

Research Stimulus Fund Final Report

Project Title: A Bioeconomy for Ireland - an evaluation of development opportunities, policies and initiatives shaping Ireland's transformation to a sustainable low carbon bioeconomy
Acronym: "BioÉire"

DAFM Project Reference No: 14/SF/857

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Principal Coordinator and Institution: Dr. Maeve Henchion, Teagasc

Email: maeve.henchion@teagasc.ie

Collaborating Research Institutions and Researchers:

UCD - Dr. Kevin McDonnell, Dr Eilín Walsh

DIT - Paul O'Reilly

tcbb RESOURCE - Bart Bonsall, Pádraic Ó hUiginn, James Gaffey, Owenroe Lemass

Teagasc - Dr Laura Devaney, Ultan Shanahan

Please place one "x" below in the appropriate area on the research continuum where you feel this project fits

Basic/Fundamental	→	Applied	→	Pre Commercial		
1	2	3	4	5 x	6	7

Please specify priority area(s) of research this project relates to from the National Prioritisation Research Exercise* (NRPE) report;

Priority Area (s)	Priority Area H - Food for Health Priority Area I - Sustainable Food Production and Processing Priority Area L - Manufacturing Competitiveness Research for Policy
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Key words: (max 4): Bioeconomy, value chains, policy, innovation.

1. Rationale for Undertaking the Research

This section should outline the rationale for carrying out the research and identify the need / problem to be addressed

With escalating global challenges related to climate change, biodiversity loss, resource scarcity, food security, economic sustainability and growing populations, the concept of the bioeconomy has emerged worldwide, coming to the forefront in transnational and national policy documents in recent years (OECD, 2009; EC, 2012; Staffas et al., 2013). According to EC (2012, p9) the bioeconomy includes “*the production of renewable biological resources and the conversion of these resources and waste streams into value added products, such as food, feed, bio-based products and bioenergy*”. Representing an opportunity to reduce reliance on fossil fuels whilst still achieving economic growth, the drivers, innovations and challenges associated with bioeconomy development are multifaceted and complex. The bioeconomy calls for radical innovation across agriculture, food, forestry, marine, energy, chemical and material sectors as stakeholders are encouraged to collaborate and diversify production systems to meet food, feed, fuel and material needs in more sustainable ways. Such innovation includes new technologies, practices, values, beliefs, configurations of actor groups, networks and policies (Darnhofer, 2015). Ireland currently lacks a coherent national bioeconomy policy that identifies complementarities between resource sectors, highlights priorities for development, engages stakeholders and ensures the sustainable and just allocation of biological resources across food, feed, fibre and material applications. Key sub-sectors of the bioeconomy are typically governed independently of one another, each with their own, and potentially competing, strategy for development. There is a need to connect the objectives of these roadmaps through one coherent bioeconomy strategy that maximises return from natural resources in an environmentally and socially sustainable way. The BioÉire project was established to conduct an evaluation of the most promising value chain opportunities for the Irish bioeconomy and provide part of the knowledge base necessary to construct a national strategy. This included undertaking research from supply, demand, business and support framework perspectives.

2. Research Approach

Specify the research methodologies employed, emphasising novel techniques and also outline any modifications from the original approved project proposal

BioÉire identified the most promising value chain opportunities and necessary support frameworks for the Irish bioeconomy through a series of interconnected research tasks. This included a detailed situational analysis of the Irish resource base, assessment of bioeconomy markets and consumer behaviour and attitudes towards bio-based products, an online Delphi study with over 75 bioeconomy experts and evaluation of the regulatory, infrastructural and commercial frameworks necessary to underpin value chain exploitation and success. BioÉire was the first project of its kind to objectively assess development pathways across the breadth of the Irish bioeconomy. This knowledge base is essential for informed, evidence-based policy development.

Examining opportunities across agriculture, food, marine, forestry and energy sectors, the first workpackage (WP1) of BioÉire involved a situational analysis of the Irish biological resource base, alongside a strategic assessment of Ireland’s capabilities in the bioeconomy arena (including an assessment of national strengths, weaknesses, opportunities and threats). Detailed literature and policy reviews, semi-structured key informant interviews, and brainstorming workshops with researchers external to the project formed the central research components of this analysis. Given the breadth of expertise required for such an analysis, a distinguishing attribute of the BioÉire project included the support and expertise provided by the Teagasc Bioeconomy Working Group (TBWG). This working group comprised

researchers with expertise across Irish resource and processing sectors and was essential in sense-checking preliminary value chain opportunities identified as well as reviewing outputs of the BioÉire project.

Once supply side and industrial capacity issues were established, a second key research phase (WP2) examined international best practice to determine market opportunities for the Irish bioeconomy. A review of international bioeconomy strategies, and literature with regards to consumer behaviour and attitudes towards bio-based products, was completed as part of this research task, alongside an examination of international markets and patents focused on the relevant value chain opportunities identified for Ireland through other work packages. Due to the wide-ranging nature of the bioeconomy, this allowed for a more focused and nuanced bioeconomy market assessment.

