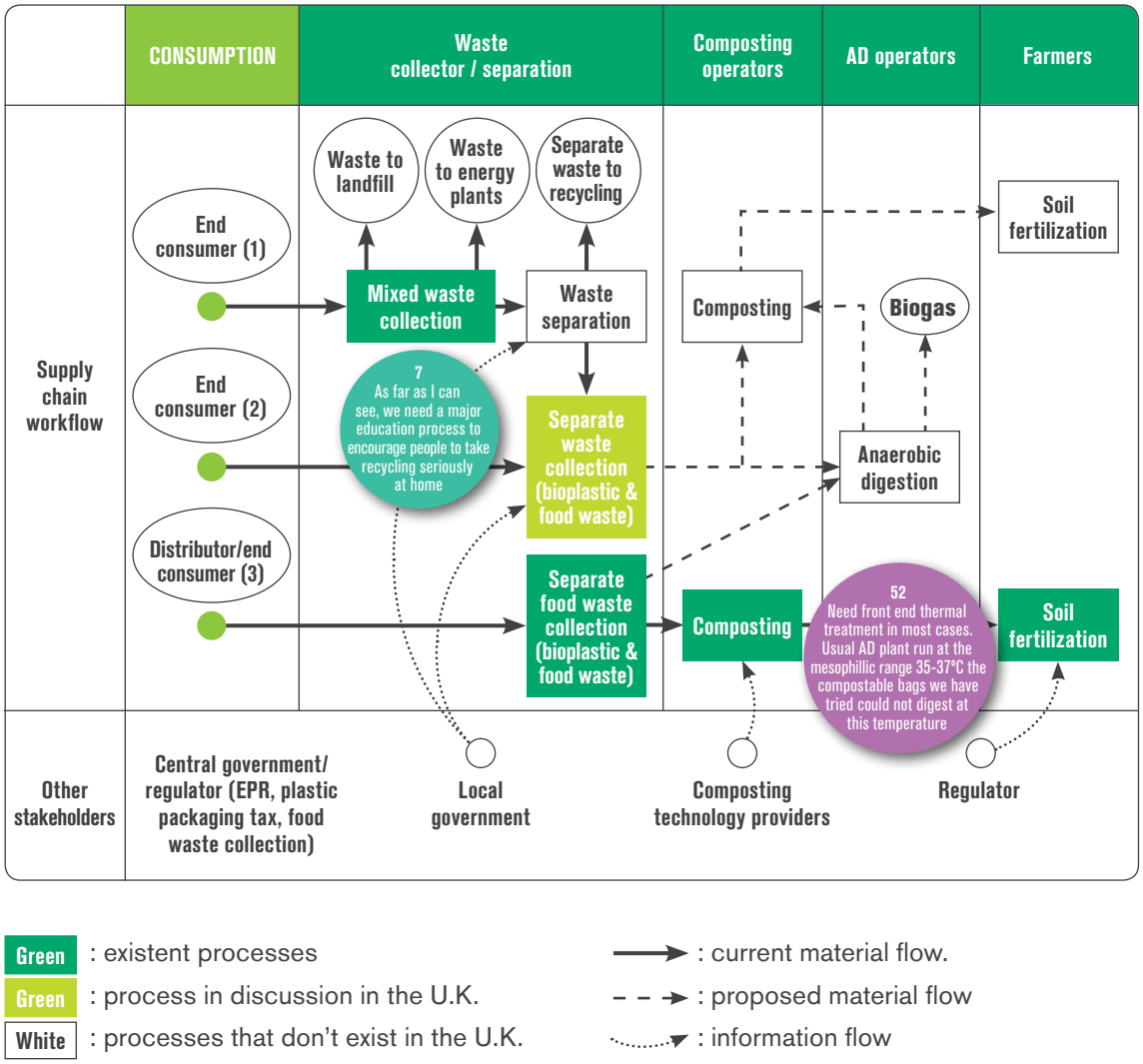


Figure 9. Waste management supply chain diagram following the second task

Further issues raised by participants when completing this task of 'what the system looks like' by the waste management group included:

- Bioplastics are not just one material but many. There are so many different types of bioplastic packaging materials that create a variance in how they are processed and, therefore, variance in various supply chain pathways.

