School of Business

Business Research Project

Bioeconomy: Regional Innovation Ecosystem (West Ireland)

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I. SUMMARY

This study has discovered key players in Academia, Industry, Government organizations, financial stakeholders and Users of west Ireland that consist of nine counties- Clare, Donegal, Galway, Kerry, Leitrim, Limerick, Mayo, Roscommon and Sligo for developing Regional Innovation Ecosystem focused on Bioeconomy for land and sea. This thesis has explored the mechanisms of Interactions that can contribute towards active collaboration of these four key players such as meetings, webinars etc. that are necessary for knowledge sharing between research centers and Industries for strategic implementation of Bio-economy. Secondary research during the thesis is done using case study analysis of existing regional innovation systems like Agri-food French Bio-economy, Sustainable forest Indicators-National Bio-economy and Marine Knowledge Exchange Network (M-KEN) in East England. Primary research is conducted through focused interviews of head of the departments of universities, firms, SMEs, NGOs and government organizations of three major sectors: agri-food, forest and fishing of bio-economy responsible for conducting research, sharing information, making policies and financing the activities. The Data collected through primary and secondary analysis is further used to develop the roadmap of interaction and have provided an analysis of the challenges that exist in implementing west Ireland Bioeconomy for land and Marine.

II. Acknowledgement

I would like to thank all the people whose help and support have contributed to this thesis. In particular, there are a number of people to whom I owe a special thanks:

Firstly my supervisors, Dr. Eoin Cullina, for his academic guidance and enthusiasm. He has always had time to discuss my work and provide guidance, for which I express my sincere thanks.

Roger Sweetman, Host Organisation (WDC) contact for his support and advise during my thesis. He has always been available for me to share my ideas and thoughts with, for which I am extremely grateful.

All of the staff in the Department of Business Analytics for their support during my time in NUI Maynooth.

STUDENT DECLARATION

I NIDHI ARORA declare that this BRP Dissertation, submitted to Maynooth University in partial fulfilment of the MSc BUSINESS ANALYTICS is my own work, except where explicitly stated otherwise. Where any content presented is the result of input or data from collaborative effort it is explicitly acknowledged in the text allowing the examiners to clearly identify how much of the work presented is from my individual effort. I have not already obtained an award from Maynooth University or elsewhere wholly or partially on the basis of this work. I have taken all reasonable steps to ensure that the work is original and does not breach copyright law. No work has been taken from any other sources except where this fact has been explicitly cited in the text. I acknowledge that this submission complies with the Maynooth University Policy on Plagiarism and General Rules of the University. I understand the implications of breaches of these policies.

I confirm that the host organisation has received a copy of the BRP Management Report and (if requested) a copy of the BRP Dissertation and evidence of this submission has been supplied.

Signed NIDHI ARORA

Date 9-SEP-2021

Table of Content:

List of Figures:

List of Tables:

III. Introduction

Regional Innovation Ecosystems are crucial for balanced economic development and growth. However, the development of these ecosystems is complex and is dependent on bringing together the key skills and resources in the region. The Quadruple Helix model provided a way to identify the key players in a regional ecosystem. The WDC had identified a regional competence in the area of the bio-economy. Western region is well placed to take advantage of global trends and become a global leader in harnessing what grows on land and sea in a sustainable manner.

A. Overview

This thesis is a study of Quadruple Helix analysis of the western Region of Ireland in order to support the development of Regional Innovation Ecosystem focused on bio-economy. Bio-economy is a complex term involving a part of the economy which uses renewable biological resources of land and sea such as trees, plants, crops, animals and other organisms to produce food and energy material for society.

Quadruple Helix type of Regional Innovation Ecosystem constitutes four different entities – Academic Institutes, Industries, Political system and Civil Society that interact with each other for knowledge production.

A variety of methods are used to provide new empirical and theoretical understanding Regional Innovation Systems across different Industries. This research is organized as separate studies, reported over two chapters.

The studies share common theme of Bio-economy; however, the objective is different across each.

Study 1: Bio-economy Key actors for Regional Innovation Ecosystem

We identify the key players across the four helices in a bioeconomy focused regional innovation ecosystem and Develop a tool to visualize the actors and their interactions in a bioeconomy focused regional innovation ecosystem.

Study 2: Bio-economy Roadmap and Obstacles to emergence of west Ireland Regional Innovation Ecosystem

We Develop a road map for the development of a regional innovation ecosystem for the bioeconomy and Identify the obstacles to the emergence of a regional innovation ecosystem focused on the bioeconomy.

The thesis fits with the Quadruple Helix analysis of Regional Innovation ecosystem for Bio-economy literature. Quadruple Helix analysis is the analysis of the actors in the four helices – academic, Industry, political and civil society of the Innovation system for Bio-economy. The conceptual framework for the empirical studies in this thesis is formulated from the Regional Innovation Ecosystems

using Quadruple Helix Models literature and Bio-economy literature.

In study 1, A documentary research and case study analysis approach is applied to identify the key players across the four helices of quadruple helix model of Regional Innovation ecosystem and developing a tool to visualize the actors and their interaction in bio-economy focused Regional Innovation Ecosystem.

In Study 2, A documentary research and case study analysis approach is applied to develop a roadmap and identify the obstacles for the regional innovation ecosystem focused on bio-economy.

In each study, Different research questions are addressed. The research questions for study 1 and 2 are as follows:

STUDY 1-

Who are the organizations that are involved in West Ireland's Industry based BE networks?

How do various actors of west Ireland's Industry Based BE networks Interact with each other – workshops, webinars and meetings?

STUDY 2-

What are the obstacles in developing a roadmap for West Ireland's Industry based BE networks?

1. Empirical Studies

A study on "Smart specialization in regional innovation systems: a quadruple helix perspective" by Linda

Hoglund and Gabriel Linton is being analysed, which aims to understand the dynamic interactions of the smart specialization strategy in relation to RIS. It explores the micro activities in relation to strategic perspective. It explored three strategic practices that evolved over time.

2. Contributions

Firstly, the research contributes new empirical evidence to the analysis of key players for Regional Innovation Ecosystem for Bio-economy and visualizing their interaction.

Secondly, the Linda Hoglund and Gabriel Linton (2017) methodology for analyzing a smart specialization initiative in the region of Sweden and its impact on RIS based on triple helix model of Industry, university and government interaction. It also includes a perspective of quadruple helix which contains civil society and users and have taken a case study approach. The research includes a micro analysis from a strategic perspective.

This study identifies two contextual complications when applying Linda and Gabriel (2017) framework to bio-economy context, difference in population of Ireland and Sweden and quadruple helix framework perspective instead of triple helix. The framework can be vigorously adjusted for the later, if geographic level data is available.

Thirdly, the data analysis contributes new understanding to the development of the regional innovation ecosystem for bio-economy of the west Ireland region for Agricultural Industry, Forest Industry and Fishing Industry. Specifically, the study contributes to developing a visual analysis of key player and actors of the quadruple helix model in universities, political system, Industries and civil society.

B. Rationale for this thesis

The Goal of the thesis is to build a regional ecosystem for West Ireland Bio-economy by fulfilling the following four objectives:

Identify the key players across the four helices in a bio-economy focused regional innovation ecosystem

1. **Develop a tool to visualise the actors and their interactions in a bio-economy focused regional innovation ecosystem**
2. **Develop a road map for the development of a regional innovation ecosystem for the bio-economy**
3. **Identify the obstacles to the emergence of a regional innovation ecosystem focused on the bio-economy**

IV. Theoretical Framework of this Thesis

A. Defining Bio-economy

Bio-economy is based on two pillars: use of raw material which is renewable instead of fossil raw material and bio-based innovations. The concept of bio-economy is linked to the use of bio-based and circular economy. The bio-based economy is conversion of raw material into food and production and it is seen as a part of bio-economy emphasizing the concepts of bio-based products such as bio polymers, bio plastics, bio-based textiles, wood products, pulp and paper.