The third BioÉire research phase (WP3) involved the strategic generation, prioritisation and evaluation of relevant bioeconomy value chains, with the aim of identifying up to eight specific applications for the Irish bioeconomy. A diverse range of experts was engaged through an online Delphi study where participants were asked, through rounds of surveys, to assess and score sixteen potential value chains identified from the results of previous workpackages, and to provide a rationale for their responses. Results of the Delphi study were collated and analysed using both quantitative and qualitative techniques, including the use of both SPSS (for descriptive statistics) and NVivo software (for consistent analysis and coding of emerging themes). The top rated value chains were subsequently subjected to a more detailed technical, economic and environmental assessment drawing on qualitative Delphi analysis, the established literature as well as a series of project team and external stakeholder review consultations (again drawing on the expertise of the TBWG).

The final research activity in BioÉire (WP4) focused on designing and identifying the support frameworks required to ensure the success of the proposed bioeconomy value chains in Ireland. This included an assessment of policy, regulatory, financial, technical, infrastructural and market measures, among others. This was undertaken utilising a combination of (grey) literature reviews of current national and international policy and regulatory frameworks, interviews with national and international experts with longstanding and direct experience in technical, commercial and policy related bio-economic fields, as well as a large number of field visits. Interviewees included active technology developers, project developers, feedstock suppliers, commercial and research, development and demonstration (RD&D) participants to establish the practices and issues that are impacting ongoing development of the Irish bioeconomy. The ultimate aim of this workpackage was to develop strategies, tactics and actions for the effective and efficient attainment of national objectives in the bioeconomy arena.

All of the BioÉire research work packages were supported by a wider project management and dissemination work package (WP5) with results ultimately feeding into DAFM and the Department of the Taoiseach as part of efforts to develop an over-arching national bioeconomy strategy. Indeed, in addition to the agreed outputs and objectives contained in the original proposal, an additional design-thinking workshop was organised in collaboration with the Department of the Taoiseach within the project timeframe. Utilising BioÉire results as a springboard for the discussion, this workshop engaged 58 high-level stakeholders from research, support agency, policy and industry representative backgrounds in a range of workshop activities to co-design a shared vision and a collaborative approach to creating the right conditions for a successful Irish bioeconomy. This workshop was the culmination of a series of meetings and interactions with the Department of the Taoiseach, representing a novel value addition to the project outcomes, and was an action specified in the National Action Plan for Rural Development (2017). Indeed, BioÉire team members have also been significantly involved in contributing to the recently established interdepartmental group on the bioeconomy that aims to draft the high level bioeconomy policy statement for Ireland. The BioÉire results launch, held in March 2017, represented another key dissemination event in the course of the project. All project partners presented at the event, in addition to speakers from appropriate international policy, research and industry backgrounds. Reflective of the traction and momentum achieved by the BioÉire project, this event was again well supported by high level industry, research and policy stakeholders with over 50 stakeholders in attendance at the event and continued

expression of interest in the associated outputs and presentations. All of the talks from the launch, as well as additional reports, papers, magazine articles and related outputs from the project team, are now hosted on a dedicated page within the Teagasc website to enable continued interactions and access to resources beyond the end of the project (<https://www.teagasc.ie/publications/2017/bioeire-results-launch.php>).

3. Research Achievements/Results

Outline main results achieved

BioÉire was established to identify and evaluate the most promising value chain opportunities for the short-medium term Irish bioeconomy as well as the support frameworks required for their implementation and success. Results will form part of the knowledge base to develop a national bioeconomy strategy for Ireland. Bioeconomy development however is diverse and complex, encompassing numerous biological resource sectors and stakeholder groups across agriculture, food, forestry, marine, chemicals, materials and energy industries. Headline results from the project, which include proposals from research subjects to develop the required framework, include:

Background:

- The current Irish bioeconomy comprises highly productive agriculture and agri-food & beverage processing, marine, forestry and municipal waste (AMFM) sectors that employ a substantial workforce to produce “traditional” (e.g. food, beverage, timber and waste management) outputs. Each sector is supported by a distinct development strategy targeting improvements in productivity, competitiveness and growth in traditional outputs to serve a growing domestic and global demand.
- Current policy, regulatory and support frameworks include measures that (a) include a substantial direct payment system supporting primary producers and the raw material supply chain, (b) require sector stakeholders to manage production activities in compliance with environmental requirements, as well as (c) provide RD&D and informational/advice supports to improve productivity, competitiveness and compliance;
- EU and State sustainability drivers target progressive moves toward market approaches to (a) improve social cohesion to overcome the urban-rural economic divide, (b) mitigate environmental impact by improving resource efficiency, waste management, and reducing undesirable emissions to leave the planet in a fit state for future generations, as well as (c) generate economic growth and employment through domestic re-industrialisation using indigenous bio-based raw materials to produce “non-traditional” outputs such as fine chemicals and functional foods, bio-chemicals, bio-materials, and bioenergy to increasingly displace non-sustainable raw material imports and products with sustainable alternatives.