- The need for capital investment. This would better connect the waste management sector with the other parts of the supply chain. However, public investment will be difficult to raise at the moment.

- The importance of putting the right material into the right local facility. A further factor that influences what the supply chain looks like here is the challenge of ensuring that the right materials are being placed into the correct bins and that this then is processed at the correct local facility. As one participant highlighted *"we're interested in trying to find a solution for industrially compostable packaging as a whole so that food waste bin users can have a simple instruction, very simple collection system"*. However, this is limited by the waste management facilitates that are available locally.

- The possible contamination of soil. A further point was the potential contamination of soil with plastic material if compostable are not degraded appropriately.

- 'Do we really want to increase the amount of plastic packaging?' The group also discussed this dilemma. It is important to note that there is an agreement that packaging should be minimised as much as possible. Compostable packaging can play a role to increase food waste collected and reduce food waste removed at organics recycling facilities (where the waste stream has negligible non-compostable plastic contamination).

- Compostable bags: If only compostable liners/bags are used for collecting unpackaged food waste and food waste from closed-loop sources, less non-compostable plastic will be in those waste streams. Therefore less of it will get through to the composts and digestates.

3. Key themes emerging from the workshop

This section now moves to highlight a number of emerging themes from the seeing the system workshop. These themes were key discussion points that cut across each of the breakout groups and the different stages of the supply chain examined. The discussion points in this section bring together the perceptions presented by participants reflected in the breakout sessions.

3.1 Standardisation, labelling and its connection to competition and innovation

One of the principle points that was shared across the three breakout sessions was the topic of standardisation, with points made both in favour and against this. Different stakeholders describe and understand the standardisation in different ways: labels/identification (e.g. OK compost HOME[1] and DIN-Geprüft home compostable[2]), certification standards (e.g. EN 13432[3] for industrial composting and anaerobic digestions), and guidelines to connect the waste management system with the supply chain.

3.1.1 Labelling and biodegradable identification

Participants in the production and consumption breakout sessions spoke about how there is a wide range of different labels which can complicate packaging materials reaching the correct waste management route. An example was given of a cup labelled as "compostable" failing to compost in a home garden compost heap after 8 years. The need for better identification of the compostable products, therefore, often relates to the different biodegradability qualities between compostable and industrially compostable plastics.

Participants described the range of different compostable products, the materials from which they are made and the labelling utilised to communicate correct waste management actions as confusing. Participants expressed a concern that without greater identification (labels) of compostable packaging, this poses a risk to the future expansion of the material's use. Comments made on how certain actors were missing or that connections were absent on the supply chain diagrams are to a certain extent reflective of the complexity of the range of bioplastic materials being utilised and their biodegradability requirements.

Further comments around identification of compostable products referred to the challenges that consumers face in knowing whether bioplastic packaging products can be processed via their local authority waste collection or via home composting. In multiple workshops, the topic was raised that instructions of what to do with food waste and biodegradable waste can differ greatly between district council areas.

Whilst participants reflected on the need for greater identification of products, others stated the difficulties and disadvantages in homogenising certification standards for bioplastic packaging production, supply and waste management.

3.1.2 Certification standards

Firstly, in relation to production, certification standards could potentially stifle competition. As one participant explained in the production breakout group, the supply chain *"has to fit into the whole mould that ends up being developed because there will be quite a lot of competition … between the manufacturers of certain products"*. The participant puts forward here that any effort to standardise the supply chain must consider the positive aspects of how manufacturers are competing with each other to produce bioplastic packaging materials.

However, this must be taken into context in that whilst allowing competition is beneficial in terms of material innovation and lowering costs, a regulatory adviser notes that in the long run, the sector

must unify for common progresses – *"I think at some point there has to be both a convergence and a consensus on what's best to use where and in what circumstances"*. One of the ways this was elucidated was to bring together current knowledge, standardising the *"integration of various bits of data that are out there"* to ensure that the expansion that the public and industry would support is on the same page as various bioplastic packaging actors across the supply chain.