An understanding of circular economy has led to many innovation success stories. It aims at eliminating waste from the economic system by enabling the reuse of resources within the economy. It affects everything from product design to finance, from technology and innovation to public policy and structure of society.

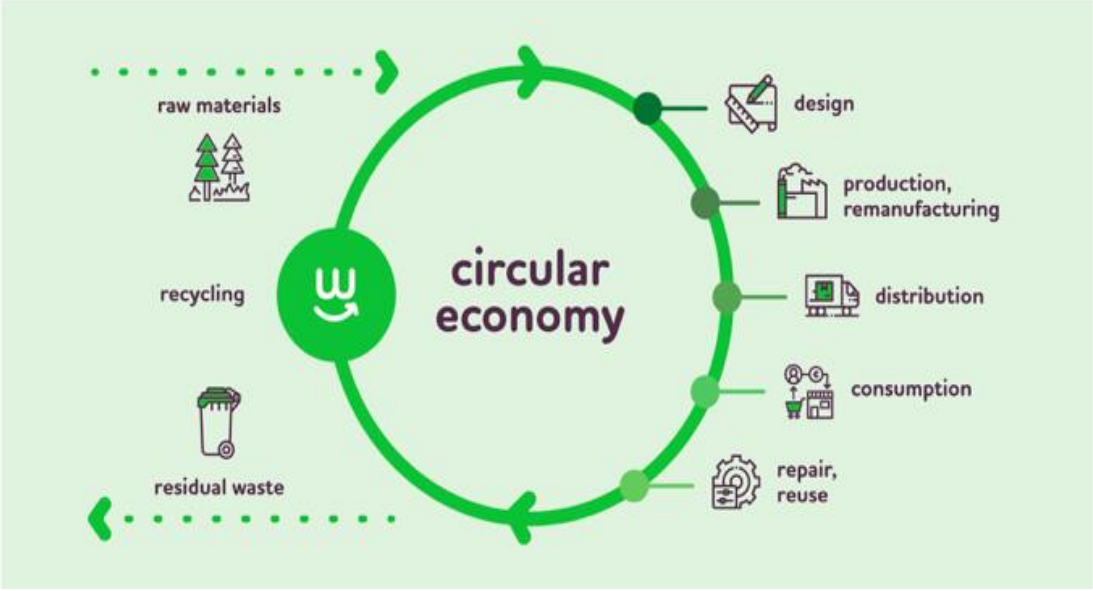

Figure 1: Circular Bioeconomy pillars

The European Bio-economy alliance, a cross sector overarching alliance of bio-economy industries associations has a comprehensive definition of bio-economy:

"The bio-economy comprises the production of renewable biological resources and their conversion into food, feed, bio-based products and bioenergy via innovative, efficient technologies. In this regard, it is the biological motor of a future circular economy, which is based on optimal use of resources and the production of primary raw materials from renewably sourced feedstock" (European Bio-economy Alliance, 2016, p. 1).

Another perspective on bio-economy comes from different industrial sectors within bio-economy:

"Sustainable, multifunctional forest management and the forest-based sector play a key role in achieving Sustainable Development Goals, for example by providing climate action, sustaining life on land, delivering work and economic growth, enhancing responsible production and consumption, boosting industry innovation and infrastructure, creating sustainable cities and communities, enhancing good health and well-being and providing clean energy. The bio-economy is a key concept to boost the potential of the forest sector to deliver solutions to these multiple challenges." (Confederation of European Forest Owners, 2017, p. 2)."

These definitions emphasis different dimensions of interest of the stakeholders involved in bio-economy.

GREEN ECONOMY

To define scope of bio-economy it considered various definitions of bio-economy, depending upon the sector, discipline, geographical location, stakeholders (scientists, policymakers, NGOs, and private sectors). 26 different definitions have evolved during this process, which results in an understanding that bio-economy is a supply and technology driven area.

""The bio-economy covers all sectors and systems that rely on biological resources (animals, plants, micro-organisms and derived biomass, including organic waste), their functions and principles. It includes and interlinks: land and marine ecosystems and the services they provide; all primary production sectors that use and produce biological resources (agriculture, forestry, fisheries and aquaculture); and all economic and industrial sectors that use biological resources and processes to produce food, feed, bio-based products, energy and services" (European Commission, 2018, p. 4)"

Green Economy is considered at reducing environmental risks, ecological scarcities resulting in improved human well-being and social equality. It helps build a greener economy and focuses on economic sectors like forestry, farming, mining, and fishing etc. It also looks at the environmental aspect like protecting water sources and biodiversity or reducing greenhouse gas emissions.

According to Karl Burkart definition of green economy, it includes six main sectors:

- Renewable energy
- Land Management
- Waste Management
- Water Management
- Sustainable Transport
- Green Buildings

Bio-economy and circular economy are synchronous concepts. Green Economy emphasises integration of bio-economy and circular economy concepts instead developing them parallelly.

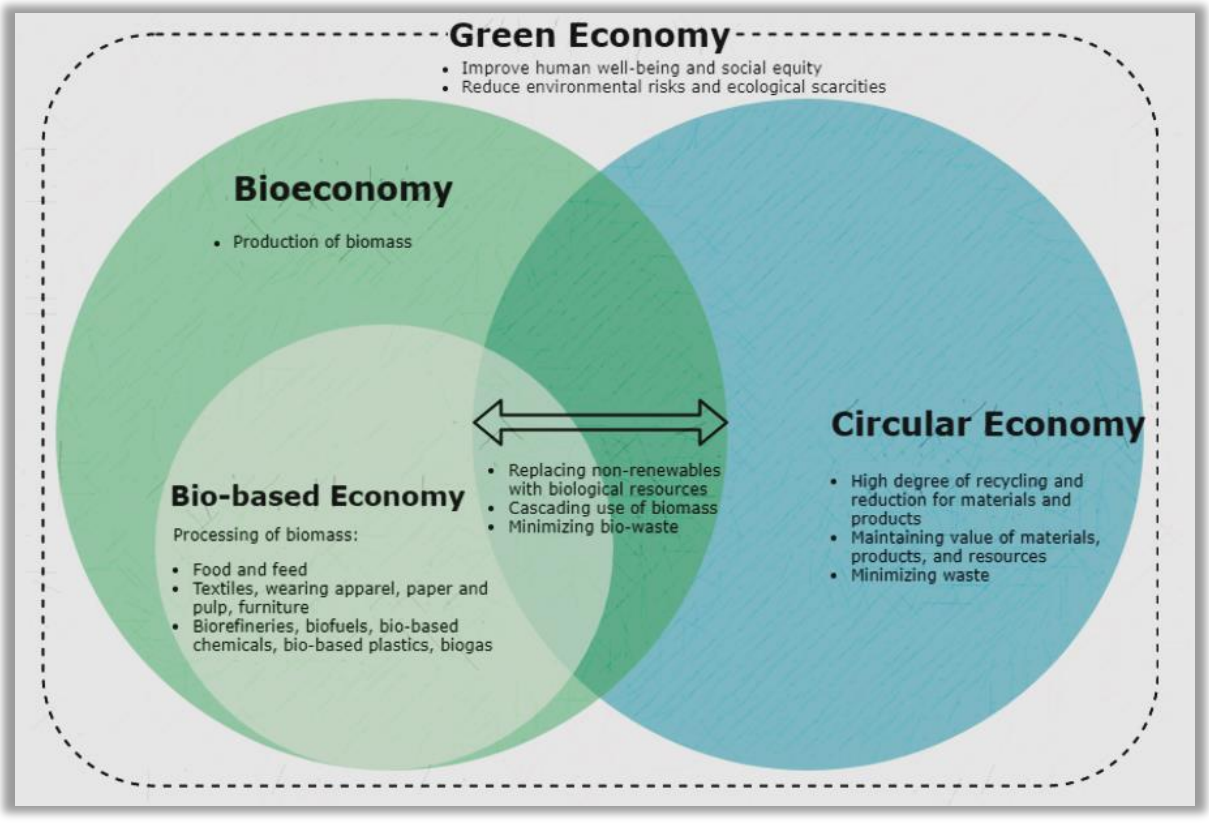

Figure 2: Karl Burkart Green Economy Sec

In conclusion, there are many definitions for bio-economy, green economy, circular economy and bio-based economy.