Results Overview

- Priority value chains for the short- to medium-term were identified within a Delphi study. These span a wide range of bio-based inputs, technologies and applications. For the longer term, opportunities for example in higher end uses for wood fibre (among other sidestreams), such as bioplastics, carbon fibres, biomaterials and eco-construction materials, will emerge arising from commercialization of current and recently funded research. Indeed there are many novel research projects funded across Europe, and further afield, that showcase new value chain opportunities for diverse national bioeconomies. The Bio-based Industries Joint Undertaking (BBI JU), a public private partnership scheme between Horizon 2020 and the Bio-based Industries Consortium is a particularly relevant funding stream. The c. 65 (and counting) innovative and cutting-edge projects funded through the BBI JU provide inspiration regarding alternative processes, technologies and products that may improve identified value chains and/or provide alternative, innovative pathways for development in the longer term in Ireland.

- The bioeconomy can be successful economically, environmentally and socially if developed under certain conditions including consideration of integrated value web approaches, robust feasibility assessments, ongoing environmental evaluation and clear support frameworks that address supply, demand, technology, business and research considerations.
- Current value chain structures need to progress beyond linear relationships to establish connections and complementarities between resource sectors, bioeconomy value chains and support frameworks which need to be connected into a more comprehensive value web, with potential to apply cascading approaches and circular economy thinking to determine the most sustainable resource uses and address fuel, feed, food, fibre debates.
- Designing a coherent national bioeconomy statement and robust governance framework around bioeconomy actions and activities will be paramount with a need for input from a diverse range of actors beyond traditional government intervention to succeed.
- Key support frameworks required are varied and complex driven by the complicated integration requirements across numerous disciplines and sectors but span regulatory, infrastructural, market stimulation and research and innovation mechanisms.
- A detailed bioeconomic strategy could incorporate adaptations of existing sectoral strategies (e.g. agri-food, marine, forestry, municipal waste) targeting incremental modular value from non-traditional outputs (e.g. functional foods, bioenergy, biochemicals, biomaterials) while maintaining and growing traditional outputs (e.g. food & beverage, timber products)
- Adaptations of sectoral strategies require (cross departmental) alignment of commercial and regulatory frameworks to overcome barriers posed by legacy market structures and market inertia. These sectoral strategies should incorporate detailed targets, and identified (resourced) implementation measures to provide a coherent integration facilitating:

Identification of non-traditional product opportunities : Top value chains identified through the BioÉire Delphi study include the use of second-generation sugar-yielding feedstock for the production of biochemicals, dairy processing sidestreams for the development of sports nutrition products (beyond whey), horticultural by-product for biocompostable packaging, marine discard for functional food and feed applications, agricultural and food waste for bioenergy production, seaweed use for food, healthcare and cosmetic applications and forestry residues for decentralised heat generation.

- Bio Eire identified a stakeholder knowledge gap in respect to bio-chemical and bio-material product opportunities relative to available supply chains, with a need to better understand conversion technologies, the relationship between mass conversion and economic values and potential market entry strategies to develop Irish opportunities. A forum could be established between decision makers and scientific specialists to undertake a detailed review of Ireland's organic chemical imports, as well as the materials used in medicines and medical device manufacturing, to identify specific market opportunities within these fields.

Facilitate timely market entry for non-traditional products and services: Bioeconomy markets are diverse worldwide but hold significant potential tapping into consumer demands for healthy and more sustainable products and services (for example, the use of dairy processing side streams for functional food creation or the use of forestry thinnings for decentralised heat generation). Challenges with consumer acceptance of products generated from side or waste streams are a concern. Market penetration requires either displacement of less-sustainable forms of products and services or stimulation of market demand for new products. As noted in WP2, market drivers that underpin procurement decisions are predominantly oriented toward standard commercial considerations (e.g. price and performance) rather than sustainability criteria, particularly when products transition from niche to mainstream. To facilitate early market entry, consumer engagement together with “pull” or “push” support measures may be required to overcome market inertia and stimulate demand. In an Irish context support for market entry strategies could include:

- Giving consideration in industrial policy to supporting displacement of imports such as fossil fuels, organic chemicals, paper and plastics, sugar, animal feeds and fertilisers as it may be easier to engineer market entry to address domestic demand than to create new export demand
- Leveraging “green” public procurement which was identified as one of the most under-utilised, viable and near-to-market methods available to support early market penetration of sustainable bio-based products (introduction of environmental and social criteria into the selection process may be required).
- Designing market supports to incorporate defined transitions to market approaches over appropriate terms to provide the long-term horizon required to support investment and supply chain security.

Bioenergy was identified as a special case, as it is arguably nearest to market of all value-add opportunities and can generate significant impact in respect of sustainability and social cohesion objectives. Market entry is constrained by current economics which are exacerbated by lack of processing infrastructure, fragmented supply chains and lack of (grid) distribution capacity. Removal of these barriers requires adaptations to regulatory and commercial frameworks, technology and business model adaptations to facilitate greater waste-to-energy applications as well as market supports to stimulate demand, market entry and supply chain development. Financing supports may be required for end user technologies to support creation of a market for biomass fired RES H (renewable heat), while capital financing may be required for deployment of production infrastructure to create a biogas supply chain.