3.1.3 Guidelines for the waste management sector

In relation to consumption and waste management aspects, participants noted that whilst a homogenised system of waste collection across the country would be beneficial, *"the cost would be greater than the defence budget"*. One participant explained that *"Wales is a very good example, you know that's one of the best recycling systems in the world, and they don't have a standardised system, every region is different"*. There are clear geographical limitations also as there is not equitable access to waste management sites that can process bioplastic packaging in AD or other facilities.

Overall whilst there was mixed views on guidelines for managing bioplastic packaging waste, a key comment made was the need for greater *"lines of sight from production through to consumption and back"*. The connection between certification standards and guidelines for the waste management sector, therefore, should foster competition (excluding unfair competition with products that are not certified) and keep in check the importance of establishing a supply chain that puts circularity front of focus. With mandated segregation of food waste in waste management systems coming into place through legislation in 2023, this could provide an opportunity to bring into line waste management procedures for compostable products. As one participant puts it *"we must have the systems in place to deal with that",* and only through a form of collective framework of efforts will this be possible.

3.2 Bioplastic material limitations and potential

The performance of compostable plastics was mentioned in the breakout sessions; this was in a framing that any material considered biodegradable was *"not as good as their hydrocarbon alternatives".* In the production breakout group, participants discussed the technical shortcomings and limitations of bioplastic materials. As one participant, a technical consultant, highlighted:

"There are some very clear technical shortcomings associated with the temperature, this isn't very good, but the moisture resistance isn't good. The gas barrier properties aren't great. There are all sorts of things that some home compost, others will only industrially compost. So, there's a whole range of challenges with bioplastics industry, technically."

Overall, the point can be made that actors across the supply chain query the current potential of bioplastic materials to replicate the properties of hydrocarbon-based plastics. Only one participant pointed out that the biodegradable nature of bioplastic presented a range of opportunities:

"So, you have loads of different applications for bioplastics. You have, for example, some in some instances you just need a thin film. Sometimes you need something much thicker and much more robust, something with a lot more material integrity. And then you have stuff that will be used in high heat applications […] some in high moisture, some in dry applications. And so I think for

any companies or for any R&D institutes or any labs that are working on this kind of thing, I think it will really help to look at the problem they have or what problem do they have at hand and try and fix that… it might be something that could be used as, for example, like disposable parts in agricultural production."

Further limitations in bioplastic materials were discussed in relation to how compostable plastics decompose in specific AD plants processes (i.e. wet, dry, etc.), or only under specific conditions or pre-processing. A clear link was drawn by participants between bioplastic materials that held a greater usability in more closely matching the properties of hydrocarbon-based plastics, and being more challenging to biodegrade or compost. For example, *"it's usually ones like PLA, which are industrially compostable and when you consider that even PLA in your garden will still won't degrade for at least like 100 years".* This was a crucial point raised in the waste management breakout group where the operating temperature range of AD plants was discussed:

"You won't convince an AD operator to change the operating range. As soon as you do that, you can get foaming event in your digester, which then shut down the plant. So you need to try and keep in that range as much as possible."

Overall the workshop uncovered somewhat of a disconnection between the innovations in bioplastic material creation and considerations of how such materials will be processed by the current waste management sector and infrastructure (current AD plants). However, it is important to recognise that there is significant potential in compostable materials to provide a range of solutions, rather than comparing their ability to traditional plastics.

3.3 Cost and scale of production

Participants discussed how the production cost and their lower-level production scale are key barriers holding back the wider use of bioplastic packaging materials and products. Lowering cost was seen as a key pathway forward; without a competitive cost price, packaging purchasers will prefer traditional plastics despite the perceived environmental benefits of using bioplastics products.

The production breakout group raised the issue that the resources used to create compostable plastics are costly, which, combined with their lower scale of production, means the cost of compostable plastics is high compared with hydrocarbon-based plastics:

"From the compounder's point of view, the primary source of the relatively high cost of plastics are the materials. And the main reason for that is very often these materials are currently being made at a much lower scale than established fossil fuel commodity, plastics, polyethylene, for instance, that are to some extent in their infancy. And until there is scale-up, then cost is going to stay relatively high."

A further point made in this discussion was that with a steady supply of primary materials, this would also bring down production cost. Given the re-useable nature of compostable plastics, a participant working as an academic researcher put forward that a waste management system that can provide this steady supply is key to reduce material cost:

"We have to have the right facility to collect that and go into composting facilities. And after that, there could be some very useful things generated."