This project will focus on creating an analytical framework for developing a regional innovation ecosystem for Bio-economy (including both land and sea) of the west region of Ireland using Quadruple Helix Model of Innovation.

B. Defining Quadruple Helix Innovation Models:

According to Elias G. Carayannis, 2017, Quadruple Helix Innovation Model emphasises the importance of cooperation in innovation, and, in particular, the dynamically connected processes of co-evolution within and across regional and sectoral innovation ecosystem. In particular, this paper aims to understand the dynamics of Quadruple Helix Model for developing a Regional Innovation System on Bio-economy. Quadruple Helix Model is enabler of regional ecosystem conceptualized as multi-level configuration of tangible and intangible assets within the resource-based view of the firm.

In a quadruple Helix Innovation System Framework, Multilevel Innovation Systems is analysed, using the knowledge of clusters and innovation Network. Triple helix model is extended by adding a fourth helix that is identified as media-based and culture-based public. Fourth helix is a combination of 'Media', 'Creative Industries', 'Culture', 'values', 'life-style', 'art', etc. This Quadruple Helix model encourages the development and innovation by

intervening users or civil society. In this the innovation system is driven by users or citizens.

Quadruple Helix Innovation conceptually evolved from Triple Helix Model concept that refers to the ideas of 'Mode 1' and 'Mode 2' knowledge production. 'Mode 1' approach is model of university-based knowledge production, compatible with linear model of innovation, whereas 'Mode 2' model, emphasizing on knowledge application and problem solving based on knowledge, which is colinear with non-linear innovation. Then further enhanced model proposed by Carayannis et al., 2017a, also called 'Mode 3', it includes fourth actor called civil society to generate Quadruple Helix Model. 'Mode 3' emphasis the development of multi-layered framework, emphasizing on innovation ecosystem that co-innovates with society. 'Mode 3' or Knowledge production systems is at the heart of Research, Education and Innovation Ecosystem. It extends Mode 1 and Mode 2 to propose a helically conceptualized knowledge creation and use system endowed with higher order learning that is aligned with 'Ecosystem as Helix' perspective.

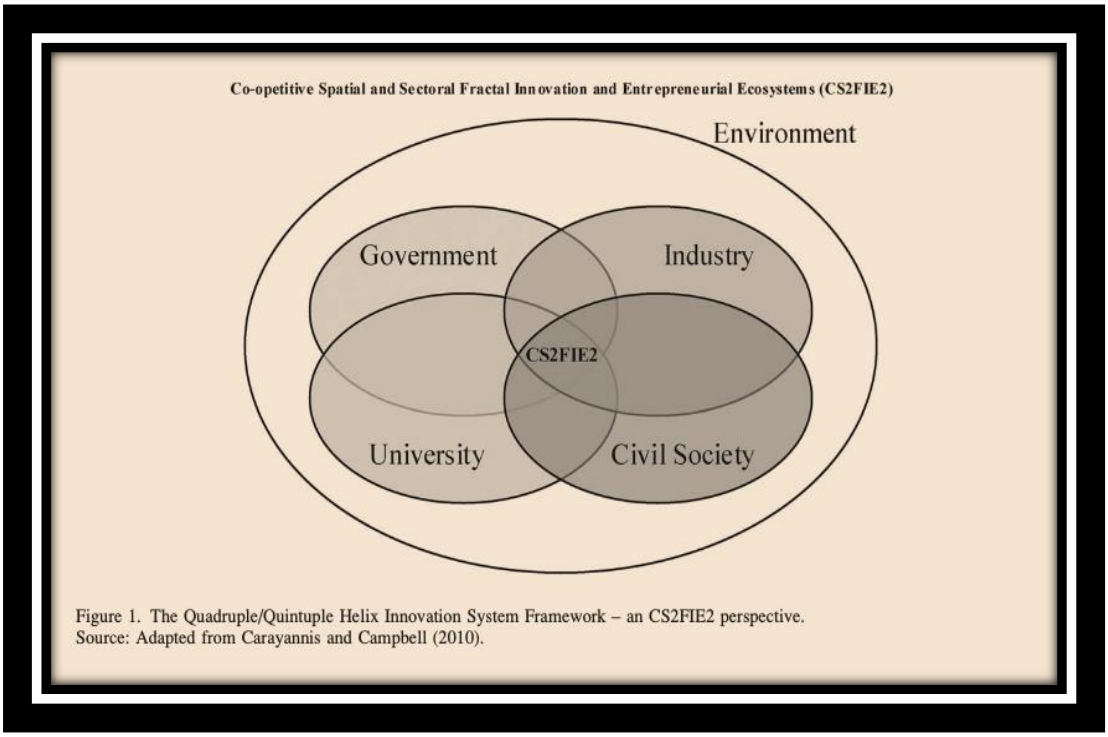

Figure 3: Quadruple Helix Innovation FMW

As per Quadruple Helix Innovation Framework:

An innovation ecosystem consists of economic agents, relations, and non-economic factors such as technology, institute, social interactions and culture. Universities play a significant role in use, diffusion and competitive knowledge creation. A university business model described by gib, 2010 comprise of core functions like teaching, research and distributing knowledge in society while Etzkowitz et al. (2000) noted that new university business models takes on a more 'entrepreneurial role'. It is dependent on multiple stakeholders' relationships between universities, business and wider community.

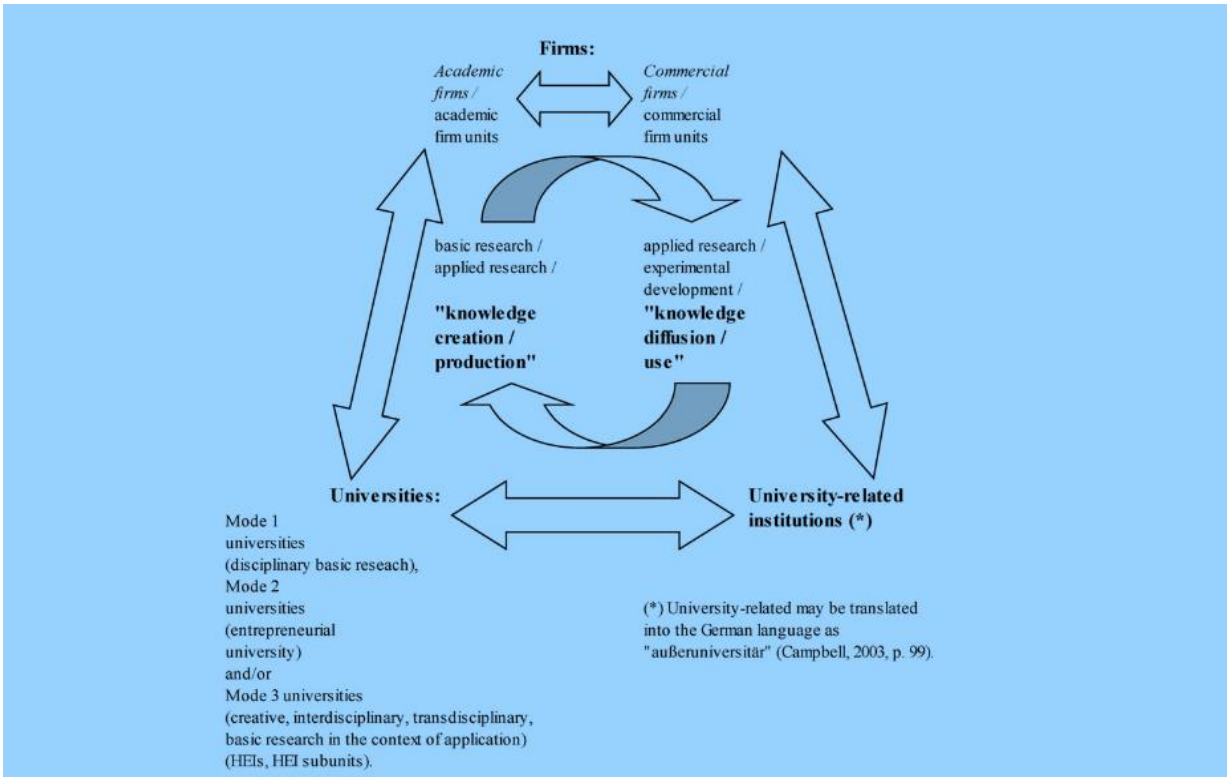

Figure 2. 'Mode 3' universities in co-opetitive entrepreneurial ecosystems.
Source: Carayannis et al. (2017a).