Facilitate Efficient and Sustainable Expansion of Primary Raw Material Supplies: The Irish resource supply base is renowned worldwide in terms of its quality and abundance; however it faces challenges of scale and fragmentation. An additional challenge is how to generate sufficient raw material supplies that can meet both the requirement to maintain and grow traditional bio-economic outputs while facilitating introduction and development of new non-traditional market opportunities. Increasing the supplies of primary bio-economic outputs will require increases in intensity, productivity and competitiveness, as well as the means to mitigate corresponding environmental impact. It will require methods to remunerate primary producers for the (financial and labour) capital required to generate growth. Considerations include:

- **Residue Valorisation:** Overall, the use of by-product and co-product streams held particular appeal in the BioÉire Delphi study highlighting the potential to valorise previously designated ‘waste’ streams and achieve economic and environmental wins in the bioeconomy. Regulatory issues need to be addressed however to realise these opportunities, including regarding the definition, use and recovery of waste streams and associated environmental licencing. The use of waste streams, however, as part of a circular bioeconomy vision, may encounter issues of consumer acceptance and risk perceptions that will have to be mediated. Public engagement from the outset of bioeconomy development will be essential to mitigate such concerns along with business model innovation.
- **Increasing Deployment of Dual Output Systems:** to maintain supply of livestock fodder as well as support expansion of bio-processing outputs it may be possible to identify plant varieties and process technologies that facilitate recovery of both livestock fodder (feed) as well as raw materials for non-traditional outputs. Examples highlighted in WP3 included processing of fish wastes for poultry or pig feed, as well as for recovery of nutraceuticals. Other examples might include processing of sugar beet, using the sucrose extract for white sugar or for bio-refining applications while the pulp and crop toppings are processed for fodder.
- **Nutrient Recycling and Intensive Production Systems to Mobilise Use of Underutilised Land:** it may be possible to develop intensive agronomic systems that use recycled nutrients and organic soil conditioners, together with improved targeting of nutrient applications, to bring “hidden hectares” back into economic productivity. Technology development may be required to facilitate recovery of organic nutrients in a concentrated form, at volume. Additionally, it may be possible to develop intensive systems such as hydroponics to reactivate otherwise non-productive lands. Economic considerations indicate that such systems would be more appropriate to supply high-value applications.

- **Restructuring Direct Payments:** Some of the current direct payments structures are not tied to productivity measures. It may be suitable to progressively adapt some of these structures to relate to productivity, and to support such measures with access to low cost finance for capital requirements targeting increased productivity;
- **Spatial Planning and Structured Supports to Overcome Fragmentation and Promote Targeted Afforestation:** To overcome fragmentation in the private forestry supply chain consideration may be given to targeted spatial plans oriented around processing plants. Incremental forestry supports could be structured to incentivise compliance with spatial plans, structured as a repayable advance against future harvest, as the economics of such a payment seems viable.
- **Aquaculture Mobilisation:** alternative forms of freshwater aquaculture may mitigate environmental concerns in respect of oceanic fish farms, facilitating supply of increasing demand for fish proteins. It may be possible to couple freshwater aquaculture systems with hydroponic or other intensive agricultural application, to take advantage of the highly- concentrated nutrients in the water effluent. Investigations would have to evaluate the economics as well as any wastewater treatment requirements necessary to treat wastewaters to a dischargeable standard. Developments internationally may provide suitable learnings for Ireland.

Municipal waste valorisation is a special case. To optimize efficiency, municipal waste collection may be considered a natural monopoly. The current multi-operator structure within a single geographic market causes fragmentation and margin pressures that precludes investment in technology development and optimal deployment of localised processing infrastructure. It poses a barrier to improved waste collection / segregation practices and local valorisation opportunities. It contributes to export of waste for valorisation in other jurisdictions. Localised waste-to-energy applications are commonly used internationally to valorise municipal waste. If the current multi-operator system cannot be adapted, it may be possible to consider public investment in “shared” infrastructure to improve local waste valorisation. Expansion of the multi-bin pay-by-weight system, as well as a greenwaste collection programme, targeting supplies of domestic, commercial and local authority landscaping residues, supported by appropriate incentives, enforcement and education, may provide an increased supply of organic feedstock suitable for renewable energy recovery. Devising a “sustainability” certification programme applicable to municipal waste collection activities may provide a mechanism to increasingly route supplies of municipal waste for local valorisation.

Timely technology development and de-risking: Near term bio-economic expansion will require timely development and demonstration of conversion technologies, which are at different stages of technology readiness levels. The State has a role to play in technology development and de-risking, especially where the imperatives driving development are societal rather than commercial. Where not already established, consideration should be given to aligning RD&D programmes with each of the bioeconomic sectors, and to re-orient RD&D programmes further along the development curve, emphasizing product development rather than knowledge accumulation. Impact may be improved by hosting centres of excellence at commercial sites supported with pilot scale facilities for process optimisation and validation, giving equal prioritization to direct funding of company research with scientific RPO services directed toward support of specific product development issues.

- Consideration should be given to use of State resources to leverage EU funding, targeting commercial demonstration of a near-to-market product offering, pursuing small scale production of commercial products and ongoing revenue streams that could be designated as sources of funding to facilitate ongoing RD&D work.