3.3.1 Life cycle cost analysis

Whilst bioplastic packaging was noted as being more expensive, participants made the point that, when considering the cost of the environmental impact, bioplastics actually present as a cost-saving. The production breakout session raised this point as compostable plastics have a lower environmental impact:

"cost is really important if you're working through a system like this that we have, whole life costing and the comparison of costs and benefits which say conventional fossil plastic film. Because if, if you put plastic film through an energy from waste plant, theoretically we should be adding things like carbon tax and things to those costs to help to reconcile the difference because, you know, the environmental impact should be costed."

The way in which the system is presented here is perhaps more of an idealised way that lifecycle analysis should work and be applied. One of the participants in this group, a technical consultant, made clear that the environmental benefits are evident for compostable plastics when viewed through a lifecycle lens:

"You've got to look at the whole lifecycle of the product and look at the benefits that you get at the end of the lifecycle from using a combustible material. So you've got to factor that in."

This shows that, although the plastic packaging sector might not yet be at the stage where its environmental impact is being adequately costed, or that bioplastic supply chains are able to provide ample and cheap circular material inputs, participants shared a vision that ultimately, when these factors are realised, bioplastic materials will be cost-effective.

There were two key barriers to consider around environmental cost. Firstly, purchasers of packaging materials will still see cost as the ultimate factor guiding their decision making, despite the environmental drive away from hydrocarbon-based plastics. Secondly, replacing fossil-based plastic materials with bioplastics will result in additional costs. In the consumption group, a participant who held expertise in operations management explained that:

"Manufacturers will be reluctant to the changeover because it'll be costly. And, you know, they're always trying to drive prices down to sell more goods."

Such statements can be connected to those made across the breakout sessions over concerns that businesses are slow to change and that the economic drivers to grow the compostable plastics sector are still weak, without fully costing the environmental impact of hydrocarbon-based plastics.

3.4 Marketing, consumer knowledge and bioplastic waste management behaviours

A narrative that was identified throughout the breakout groups was that the marketing of compostable plastics, in terms of how end-users understand their purpose and use, was not clear.

3.4.1 Bioplastic marketing

Firstly, participants raised concerns about the 'eco-friendly' association that compostable plastics held, again linking this back to the complexity they stated consumers face in taking the right disposal action with a bioplastic packaging product. In the production breakout sessions, for example, packaging companies were noted as *"surfing on the back of the compostable description"*. The same participant who described purchasing bioplastic packaging went on to say that these packaging companies *"they won't say, oh, it's only industrially compostable, and it's they'll just say, oh, this is biodegradable and compostable. This is a bioplastic."*

Participants often referred to large coffee companies as examples of how compostable packaging is, in their opinion, not being marketed and presented to the consumer accurately. Participants that held a footing in the consumption part of the supply chain absorbed the limitations of such companies providing industrially compostable packaging, with the perception that *"they'll just go to landfill anyway".* An engineer working in the bio-industry made the point that retailers are normally much more focused on recycling goals, rather than composting their packaging.

3.4.2 Consumer perceptions

Participants of the breakout groups agreed that there was a lack of consumer knowledge and awareness of compostable packaging products. A participant in the consumption area of the supply chain explained that whilst a packaging product that is seen as good for the environment is a bonus as a selling proposition, *"most customers just don't care."* This participant acknowledged that customer awareness of compostables is improving, but yet *"it doesn't matter to most people."* The conversations highlighted that the perceived environmental benefits of compostable products are not yet a feature to end consumer's purchasing decisions, except for a minority of those that are more environmentally conscious.

A discussion in the consumption breakout group explained that a greater presence of compostable plastics products in the retail settings that consumer's frequent would improve their perception. This was offset against concerns that consumers would incorrectly dispose of bioplastic materials:

"If bioplastics become quite a regular thing in retail shops and food packaging, everything, blah, blah, blah, consumers may start to think that because these are such a large occurrence that everything is made out of bioplastics and that everything can be continued to go into the green, then all the food."