Figure 4: Etzkowitz et. Al. Stakeholder relationship

Regarding the adoption of quadruple Helix Framework, several projects have adopted this framework including:

- The Start-up sauna: Funded by government, business, and academia occupying a warehouse next to Aalto University.
- Linas Matkasse: A company co-founded by Niklas which apply IKEA do-it-yourself model to family dinners.
- Asunto Oy Helsingin Loppukiri : It is a finish private housing association that has a housing community in suburb of Helsinki.
- Rovio Entertainment: Angry Birds game that involved catapulting irascible avians at elaborate fortresses constructed by evil pigs.

In innovation theory, networks and clusters are two important factors that introduce new ideas in the form of innovation networks and knowledge clusters. Triple helix focus on university-industry-government relations (Etzkowitz and Leydesdorff, 2000) , which is the basic model for knowledge production and innovation application. While Quadruple Helix Innovation system frameworks setup are able to interpret complexity in knowledge production and application. Also, Quadruple Helix Models can conceptualize to augment the design of multi-level innovation system in order to understand the meaning of regional innovation systems adequately (Elias G,2017) . Therefore, Quadruple helix framework provides a design for sectoral and regional competitive innovation ecosystems.

It is an approach that recognizes the increased role end users play in a Regional Innovation Systems (Leydesdorff, 2012). The quadruple helix system is driven by coevolution of the political and knowledge systems due to the increased demand for participation of society in development of society in general. Also, Colapinto and Porlezza (2012) highlight that a core part of the fourth helix is related to the network, knowledge transfer, and human capital.

In the EU, depending on where the labour market is concentrated and the productivity level of bio-economy, four groups of member state are identified: 1) strongly specialized labour market in bio-economy sector, but have low level of productivity; 2) EU member states with medium specialization of labour market in bio-economy sector ;3) EU member states with a low-to-medium specialization of labour market and medium-high level of

productivity ; 4) EU member state with low level of specialization in bio-economy sectors in their national labour market. Therefore, territories that are specialized in biomass production, food processing and other bio-based sectors and others are less productive, there exist a division at national level.

With Biomass resources in abundance, current cluster of bio-economy can be advantageous or disadvantageous to the development of innovative bio-economy. According to NACE classification, following economic activities are a part of bio-economy development: agriculture, forestry, fishing and aquaculture, manufacture of food, beverage and tobacco, bio-based wearing apparel, wooden furniture, and paper, manufacture of bio-based chemicals, bio-based pharmaceuticals, manufacture of bioethanol and biodiesel, bio-based plastic and rubber.

pharmaceuticals, chemicals, plastics and rubber, are high and medium technology sectors of bio-economy, while others are low R&D intensity bio-economy sectors. Regions with high and medium technology sectors have advantage with respect to R&D base and can result in greater capacity to create bio-refinery technology and products, also including those from biological waste which is recognised to be of potential by Central and Eastern Europe. It is found that for greater progress in bio-economy development, stronger communication is required between business and research communities, as well as with government sector on two important functions building investor confidence in bio-economy and methods of access to financial support.

A study by Virginija Kargytė, 2018 focused on exploring the link between factors like local biomass availability, regional bio-

economy business cluster and regional innovation potential, how bio-economy can evolve in different regions based on their biomass, business and entrepreneurial and R&D resources. Hypothesis were selected based on how value of local biomass availability is related to size of regional innovation potential. Variables based on Agriculture biomass, Forestry biomass, waste etc were chosen from BERST project on a sample of 237 regions of Nordon, western and central Europe from 150 000 to 800 000 citizens. The statistics were investigated for EU Regions on the basis of their Innovation Plans and strategies for smart specialization on bio-economy and PCA was run.

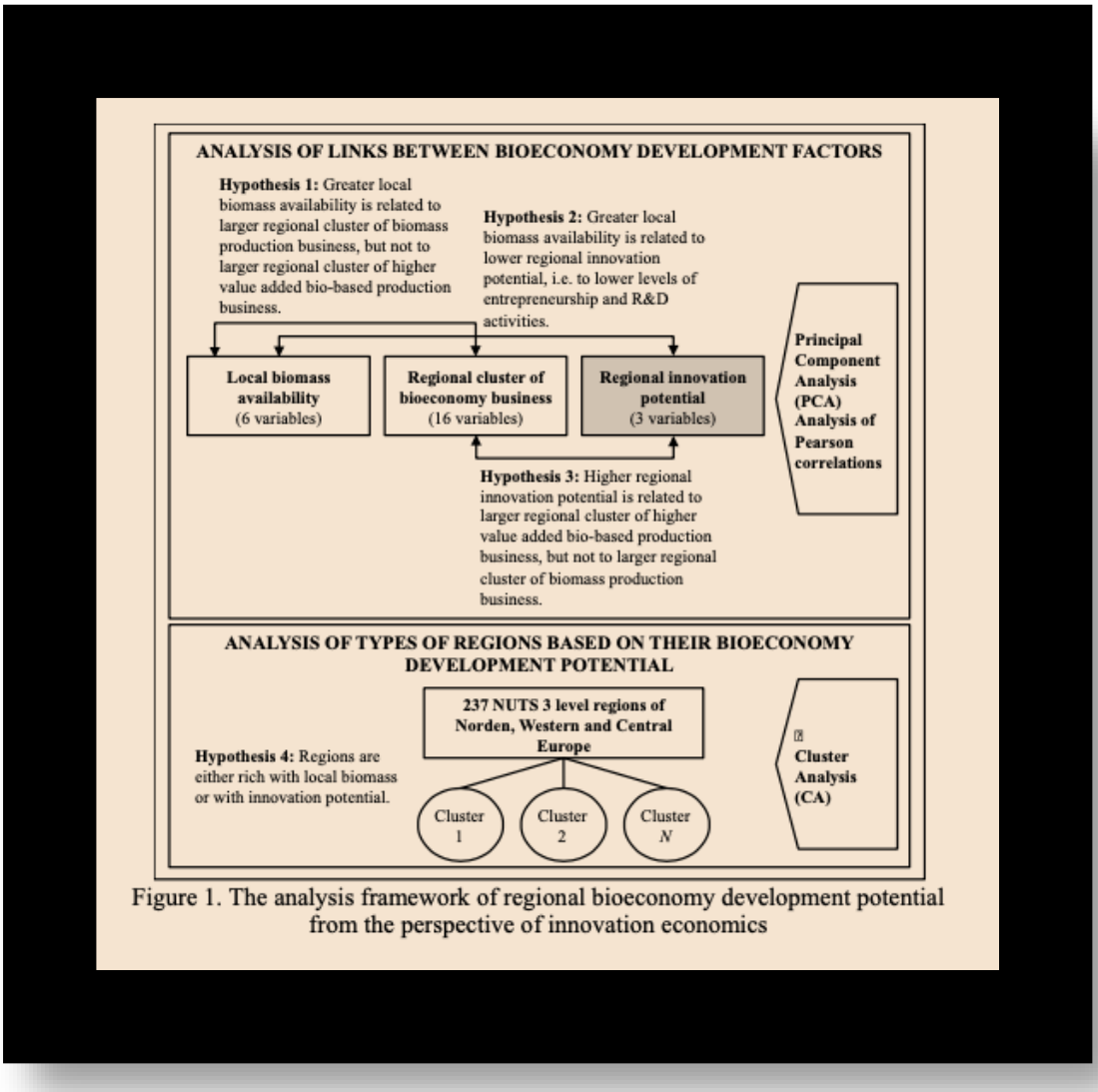

Figure 1. The analysis framework of regional bioeconomy development potential from the perspective of innovation economics