Timely Technology Deployment: New products and services will require investment in production infrastructure. To facilitate timely deployment the State may consider introduction of special incentives to redevelop brownfield sites. Alternatively use of under-utilised WWT or waste recycling sites may be suitable to host certain types of waste-to-energy production infrastructure. Modification of Regional Assembly

operational plans may facilitate access to ERDF finance mechanisms to overcome market failures in respect of accessing finance for early market applications.

- Current planning and licensing regimes pose a barrier to investment in plant and infrastructure. Adaptation of the planning and licensing process to allow 1 point of contact may increase efficiency in respect of ABP authorisations. A means to limit spurious appeals and enforce timeliness of An Bord Plaenala decision timeframes will expedite deployments.
- Consideration should be given to resourcing EPA with equipment and capacity to test and evaluate environmental impact from deployment of new technologies on a timely basis, to establish compliance with environmental regulations. A multi-disciplinary body tasked with reviewing, authorising and evaluating demonstrations of new environmental technologies on a timely basis may be considered.

Promote Viable Business Models to Mitigate Risk and Achieve Objectives: The potential for new business models, centralised facilities and indeed decentralised options may provide some solutions across diverse opportunity areas. Inherent price tensions between primary producers and processors in traditional horizontally aligned business models cause frictions in immature markets that preclude organisation of the supply chain and access to financing. Vertically integrated models such as co-ops, corporate structures or Public Private Partnerships (PPP's) may facilitate access to capital, expedite development of the supply chain and provide a means to remunerate primary producers for capital investment and increased effort.

As the definition and policy direction for the Irish bioeconomy is established, there is a need for a balanced and systematic deliberation of all options available backed by coherent and objective evidence base.

4. Impact of the Research

A summary of the tangible impact of the research project should be provided under the 'outcomes' and 'outputs' heading below. In addition, please provide a short narrative synopsis of the benefits / improvements the research has made to the area under investigation particularly as regards end users, e.g. industry, consumers, regulatory authorities, policymakers, the scientific community, etc

The bioeconomy, as a practical, tangible and realisable development pathway, holds potential to benefit numerous stakeholder groupings if developed in a sustainable and objective manner. For example, this ranges from its ability to diversify rural income and benefit rural development, support SMEs, benefit large industries and provide sustainable and desirable products for society. Key external stakeholders to benefit from the BioÉire project thus include policymakers charged with developing the national policy statement and subsequent strategy (particularly the Department of the Taoiseach, the Department of Agriculture, Food and the Marine and the interdepartmental group on the bioeconomy who have actively engaged in the project and resultant events and outputs), bioeconomy industries nationally, researchers, farmers and consumers. Project results have been made available to these stakeholders through multiple dissemination formats including a dedicated results launch website, Delphi and workshop results reports, peer-reviewed publications, national and international presentations and media outputs and tailored stakeholder meetings.

Involving value chain actors in the identification of development pathways is crucial for future bioeconomy buy-in, commitment and success, establish interconnected relationships and translate research into practice. Over 75 bioeconomy experts were engaged directly in the BioÉire Delphi study, 58 high-level stakeholders in the BioÉire-Department of the Taoiseach collaborative design thinking workshop and countless other interactions and stakeholder engagement exercises throughout the two-year desk study project. The momentum and traction gained by the BioÉire results is symptomatic of its timely nature and high quality outputs, with the identification of common areas of consensus, caveats and conditions providing a foundation for further collaborative discussions, stakeholder participation and consultation. It is in this

way that we may work towards establishing Irish bioeconomy principles (e.g. food first, grass first, pharma strength) and aims (e.g. rural development, business benefit, farmer roles) for holistic and tangible bioeconomy development. This policy influence has been the most direct and tangible impact of the BioÉire project, with BioÉire team members actively sought after for their contributions and expertise following participation in this two-year study.

Further impacts are evident in terms of international engagement through leveraging of BioÉire expertise to ensure Teagasc membership of the EU funded CASA consortium and an invitation to present at an OECD Workshop hosted by the Finnish Funding Agency for Innovation, Tekes and the Ministry of Economic Affairs and Employment in collaboration with Climate-KIC of the European Institute of Innovation and Technology, and Natural Resource Centre of Finland, Luke. This workshop is entitled “New innovation ecosystems and circular solutions to boost the bioeconomy”, and will be held in Helsinki on June 07, 2017. Further international impacts are expected following the award of two scholarships to Teagasc post-doc Laura Devaney to research bioeconomy development and governance in Canada and the United States respectively.

4(a) Summary of Research Outcomes

(i) Collaborative links developed during this research

As detailed above, BioÉire results have gained traction with the national Department of the Taoiseach and the Interdepartmental Group on the Bioeconomy, culminating in a collaborative design thinking workshop in February 2017 that will help to shape a national bioeconomy policy statement.