Participants expressed doubts about end consumer's ability to separate their waste, describing consumers as *"uninterested or potentially just lazy, they will just assume that everything can go in one bin."* UK households have lower recycling rates compared with elsewhere in Europe,[4] which may explain the participants' perceptions. Nevertheless, the conclusions drawn from the consumption breakout session show that there is currently a lack of faith in consumers to successfully dispose of compostable plastics in household waste collections. The comment below by a community composting expert is a good example of this:

"A lot of people are involved at home with composting, getting rid of the waste, one of the problems is that they said they just don't know what to do... And the problem, I think, is that we have such a diversity of things across the country. And to move forward, we've got to have some sort of centrally devised method that everybody knows where they know what needs to be done and what goes where."

Points around wanting a more standardised domestic waste collection system return here, reflecting the perceived confusion that households are facing. Members of the breakout groups that were involved in composting made similar comments that juxtapose composting solutions as straightforward, against the apparent complexity of the different conditions under which compostable plastics are disposed. A move towards ensuring all biobased biodegradable plastics are home compostable is one way in which this was explained:

"If we can make materials that are home compostable and if we can make them better, that would eliminate the need for educating most people. If people can have the same products and throw it in their flowerbed or their home compost, then that would eliminate the need for extra education or eliminate the need for writing all these little caveats on the packaging as well."

3.5 Infrastructure required

Particularly in the waste management group, the topic of the infrastructure was discussed mainly in relation to the technical limitations of the composability of waste and the ability of the current AD infrastructure to process the compostable plastics waste in the UK. Participants made points around how the bioplastic waste processing infrastructure was not as developed as other EU countries. Further issues raised related to issues with compostable caddy liners and how *"there just simply is not a compostable or biodegradable bag on the market at the moment which would actually be suitable",* here referring to use in the (wet) AD process.

In documenting what was shared in relation to infrastructure requirements, the purpose here is not to provide comprehensive technical detail on the issues raised, rather to collate concerns that participants raised in the context of seeing the current system. Technical challenges that participants raised were seen as a danger to the successful functioning of the lifecycle, circular vision that participants held with regards to what the bioplastic supply chain could be. Providing the correct biodegradable caddy liners was one issue that illustrates this as one participant working for a public body set out:

"We need to make it easy for people to do the right thing, so that means supplying them with the right bag [...] So it's got to go in some bags, I'm putting it in that, and I know it's not going to work. It's just going to turn into silly string in the AD process, and gassing up costs money to get it emptied and dealt with."

To a certain extent, this shows how the infrastructure can only be as efficient as the inputs within the waste management processes and that without collaboration with both producers and consumer actors in the supply chain, this will not improve. It is understandable how compostable plastics were seen as an additional "danger" given the number of issues they already dealt with relate to food waste composting. A further existing issue that was raised was spreading the digestate that AD plants generate, in that there is only so much you can spread on land:

"We still have to get rid of all digestate. And the landbank that we send this digest to is not infinitesimal. A landbank opportunity is hard enough to get at the minute, and it is a dog eat dog competition."

Stakeholders also evidenced the same waste management problem for fossil-based plastics. An engineer working in the area stated that there is not a suitable infrastructure to process fossil-based flexible packaging *"I think four percent of flexible plastic is recycled currently".* Those with technical knowledge of AD processes highlighted a range of difficult food stuff that are difficult to process, from fruit labels, tea bags, and coffee capsules to packets with food inside.

"They're obviously very difficult to recycle, very small format flexibles as well. That won't ever be recycled realistically because they're such a nightmare, you know, to collect, and the facilities won't be sort of geared up."

Overall, the points raised by participants relating to infrastructure raise a number of issues. These are not siloed to technical fixes but instead show that decisions taken earlier in the supply chain have significant implications for how compostable plastics are disposed of, collected and processed amongst other waste streams.

4. Conclusion and next steps

This report has provided an overview of the significant potential of the bioplastics sector, introduced the SIMBIO project and detailed the main points of discussion and outcomes of the seeing the system workshop and breakout session tasks.