Figure 5: Leydesdorff, 2012 Regional Bioeconomy framework

Based on the PCA, Hypothesis were rejected, and it was found that greater agricultural biomass resources are linked with higher level of employment in food and feed production, construction and textile business. Secondly, higher local biomass availability is not related to lower regional innovation potential. Thirdly, variable R&D production is positively correlated with primary biomass production, energy and biotechnology firms.

Also, Regions in economically developed countries have different resources for development of bio-economy. Out of which, 4 Norwegian regions and 2 Estonian regions with high potential to develop knowledge-based circular economy.

Finally, it was also found that relationship between explored bio-economy factors like biomass availability, bio-based business cluster and innovation potential is weak in analysed regions.

C. Literature Review on Regional Innovation Ecosystem

Literature on RIS has emphasized on applying triple helix approach to RIS which focuses on regional level analysis and have not emphasized on the role of international relations that can strengthen RIS (Leydesdorff, 2012; McAdam et al., 2012). Recently in 2016, some scholars have emphasized the need to include additional dimensions, such as role of civil society and stakeholders, in the Triple Helix -calling it Quadruple Helix or an N-tuple – to comprehend regional development and knowledge based economy (Carayannis and Campbell, 2009; Leydesdorff, 2012; McAdam et al., 2012; Miler et al., 2016). Empirical research by Yong Kyu, Zaheer Khan and Sara in 2016 on importance of international connections for enhanced regional innovation system in North Italy explores a single RIS in Italy. The case shows the role of three actors (the provincial government, academia/research centres, and firms) are vital in creating RIS and extends to importance of role of international connections within RIS, thus shifting towards quadruple helix (Yong Kyu Lew, Zaheer Khan and Sara Cozzio 2016).

An empirical research (Donald, David, Albert et. al. 2003) has established the importance of environmental and Institutional factors that contribute to the productivity of university technology transfer offices (TTOs). It has concluded that the most critical organizational factors are faculty reward systems, TTO staffing/compensation practices, and cultural barriers between universities and firms by inductive qualitative research.

A study on triple helix of university-industry-government relations (Henry and Loet Leydesdorff, 2000) has established that University research functions as a locus in the laboratory of knowledge intensive transitions like that of reorganization of industrial sectors and nation states due to new technologies like biotechnology, ICT. Therefore, the institutional layer is considered as a retention mechanism of a developing system.

Another study on development of university technology transfer stakeholders' relationships (Rodney McAdam, Kristel Miller, et. al., 2011) established that increasing importance on regional development and knowledge-based economy as economic growth stimuli has led to changing role of university and their interaction with business community through transfer of technology from academia to industry. Regional Development Agencies (RDAs) are replaced by Local Enterprise Partnerships (LEPs). The paper examined the stakeholder relationship between three regional universities in context of TTO (Technology transfer office) and RDA to determining lessons learned for emerging LEPs. The interpretation used for stage-based stakeholder models, show the longitudinal development of the TTO-RDA stakeholder relationship for each case dependent on stakeholder stage and stages where specific targeting of funding was dependent on

stakeholder stage. However, over reliance on relationship may lead to lack of funding from other stakeholders.

A study on Regions, networks and innovative performance: The case of knowledge-intensive industries in Norway by (Arne and Knut, 2010) showed that regional characteristics influence innovation patterns of firms. Based on sample of knowledge intensive firms in Norway, the paper examines three types of region: large urban, small urban and rural. It found firms innovative performance and knowledge sources quite similar. It also found that firms in rural and small urban areas have higher share of innovation than in urban region. However, firms in large urban regions have higher new firm formation rates due to their reliance on open innovation.

According to Kristel Miller, Rodney McAdam et. al, stated that there are wider opportunities for regional innovation with increased understanding of knowledge transfer from universities to wider regional knowledge ecosystem. It aimed at understanding the KT phenomenon in quadruple helix where multiple stakeholders are interacting. It resulted in a new ex post framework to aid understanding and conceptualization of core KT process shown below:

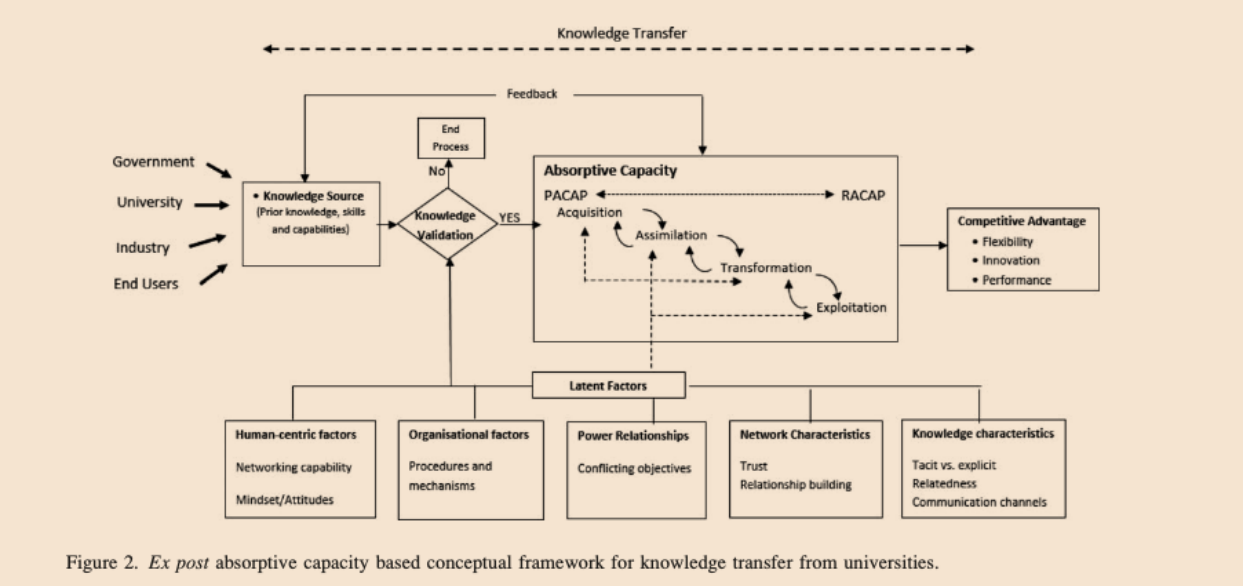

Figure 2. *Ex post* absorptive capacity based conceptual framework for knowledge transfer from universities.

Figure 6: Kristel Miller and Rodney McAdam-2011 Kristel Miller and Rodney McAdam-2016

D. Literature Review on Quadruple Helix Model

An explanatory model for analysing the knowledge-based economy using triple helix, quadruple helix and N-tuple of helices by Loet Leydesdorff, university of Amsterdam, the Netherlands 2011 measures the extent to which innovation is systemic using triple helix model of university-industry-government relations instead of just being assumed of existence of national or regional system of innovation on a priori grounds. Functions of wealth creation, knowledge production and normative control Integration takes place at the interfaces in organizations while market exchanges, knowledge production through scholarly communication and political discourse varies globally. Evolutionary models of triple helix model enable to capture these differences reflexively.