As a result of the BioÉire work and outreach, new research links and funding collaborations have also been formed between Teagasc and UCD. In this time period of the project, two collaborative funding proposals were submitted: one under the DAFM Industry Co-Funded Agri-Food and Bioeconomy Innovation Platform Funding Instrument (January 2016) and a second SFI Centre proposal bid in the form of the BEACON project (April 2016). The SFI Centre (BEACON) was successful and will involve members of the TBWG. Teagasc’s involvement as a partner in the EU funded CASA project was very much supported by the knowledge and networks developed during BioÉire and will result in the development of new collaborations at EU level within the research community and at policy level. The winning of the Dobbin and Fulbright scholarships by Teagasc post-doc Laura Devaney was underpinned by knowledge and expertise gained during BioÉire and will lead to international collaborations with the University of Dalhousie (Nova Scotia, Canada) and the University of Berkley (USA).

Three collaborative funding proposals were developed by tcbb RESOURCE involving collaborations with researchers, companies and community groups. These include a proposal to SFI, led by NUIG, to establish a Renewable Energy spoke in the Marine and Renewable Energy Centre involving several RPO’s, companies and Teagasc (April 2016), as well as a proposal to Enterprise Ireland to develop an efficient slurry dewatering technology supporting supply of dewatered slurry solids for renewable energy recovery, as well as a proposal to SEAI to define the detail parameters of a community based renewable energy centre (February 2017).

(ii) Outcomes where new products, technologies and processes were developed and/or adopted - N/A

(ii) Outcomes with economic potential

All of the bioeconomy value chains identified through the BioÉire project hold economic potential, to varying degrees, for development in the short-medium term Irish bioeconomy. Qualitative results are available related to the economic feasibility of the top rated chains to emerge from the Delphi study, highlighting benefits, caveats and conditions for further assessment and development.

(iii) Outcomes with national/ policy/social/environmental potential

As detailed above, one of the most direct and tangible outcomes of the BioÉire project include its contributions to national bioeconomy policy development. The identification of appropriate and feasible bioeconomy value chains promises **economic**, **societal** and **environmental** impacts providing a new direction for economic growth and job creation as well as environmental and social benefits shifting society away from a reliance on fossil fuels in a way that has the potential to also enhance rural development and livelihoods.

The contribution to policy-making in this way also holds direct **policy and public service** impact, with ongoing interactions and consultations with DAFM colleagues and discussions with the Department of an Taoiseach as to the best bioeconomy development pathways in Ireland. Input to frame future funding calls and innovation policies has also been sought from BioÉire team members, further contributing to impact in this space.

Human capacity impacts have also been achieved by the project including through bioeconomy-related lecturing in national and international universities, the supervision of two international interns and provision of training to international research visitors based on the work of BioÉire.

4 (b) Summary of Research Outputs

(i) Peer-reviewed publications, International Journal/Book chapters.

Devaney, L., Henchion, M. and Regan, A. (2017) "Good Governance in the Bioeconomy", *Eurochoices*, Available Online Early View, DOI: 10.1111/1746-692X.12141.

Devaney, L. and Henchion, M. (2017) "If opportunity doesn't knock, build a door: reflecting on a bioeconomy policy agenda for Ireland", *The Economic and Social Review*, 48 (2), 202-229, ISSN: 0012-9984

Devaney, L. and Henchion, M. (accepted) "Consensus, caveats and conditions for bioeconomy development: results of an online Delphi study", *Journal of Cleaner Production*.

Devaney, L. and Henchion, M. (under review) "Selecting expert participants in a Delphi study – who is the bioeconomy 'expert'?", *Futures*.

(ii) Popular non-scientific publications and abstracts including those presented at conferences

Devaney, L., Regan, A. and Henchion, H. (2016) "Imagine the Future", *Taste of Science* [online magazine] Available at: <https://www.tasteofscience.com/articles/609/imagine-the-future.html>

Devaney, L. and Henchion, M. (2015) "The future is bio", *TResearch* [online magazine] Available at: <https://www.teagasc.ie/media/website/publications/2015/3788/TResearch-Winter2015.pdf>

Devaney, L. and Henchion, M. (2016) "BioÉire: a bioeconomy for Ireland - Delphi Round 1 Results", July 2016, Teagasc, Dublin.

Devaney, L. and Henchion, M. (2016) "BioÉire: a bioeconomy for Ireland - Delphi Study Integrated Results Report", November 2016, Teagasc, Dublin.

Bonsall, B and Lemass, O (2016) A Technical and Economic Feasibility Study for Enterprise Ireland (unpublished): The Market Potential for Development of a Slurry De-Watering & Effluent Treatment Technology Supporting Renewable Energy Recovery

Bonsall, B and Lemass, O (2016) A Technical and Economic Feasibility Study for Mayo County Council (unpublished): Integrating GREENGAS Technologies at Derrinmera Landfill Site to Generate Revenues Offsetting Landfill Leachate Management Costs

(iii) National Report

Heery, D. (2017) Pursing added value in the Irish agrifood sector: an application of the global value chain methodology, available at: <https://www.teagasc.ie/media/website/publications/2017/Global-Value-Chain-Case-Study---Thesis---Declan-Heery---August-2015.pdf>

Walsh, E., McDonnell, K., Devaney, L., Henchion, M., Shanahan, U., O hUiginn, P., Gaffey, J., Bonsall, B., Lemass, O., O'Flaherty, V. and O'Reilly, P. (2017) The Irish bioeconomy, definition structure and situational analysis, available at <https://www.teagasc.ie/media/website/publications/2017/WP1-Deliverable---Final-Jan-2017.pdf>

Devaney, D. and Henchion M. (2017). BioÉire: a bioeconomy for Ireland, Teagasc, Technology Update, available at https://www.teagasc.ie/media/website/publications/2017/BioEire_A_bioeconomy_for_Ireland_Maeve_Henchion.pdf

Devaney, D., Henchion M., Bondall, B., O'Reilly, P. and McDonnell, K. (2017). BioÉire Feasibility Analysis: Preliminary Assessment of Delphi Value Chains, available at <https://www.teagasc.ie/publications/2017/bioeire-results-launch.php>.