Five key themes emerged from the workshop. **The first** of these looked at the standardisation of labelling and how this connects to competition and innovation. Points were made both in favour and against standardisation. Standardisation was a point that was interpreted in different ways by different actors. It included labelling and bioplastic identification standards as well as certification for industrial composting AD digestion and waste management procedure. Participants commented that the range of labelling and types of bioplastic material was confusing, meaning it was difficult for consumers to make the correct disposal choices. In relation to certification, participants expressed concerns that enforcing standards would stifle competition, as healthy competitive innovation is helping progress bioplastic material innovation.

The second emerging theme was the limitations and potential of bioplastic materials. The shortcomings of bioplastic materials were identified as challenges in how they handle temperatures, moisture resistance, gas barrier properties and compostability. It is questionable whether bioplastic material innovations should continue to follow a pathway of aiming to mirror the properties of hydrocarbon-based plastics, but instead focus on its unique applications and advantages. Whilst the report did not seek to provide a technical breakout of bioplastic material properties, the breakout sessions did feature discussion of how materials that better mirror the properties of hydrocarbon-based plastics have more specific conditions under which they decompose. To some extent, the report identified a disconnection between the innovations in bioplastic material creation and consideration of how the waste management sector will process such materials.

The third emerging theme was cost and scale of production. This highlighted that a factor holding back the sector is the high cost of production and input materials. The current low-scale production of bioplastic packaging products cannot compete on price with products made of hydrocarbon derived plastics. When considering a life cycle cost analysis approach where the environmental impact of traditional plastics is factored in, bioplastics presents a cost-saving. Participants were keen to note that if such impacts are factored in, bioplastic packaging materials have a significant potential to become more cost-effective. Currently, however, decisions by packaging purchasers are made on the basis of cost, which limits the uptake of bioplastics.

The fourth emerging theme brought together points around marketing, consumer knowledge and waste management behaviours. Participants noted that 'Eco-friendly' labels were being used inappropriately in cases where packaging products were only industrially compostable plastics. The report highlighted that consumer awareness and drive to increase the use of bioplastic packaging through their purchasing decisions were lacking. Whilst the greater presence of compostable packaging in retail settings would aid this, doubts were shared about consumer's ability to properly separate out bioplastic packaging in waste collection streams.

The fifth emerging theme covered the role of infrastructure, focusing on waste management. The compostable waste processing infrastructure in the UK is not as developed as elsewhere in Europe. The report highlighted the concerns of participants relating to the biodegradability of current food waste caddies available on the market to consumers and the implication of this for bioplastic packaging collection and processing. An important point raised was that the waste management infrastructure can only be as efficient at processing and recycling food and bioplastic packaging waste as its inputs.

Looking forward following our discussion with the stakeholders in the workshop and literature review, it is clear that some compostable solutions that are difficult to recycle, such as flexible packaging and food contaminated packaging, could play a significant role in achieving the UK bioeconomy targets and circular economy.

5. Recommendations

The further steps suggested to connect the supply chain are:

- Develop clear and consistent legally binding labelling for product guidance to help consumers identify compostable products (for example, a product labelled “compostable” must be certified).
- Develop clear guidelines for processing compostable plastics waste for the waste management industry.
- Enforce current certification standards to ensure certainty about producers’ claims for their products and materials.
- Connect the current certification standards with a compatible labelling system and procedures for the waste management industry.
- Develop clear and consistent terminology to avoid current confusion. For example, bio-based biodegradable products can be renamed as industrially compostable plastics or home compostable plastics in coherence with labelling.
- Develop educational programmes for home composting biodegradable products.
- Dedicated use of compostable products for applications that are difficult to recycle.
- Develop infrastructure for disposing of compostable materials at industrial levels, such as a separated food waste collection bin and processing of composting packages in composting facilities and adequate AD plants.
- Research and development of other feedstocks, for example, from waste.
- Adopt consistent policies to support the use of compostable plastics.

Biographies

Professor Benny Tjahjono

Benny Tjahjono is Professor of Supply Chain Management, and also a co-leader of the Sustainable Production and Consumption cluster at the Centre for Business in Society. His overarching research area includes Sustainable Operations and Supply Chain Management, in particular, the exploration of Circular Economy principles in manufacturing and supply chains. He has a vested interest in ensuring the achievement of the triple sustainability objectives, '*doing good for people, planet and profit*'.