One can analyse whether innovation system is technology specific or sector based using triple helix indicators. For example, using co-authorship data from science citation index can be used to show that if the relations between university-industry-government relations have declined or improved despite policies to stimulate such relations. University scholars in Japan have co-authored with foreign colleagues, favouring internationalization therefore adding internationalization as a fourth dimension in the design can improve the explanation.

Another advantage of using triple helix model in quantitative analysis and research is increased awareness that analysis of knowledge-based development requires at least three relevant dimensions. An example of transformation for a national innovation system is the case of Hungary which requires three different regional development strategies. When OECD analysis regions, administrative borders are taken for granted and thus analysis reduces to political economy of region. Knowledge is considered as exogenous source of economic activity and is only analysed contextually. However, the patent portfolio may be complementary and synergetic and a redefinition of geographic boundaries is advisable on the basis of an analysis of knowledge based sub-dynamics.

Triple helix model encourages the researchers to reflect on more than one dynamic (market and governance). One may wish to consider one of these contexts as given but the reason for reduction should be deliberate and explained in argument. Such an explanation is expected to enrich semantics because at least three selection mechanisms are relevant for study of knowledge-based developments.

One may wish to move beyond three relevant selection environments but also to fourth or fifth dimension would require sufficient specification, operationalization in terms of data and even relevant indicators.

E. Literature Review on Bio-economy

Bio-economy is at the centre of innovation policy in EU and represents a priority of R&D. It aims to emphasize the use of renewable biological resources to provide sustainable growth and use of biotechnologies on a large scale in economical processes. In an effort by Bratianu C., 2018 to develop a perspective on use of Intellectual capital and knowledge management for Bio-economy presented a theoretical and practical issues in addressing knowledge management role in developing a sustainable bio-economy.

It aimed at developing new ideas and principles of using efficiently and intelligently all the intangible resources of organisation to create value for society.

The three group of papers presented different views on Intensity of involvement of teachers and researchers from Romanian universities in bio-economy knowledge flows. The role of university in developing the human capital for a sustainable bio-economy and the role of universities in consolidating intellectual capital and generating new knowledge for a sustainable bio-economy, which focus on the role of universities in the knowledge economy.

Second research paper is regarding influence of knowledge management practices on employee's satisfaction in Romanian healthcare system, financial performance and Intellectual capital of biotech companies in pharma industry and eWOM communication.

Two papers on food industry in Serbia are based on new market segmentation knowledge in the function of bio-economy development. Another paper modelled interdependencies between intellectual capital, economic growth and circular economy in the context of bio-economy and development of bio-economy and use of intellectual capital by SMEs in field of bio-economy.

A point of view on bio-economy for sustainable development by Alfredo Aguilar, Roland Wohlgemuth, 2019 has emphasized that bio-economy is an emerging paradigm that is building bridges between biotechnology and economy as well as between science, industry and society. Key success factors vary widely for high-tech bio economies in different countries.

According to porter, a cluster is a geographic concentration of interconnected companies and institutions in a specific field. The European smart guide to cluster policy emphasizes that: 'Clusters cannot be understood as fitting into the narrow sectoral view but is considered as regional ecosystems of related industries and competences featuring group of firms, related economic actors, and institutions located near each other and there is sufficient scale of specialized expertise, resources and skills. Porter found that clusters extend to channels and customers and manufacturers of complementary products and related industries.

A bio-economy cluster is a co-geographically located connected actors from R&D institutes, enterprises, and policymakers to develop bioeconomy. There are multiple sectors located within bio-economy and the clusters are rather heterogenous. Author has emphasized that innovation is at the heart of clusters. European competitiveness report 2012 has given in depth similarities and differences between networks, clusters and cluster initiatives.

The preconditions of critical mass, location, active collaboration linkages and related industries for successful clustering development are fulfilled by densely populated urban areas. Rosenfeld lists the contributing factors for clusters as innovation, imitation and competition, entrepreneurial energy, networking and networks, specialized workforce, talent and knowledge. Further, strong clusters mean higher business formation and start-up employment. However, Beaudry and Breschi have shown that clustering is not conducive to firms' innovation. While, other innovative companies within a firm's industry of a cluster affects positively firms innovation activities whereas non innovative companies have an opposite effect. Further clustering is more beneficial to younger firms with higher knowledge stocks.

there is even evidence that firms are more likely to fail as a cluster gets very large. However, the reasons behind these phenomena are complex, the positive relationship between clustering and generalized innovation does not exist and different performance differences are not understandable.

F. EU Innovation Ecosystems and Clusters:

The European commission's smart guide to cluster policy notes that innovation ecosystems considers clusters and cluster initiatives an important part and the differences are as follows: Innovation ecosystems are similar to clusters, but they differ in their focus on specific industry type. They consider all activities of innovation as similar activities. As this practice leads to focus on research-driven innovation and linkages to academia and business. It does not consider the specificity of a distinct cluster and have more of supply driven rather than market driven perspective.

According to Jackson, innovation ecosystem is a combination of distinct economies: research economy, driven by fundamental research and commercial economy driven by marketplace. According to his model, when a small amount of profit is sacrificed to finance the research, it results in a feedback loop called virtuous circle.

Therefore, when an innovation-induced profit increase exceeds R&D investment, it grows innovation ecosystem.

Durst and Poutanen's research on innovation ecosystem have been described in multiple ways, suggesting innovation ecosystem is hybrid of networks and collaborative arrangements.

For example, Industrial collaborative arrangements like local concentration of clustering. Additionally, open innovation ideas expand scope of participants in innovation process from internal actors of R&D function to co-creators and co-innovators outside the organisation. Therefore, ecosystem thinking is close to open innovation but the ecosystem analogy to describe innovation

ecosystem that are influenced by economic, social and political factors has been criticized. A continuous cross pollination of ideas, knowledge and technology between research is necessary to collaborate perfectly for an ecosystem to be innovative. However, in reality many kinds of barriers prevent interaction and creates gap which also prevents innovation processes.

The Gap Model – having seven innovation gaps with five innovation gaps within a cluster and two external gaps, one between cluster and other cluster and another between cluster and global market.

According to Lindqvist et al., Bridging internal gaps is the key role for cluster organisation along with bridging the external gaps. Over-coming the innovation gap is done by bringing together different types of actors together.

Cultural factors influence the interaction between different actors like communication and willingness to share and receive information and trust relationships.

Jackson's research suggest that a healthy ecosystem provides mechanisms for building relationships and intangibles between actors and entities.

BERST results show the roles of entrepreneurs, policymakers and knowledge institutions

and their interactions as the key assets involved in clusters.

Entrepreneurial culture is the key driver towards successful implementation. Clusters leverage active participation of

individuals with flexible, take risk, and willingness to try new ideas entrepreneurial spirit.

Entrepreneurial culture is a critical success factor. Other success factors are organisations that provide technical know-how and innovation for developing bioproducts and political leaders providing governance, institutional structures and financial support.

According to Durst and Poutanen, factors for successful innovation ecosystem include areas of resources, governance, strategy and leadership, organizational culture, HRM, people, partners, technology and clustering.

As examined by Jackson, there is gap in academia and commercial marketplace of innovation ecosystem. For Instance, government investment is concentrated in fundamental research in academia while industry investment is in direct product development in commercial market place. Between the two, there is gap in resources for technology demonstration and development called the Valley of Death. Actors engaged in moving innovation from discovery through commercialization are academia, small businesses, investor community, and commercial industry. Many innovations die within valley of death due to lack of resources from being developed where industry and investor community can recognize their commercial potential and assess the risk of bringing them to market.

According to Tevecia Ronzon, 2018, In its research on socioeconomic indicators to monitor EU's bio-economy in transition. Monitoring of EU bio-economy is hampered by lack of statistics on emergent and partially bio-based sectors. They

identified four broad patterns within EU bio-economy that differ according to member state's labour markets in bio-economy distributed across Eastern member states, central and Baltic member states , western member states and Northern member states which are related to the GDP per capita in the member states and to their political histories.