(iv) Workshops/seminars at which results were presented

Oral presentations:

Bonsall, B. (2017) The business case: support framework conditions and considerations, BioÉire Results Launch: Next Steps for the Irish Bioeconomy, Teagasc Food Research Centre, Ashtown, Dublin, March 2017.

Bonsall, B. (2016) Non-Food Opportunities Underpinning Development of an Irish Bio Based Economy - Biofuels, Bio Chemicals, Bio Materials and Bio Energy, Teagasc Working Group, Botanic Gardens, Dublin

Bonsall, B. (2016) Efficiencies from Clustered Renewable Energy Technologies, BioBase4SME InterReg Consortium, York

Bonsall, B (2017) Sugar Beet as Biochemical Feedstock, Development Concept for Discussion Agri4Valor Event, Teagasc Centre, Grange

Devaney, L. (2017) "BioÉire Delphi Results: value chain opportunities for the Irish bioeconomy", BioÉire Results Launch: Next Steps for the Irish Bioeconomy, Teagasc Food Research Centre, Ashtown, Dublin, March 2017.

Devaney, L. (2017) "Project Overview of BioÉire: a Bioeconomy for Ireland", Meat Co-Products Workshop, ReValue Protein, Teagasc Food Research Centre, Ashtown, Dublin 15, February 2017.

Devaney, L. (2016) "Ireland's transformation to a sustainable, low carbon bioeconomy: the BioÉire project", PUREeOPE conference, RDS, Dublin, September 2016.

Devaney, L. (2016) "BioÉire: identifying the most promising value chain opportunities for the Irish bioeconomy", AGRIFORVALOR project meeting, Tralee, Co. Kerry, September 2016.

Devaney, L. (2016) "Food Innovation in the future bioeconomy: opportunities & challenges for value chain development", Guest Lecture to UCD MSc students, National Botanic Gardens, April 2016.

Devaney, L. (2016) "Use of processing waste streams in the future bioeconomy", FoodStars workshop, Institute for Food Technology, Novi Sad, Serbia, March 2016.

Henchion, M. (2017) "Beyond BioÉire: the active bioeconomy space, workshop results and next steps", BioÉire Results Launch: Next Steps for the Irish Bioeconomy, Teagasc Food Research Centre, Ashtown, Dublin, March 2017.

Henchion, M., Devaney, L. and Shanahan, U. (2017) Bio-Éire: towards a national bioeconomy strategy, Interdepartmental Working Group, Department of the Taoiseach, Merrion Square, Dublin. 25th January, 2017

Henchion, M., Devaney, L. and Shanahan, U. (2016), *Creating a bioenergy value chain in Ireland*, Irish Renewable Energy Summit, Crowne Plaza, Santry, Dublin, 13th December 2016

Henchion, M. and Devaney, L. (2016), *New Value Chains: Ireland's Opportunity Landscape, The Bioeconomy: Creating Value for farmers and foresters*, 23rd November, City West Hotel, Dublin.

Henchion, M., Devaney, L. and Shanahan, U. (2016), *A bioeconomy for Ireland: The place of forestry*, Coford Bioeconomy Working Group, Agriculture House, Kildare Street, Dublin 2, 26th August, 2016

Henchion, M., Devaney, L. and Shanahan, U. (2016), "Bio-Éire: towards a national bioeconomy strategy", ChemREG Model Demonstrator Region European Sustainable Chemicals Event, Science Centre, UCD, 23rd January.

McDonnell, K. (2017) *Impact of regulation on Feedstock availability for a Bioeconomy* BioÉire Results Launch: Next Steps for the Irish Bioeconomy, Teagasc Food Research Centre, Ashtown, Dublin, March

O'Reilly, P. (2017) *Market making issues in the bioeconomy*, BioÉire Results Launch: Next Steps for the Irish Bioeconomy, Teagasc Food Research Centre, Ashtown, Dublin, March 2017.