His research track record has been demonstrated by winning and successfully delivering several research grants from EPSRC, ESRC, InnovateUK, European Union, overseas funding agencies and directly from the UK industry. He was a member of a consortium consisting of seven universities in Europe recently being awarded the Horizon2020 MSCA Innovative Training Network aiming to formulate the service-oriented business for the European Circular Economy. His most recent research grant was funded by the Academy of Medical Sciences' Global Challenges Research Fund (GCRF) in the area of Circular Food Supply Chain. Currently he is leading three research projects, one is funded by ESRC in the area of Social Innovation of Bioplastics and the others are funded by EIT RawMaterials (to investigate the recovery of metals in façade industry) and Erasmus+ (to equip engineering students with entrepreneurial skills).

Representing Coventry, he is one of the founding members of the newly established UK-Indonesia Consortium for Interdisciplinary Sciences (UKICIS) with an aim of harnessing the research and knowledge transfer activities between the two countries, in the topical areas of resilience and climate change.

Dr Jordon Lazell

Dr Jordon Lazell has held the role of Research Assistant at the Centre of Business in Society, at Coventry University, UK, since 2013. His research interests lie in the area of food waste, specifically food consumption, waste and mitigation behaviours of consumers as well as food waste within retail supply chains. Jordon is a co-editor of the first Routledge Handbook of Food Waste and is also co-founder and administrator of the International Food Loss and Food Waste Studies Group, a research platform for academics and practitioners operating in this area.

Dr Macarena Beltran

Dr Macarena Beltran is a Research Assistant at the Centre of Business in Society at Coventry University, UK and is part of the Sustainable

Production and Consumption cluster research team. Her training in the field of sustainability came from her PhD at Newcastle University in Urban Energy, where she studied how the interactions of physical and occupants' behavioural factors intervene in the energy demand. Her research interest area includes socio-technical research and the exploration of Circular Economy and Bio circular principles in manufacturing and supply chains. She has also worked evaluating the impact of the Office for Students related projects. She has more than 10 years of experience working on assessing and developing supply chains (e.g. Steel and financial companies). Dr Beltran also holds an MA in Planning and Environment Research, a Master in Marketing and Business, Industrial Engineering and a BSc.

Dr David Bek

Dr David Bek is a Reader in Sustainable Economies and co-leader of the Sustainable Production and Consumption Cluster in the Centre for Business in Society. David has extensive experience in undertaking research into sustainability within horticultural supply chains, especially cut flowers. He has worked alongside organisations in the fruit, wine and flower sectors in South Africa to develop training courses and monitoring and evaluation tools to promote enhanced sustainability in practice. He has undertaken work with the UK horticultural sector exploring the sustainability impacts of plastics and growing media. David is currently involved in a project investigating the impacts of Covid-19 upon the resilience of cut-flower supply chains (funded through the UK Department for International Development), whilst he is leading a project funded by the Dutch Sustainability Initiative (IDH), which is seeking to identify certification and assurance mechanisms for promoting sustainability in the global wildflower harvesting sector.

Dr Anna Bogush

Dr Anna Bogush is an Associate Professor at the Centre for Agroecology, Water and Resilience (CAWR, Coventry University, UK). Her research and teaching interests lay in the interdisciplinary area, including chemistry, environmental engineering, material science, circular economy and industrial symbiosis. Her work is largely directed towards understanding the fate of pollutants in the natural-anthropogenic system and developing sustainable materials & technologies using concepts of industrial symbiosis and circular economy to tackle the environmental issues. Currently, she is working on the understanding fate of submicron and microplastics in the environment and developing novel technologies to reduce plastics pollution. She contributed to secure 32 internal and external funding in projects funded by H2020, RAEng, EPSRC/NSFC, COST, UCL, CU, RFBR, RAS, SB RAS, NASU, industry and the Environment Agency. She is an author of 4 book chapters and over 50 peer-reviewed papers. She is an independent external expert in the European Cooperation in Science & Technology (COST Association) and Newton Prize 2020 reviewer (UK National Commission for UNESCO). She is an Associate Editor for the Section 'Circular Economy' within the Journal Frontiers in Sustainability, a topic editor for the journal Minerals (MDPI), and a guest editor of the Special Issue on "Advanced materials in Environmental Chemistry" at the journal "Molecules".

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