Bio-economy strategy aims to balance social, environmental and economic gains by linking the sustainable use of renewable resources with the protection and restoration of biodiversity, ecosystem and natural capital across land and water.

The assessment framework in particular provides SMART (specific, measurable, attainable, relevant and timely) indicators across relevant sectors.

Addressing the economic performance through productivity measures gives further insights into potential of growth within specific sectors of bio-economy in individual member states.

According to NACE classification that do not differentiate between bio-based and non-bio-based activities, bio-economy consists of following sectors:

Table 1. NACE sectors considered part of the bioeconomy.

NACE Code	Bioeconomy Sector (Parent Categories in Bold)
A01	**Agriculture**
A02	**Forestry**
A03	**Fishing and aquaculture**
A032	Aquaculture
A031	Fishing
-	**Manufacture of food, beverages and tobacco**
C10	Manufacture of food
C11	Manufacture of beverages
C12	Manufacture of tobacco
-	**Manufacture of bio-based textiles**
C13 *	Manufacture of bio-based textiles
C14 *	Manufacture of bio-based wearing apparel
C15	Manufacture of leather
-	**Manufacture of wood products and furniture**
C16	Manufacture of wood products
C31 *	Manufacture of wooden furniture
C17	**Manufacture of paper**
-	**Manufacture of bio-based chemicals, pharmaceuticals, plastics and rubber (excluding biofuels)**
C20 *	Manufacture of bio-based chemicals (excluding biofuels)
C21 *	Manufacture of bio-based pharmaceuticals
C22 *	Manufacture of bio-based plastics and rubber
-	**Manufacture of liquid biofuels**
C2014 *	Manufacture of bioethanol
C2059 *	Manufacture of biodiesel
D3511 *	**Production of bioelectricity**

* hybrid sector.

Figure 7-Travacia Ronzon-Sustainability

The sectoral bio-based share for sectors can be estimated by using production value from EUROSTAT-Prodcom dataset using below equation:

$$\mathrm{BBS}_{i,k,l} = \frac{\sum_{j=1}^{n} \mathrm{bbs}_j \times \mathrm{Production\ value}_{j,k,l}}{\sum_{j=1}^{n} \mathrm{Production\ value}_{j,k,l}},$$

Equation 1: Travacia Ronzon- Sustainability

Where,

- BBS $_{i,k,l}$ is the bio-based share of sector *i* (NACE Rev. 2), in EU Member State *k* and for year *l*;
- bbs*j* is the bio-based share of product *j*, given that sector *i* manufactures *j* = *n* products. Bio-based shares vary from 0 for products that do not incorporate biomass (e.g., Prodcom code 20.12.23.30, Synthetic organic tanning substances) to 1 for those that are made entirely of biomass.
  (e.g., Prodcom code 20.12.22.50, Tanning extracts of vegetable origin);
- Production value $_{j,k,l}$ is the production value of product *j*, by EU Member State *k* and for year *l*.

This study analysed the number of persons employed in bio-economy sectors, their turnover, value added and derived indicators.

- The number of people employed is the total number of persons working in observation unit and people who work outside the unit but belong to it (code V16110 in EUROSTAT -structural business statistics)
- The turnover consists of total invoiced by observation unit (code V12110 in EUROSTAT- structural business statistics)
- Value added is the factor cost and the gross income from operating activities after adjusting taxes (code V12150 in EUROSTAT)

Data for these indicators is retrieved from different EUROSTAT datasets and from scientific, technical and Economic committee for fisheries (STECF) report as shown below:

Table 2. Data source for fully bio-based sectors.

Bioeconomy Sector	NACE Code Used for Calculations	Number of Persons Employed	Turnover	Value Added
Agriculture	A01	EUROSTAT—Labour Force Survey (lfsa_egan22d)	EUROSTAT—Economic accounts for agriculture (aact_eaa01)	EUROSTAT—National accounts (nama_10_a64)
Forestry	A02	EUROSTAT—Forestry Employment (for_emp_lfs)	EUROSTAT—Forestry economic accounts (for_eco_cp)	
Fishing	A03	STECF 2014	STECF 2016	
Manufacturing sectors	C10; C11; C12; C15; C16; C17	EUROSTAT—Structural Business Statistics (sbs_na_ind_r2)		

Sources: [10–12].

Figure 8:Travacia Ronzon- Sustainability

The socioeconomic indicators results showed the contribution of bio-economy sectors to the bioeconomy Labour market, turnover and value added (%) EU-28,2015 as shown below:

Table 3. Contribution of bioeconomy sectors to the total bioeconomy labour market, turnover and value added (%), EU-28, 2015.

Sector	Workers	Turnover	Value Added
Agriculture	51.0	16.8	28.0
Forestry	3.0	2.2	3.8
Fishing	1.2	0.5	1.1
Manufacture of food, beverages and tobacco	25.1	51.0	37.6
Manufacture of bio-based textiles	5.6	4.6	4.6
Manufacture of wood products and furniture	7.8	7.7	7.6
Manufacture of paper	3.6	8.3	7.3
Manufacture of bio-based chemicals, pharmaceuticals, plastics and rubber (excluding biofuels)	2.5	7.8	9.1
Manufacture of liquid biofuels	0.1	0.5	0.4
Production of bioelectricity	0.1	0.5	0.5

Figure 9: Travacia Ronzon- Sustainability

Therefore, there is a large potential for development of bio-economy in member states. This is in line with bio-economy index calculated in 2017. The index refers to the R&I maturity level of given country or region. It derives from four variables: a) the

innovation capacity and activity, b) the existence of specific bio-economy strategy, c) existence of bio-economy related clusters, d) the intensity level of bio-economy-related activities.

According to Swedish research and innovation strategy for bio-based economy, the major challenges in converting to a bio-based economy are the basis of research and development and innovation-fostering measures are necessary to convert to a bio-based economy.

1. **The replacement of fossil-based raw materials with bio-based raw materials.**
2. **Smarter products and smarter use of raw materials.**
3. **Change in consumption habits and attitudes.**
4. **Prioritization and choice of measures.**

Bio-economy value chain:

Ecosystem services is the foundation of bio-based economy. In bio-based economy raw material originates as the product of different ecosystem. Bio-based economy framework is therefore imposed by the limitations of the ecosystem services that contribute to this production. Ecosystem services consist of benefits that people can get by using from the ecosystem and can be sub divided into following categories:

1. **Ecosystem provisioning services-food, drinking water, timber, biomass etc**

2. **Regulating and supporting ecosystem services – nutrient production and turnover, oxygen and carbon, air-quality and climate regulation, pollination, flooding controlling etc.**
3. **Cultural ecosystem services- tourism, recreation, and ethical value of the conservation type of nature, plants and animal species, cultural heritage etc.**

As the ecosystems are interdependent, therefore the increased use of one ecosystem can conflict with the objective of another ecosystem. It is important to consider the value chain turnover in ecosystem services for a bio-based economy and its challenges.

The production of bio-based raw material for a bio-economy is produced from land and sea-based ecosystems through different forms of husbandry. To achieve growing bio-economy and reduce the use of fossil based raw materials, the challenge is to increase production volumes and produce good quality raw materials for both animals and vegetables taking into consideration social, economic and ecological consequences.

Next step is further refining of the biomass into products- The refining or processing chain aims to increase the value of the biomass while the length of the process is dependent on the path to the end product. Although this path is short for agricultural products but still many agricultural products require more downstream refining and processing. In both cases there is great potential for generating added value in further refining and use of bi-products. Challenge in this part of value chain is to achieve 'smarter' products and more efficient processing which in turn will achieve a growing bio-economy and generate more jobs. Further, if the refining process is improved, it results in less negative impact

on environment. There are opportunities to create new profitable value chain.