Poster Presentations:

Devaney, L. (2016) "BioÉire: a bioeconomy for Ireland", poster presentation to the International Scientific Advisory Board, Teagasc Food Research Centre, Ashtown, Dublin, June 2016

Devaney, L. (2016) "BioÉire: a bioeconomy for Ireland", poster presentation at Energy in Agriculture 2016 event, Gurteen, Co. Tipperary. August 2016

(v) Intellectual Property applications/licences/patents - N/A

(vi) Other

Contributions from Teagasc and TCBB team members to three DAFM input requests (regarding the Strategic Working Group "Sustainable Bio-Resources for a Growing Bioeconomy" in April 2015; a Bio-based Industries Joint Technology Initiative consultation in July 2015; and Ireland's Strategy for Science,

Research and Innovation to 2020 in October 2015). Contributions were also made by Maeve Henchion (Teagasc), Kevin Mc Donnell (UCD), Laura Devaney (Teagasc) and TBWG members to the Teagasc Foresight 2035 exercise. This culminated in a section dedicated to ‘Transformation in the Food Value Chain System’ in the final strategic document with a dedicated piece on potential new bioeconomy value chains. This brief was also sent to Patrick Barrett (DAFM) as the national contact point for Horizon 2020 and contributed to a briefing document for inhouse use within DAFM. BioÉire Delphi reports and research articles have also been widely circulated in DAFM and also the Department of Jobs, Enterprise and Innovation.

5. Scientists trained by Project

Total Number of PhD theses: 0

Total Number of Masters theses: 1

As part of this project, Declan Heery completed part of his MSc thesis titled “Pursuing added value in the Irish agri-food sector: An application of the Global Value Chain methodology” which submitted to NUI Galway in 2015. Part of his thesis was based on value chain analysis in WP3 in this project and resulted in the production of D3.2

6. Permanent Researchers

Institution Name	Number of Permanent staff contributing to project	Total Time contribution (person years)
Teagasc	2	0.92
UCD	1	0.20
NUIG	0	0.00
DIT	1	0.35
Total	4	1.47

7. Researchers Funded by DAFM

Type of Researcher	Number	Total Time contribution (person years)
Post Doctorates	2	3.20
PhD students	0	
Masters students	0	
Temporary researchers	0	
Other	0	
Total	2	3.20

8. Involvement in Agri Food Graduate Development Programme

Name of Postgraduate / contract researcher	Names and Dates of modules attended
N/A	N/A

9. Project Expenditure

Total expenditure of the project: €238,795.16

Total Award by DAFM: €270,854.45

Other sources of funding including benefit in kind and/or cash contribution(specify): €0

Breakdown of Total Expenditure

Category	Name Teagasc	Name NUI Galway	Name UCD	Name DIT	Total
Contract staff					
Temporary staff					
Post doctorates	78,732.42	29,381.31	53,704.68		161,818.41
Post graduates					
Consumables	230.07		348.50		578.57
Travel and subsistence	2,444.33	379.16	861.93		3685.42
Sub total	81406.82	29,760.47	54,915.11		166082.40
Durable equipment					0
Other	5,996.15				5996.15
Subcontracting		25,196.01			25196.01
Overheads	20,351.71	7,440.12	13,728.78		41,520.61
Total	107,754.68	62,396.60	68,643.89		238.795.17

10. Leveraging

Summarise any additional resources'/funding leveraged by this award from other sources e.g. Additional Staff, National/EU funding secured, EI Commercialisation Fund, etc.

While working on the BioÉire project, postdoctoral researcher Laura Devaney was awarded both a Dobbin Atlantic Scholarship (€3,550) and a Fulbright Scholar Award (\$12,500) to research bioeconomy development and governance in Canada and the United States respectively. Laura will commence these research visits on completion of her BioÉire contract.

While working on the project tcbb RESOURCE and collaborating partners were awarded an InterReg project led by the Bio Base Pilot Plant in Ghent, Belgium: Biobase 4 SME that targeted development of bio based innovation support for SME's, with a total Irish budget allocation of € 700K (60% funded).

Knowledge and networks formed for BioÉire were instrumental in Teagasc becoming a partner in the EU funded project CASA and membership of the successful SFI bid as part of the BEACON consortium.

11. Future Strategies

Outline development plans for the results of the research.

tcbb RESOURCE intends to contribute to development of integrated sectoral strategies referenced in the research outcomes, and in the near term intends to pursue development and deployment of pilot scale and commercial demonstrators that it believes should form part of 2 of the integrated sectoral strategies, namely:

- Demonstration of an integrated Community Sustainable Energy Concept, and
- A distributed sugar beet refining system supporting re introduction of an Irish sugar beet crop for co-production of white sugar and biochemicals

Tcbb RESOURCE will work with collaborating partners, with whom relationships were established during the Bio Eire project, to pursue these concepts.

Teagasc will continue its research on strategic and policy issues of relevance to the developing of the bioeconomy in Ireland through involvement in CASA and BEACON.

Following from the BioEire Results presentations at Teagasc in March 2017, Kevin McDonnell (UCD) has been invited by the Department of Taoiseach to contribute to a working group on developing a strategy for the bioeconomy in Ireland.

12. Consent to Publish Final Report on the DAFM Website and/or Through Other Dissemination channels

I consent to this report being made available to the public, through the Department's website and other dissemination channels. *

Yes X No

13. Declaration

I declare that the information contained in this final report is complete and true to the best of my knowledge and belief.

Signed:  Project Coordinator

Date: 29/05/18

*IPR sensitive information that the coordinator does not wish to make public should be highlighted in red font. All text in red font in this report will not be made publicly available by DAFM.