Consumption: The challenge of bio-based economy is to sell the bio-based products therefore the goods should be more attractive than those intended to replace. Also, another challenge is to generate consumer awareness and a desire to contribute to bio-economy which is possible by changing purchase and travel habits. Besides bio-based products new services can generate added value in a bio-economy. Decoupled services can contribute to growth without depleting energy or raw material resources.

Replenishing and recycling: For a sustainable bio-economy, raw material should be used optimally to generate added value and revenue for society. Bi-products and waste products can be further used to provide energy by converting them into new raw material. To maintain an ecosystem production capacity, nutrients and other substances which are important for the functioning of land and water-based ecosystem must be compensated which is possible by replenishing nutrients and soil improvement such as use of ash and waste sludge.

Through Research and Development and existing good pre-conditions it is possible to augment bio-based economy. Looking for augmenting multifaceted solutions to the problems in a region is vital to the success of bio-based economy. This necessitates global perspective and initiative towards collaboration, research and development and innovation.

Actors and Development Opportunities:

Many countries have good preconditions to facilitate conversion to bio-based economy. Production and refining of biomass contribute significantly by providing jobs and relatively large net export revenue. Increased production of biomass and harvesting through genetic breeding programs, more efficient production and harvesting methods means that industry has retained its competitiveness. There is increased competition for renewable resources which brings increased challenges for raw materials.

There is increased potential for good opportunities for an increased use of biomass raw materials within commercial sectors besides food and agriculture Industry. There is potential within construction sector to replace steel and concrete with new bio-based materials. In chemical Industry, introducing new products based on renewable biomass can reduce dependence on fossil based raw materials.

Government and Parliament dictates the pre-requisite in terms of legislation and governance, etc for promoting to a bio-based economy.

Other important actors in switching to a bio-based economy are universities, colleges and research institutes, and regions, municipalities and commerce.

Achieving bio-based economy necessitates overall system solutions. Developing such systems require research in different

disciplines, interdisciplinary research projects and transdisciplinary research projects in which users and researchers collaborate and exchange knowledge to develop better solutions.

Regions and municipalities, are a driving force with their developmental and administrative organisations as they can develop research and innovation strategies jointly with commercial enterprises to utilize resources efficiently.

Government agencies also have a role to play in bio-based economy.

Universities, Colleges and Research Institutes: They are of vital importance when it comes to growth, innovation potential and competitiveness. There is an increasing demand on them for participation in providing knowledge and competence for growth of bio-based economy. Research institutes collaborate with industry and academia on several relevant projects to promote bio economy development.

Small innovation driven companies: Other actors in the area are small innovation driven companies.

State funding and other research funding bodies: These are vital in funding research and development to stimulate the transition to a bio-based economy. Many research projects have associations with bio-based economy. Initiatives that address climate change and globalisation have been initiated through the research foundations like Mistra's support for future forests and future forests. There are energy agencies like VINNOVA that support development of biorefinery of future.

Developing collaborations within research and innovation is important. For example, with other EU and partner countries. For example, new EU research program, Horizon 2020 and industrial technology platforms for food Industry and forestry industry, European technology platform – food for life and forest-based sector technology platform respectively, where Swedish industry is the driving force. Also, with Nordic countries, there is several advantages in collaboration in area of research and innovation for developing bio-based economy due to their similar pre-condition needs.

V. The Empirical Setting

A. Strategic Objective

Problem Statement:

Prob-1: How do various actors of west Ireland's Industry Based BE networks Interact with each other – workshops, webinars and meetings?

Prob-2: What are the obstacles in developing a roadmap for West Ireland's Industry based BE networks?

Cause of the Problem: There are many institutes and actors involved but there is no specific platform that can coordinate the interaction.

Assumptions behind problem: Areas with similar population can act as the reference point by understanding the methods adopted by them in implementing the existing Innovation Ecosystems based on Bio-economy.

PICOC

P ➔ Methods of Interaction between actors

I ➔ Clusters and Regional Innovation Ecosystems.

C ➔ In comparison to other areas of similar population.

O ➔ Key Players and methods of Interaction.

C ➔ West Ireland

Evidence of the Problem: Scientific Evidence is used to find the existing problem.

Source and trustworthiness of the problem ➔ ABS Ranked Journals are used that are considered a trusted source.

Scientific Evidence (Journals) and Practitioner Evidence (Interviews) are used for collecting evidence.

VI. Research Design

A. Methodology

Qualitative Methods or Quantitative Methods? → Qualitative method of Documentary Case Study
Cross sectional survey or Qualitative Interview? → Qualitative Interviews
Population of Interest → West Ireland Universities, Research Institutes, Organizations and Users

Sampling Strategy → Cluster probabilistic sampling
When and Where will you collect data from? → Telephonic Interviews or Emails
Evaluation of data collection design → Finding the contributing factors in effective Interaction between actors

VII. To identify the key players across the four helices of quadruple helix model of Regional Innovation ecosystem for West Ireland Region Bio-economy

A. Introduction

1. Key Bio-economy Player across quadruple helix model- University, Industry, Government and Civil Society

West-Ireland-Bio-economy cluster (Sector)	Industry/large organizations	SMEs	Educational Institutes	Government	Finance stakeholders

Agri-food		BHSL Hydro- Co. Limerick Contract laboratory solution- Galway https://cls.ie/about-	GMIT - Mayo, IT Sligo, LYIT- Donegal, Ulster University.		
Forest				COFORD Council 2019-2021 Forest Sector Development (DAFM) Forest Service (DAFM) Food & CODEX Co-ordination (DAFM) Sustainable Energy Authority Ireland (SEAI) IFA Murrays Timber Group Ltd University College Dublin Enterprise Ireland Forest Industries Ireland Coillte Teagasc Northern Ireland Forest Service Woodlands of Ireland Irish Timber Growers Association **COFORD Council Working Groups 2019-2021** Forest Genetic Resources Roundwood Forecasting and Wood Mobilization Forests, Climate Change Mitigation and Adaption Forest Policy, monitoring of implementation Promotion of Forestry and Afforestation	

				Socioeconomic contribution of the Irish forest sector http://www.coford.ie/aboutcoford/	
Fishing			Ryan Institute- NUI Galway		
Bio chemicals and plastics					
Bio chemicals- pharmaceuticals			GMIT, IT Sligo, LYIT, Ulster University		
Bio based Industry		Modular Automation - Clare https://www.modular-global.com/our-services/	Limerick university- Limerick		

2. Research Question

Study 1

Table 1: Key-Players across Bioeconomy Sectors

Who are the organizations that are involved in West Ireland's Industry based BE networks?

How do various actors of west Ireland's Industry Based BE networks Interact with each other - workshops, webinars and meetings?

Study 2

What are the obstacles in developing a roadmap for West Ireland's Industry based BE networks?

B. West Ireland's Innovation Ecosystem

1. Existing Innovation Ecosystems and their communication techniques for Bio-economy in Ireland

Industry Associations	• Irish Bioenergy Association (IrBEA) • The Composting and Anaerobic Digestion Association of Ireland (Cré) • Irish Bioindustry Association (IBIA) • Renewable Gas Forum Ireland (RGFI) – this is a forum of both consumers and producers • Irish Bio-economy Foundation, founded in 2017 • Irish Forestry and Forest Products Association (IFFPA)

Farming associations	• Irish Farmers Association (IFA) • Irish Cattles & Sheep Farmers Association (ICSA), which has been one of the more proactive farming organisations in bioenergy and the bio-economy
Network and Enterprise support organisations	• BioConnect Ireland led by Enterprise Ireland • Knowledge Transfer Ireland (KTI)

Table 2: Existing Networks and Clusters in Ireland

Table above lists some of the most important associations and clusters in the field of Bio-economy present in Ireland. The Irish Bioenergy Association (IrBEA). There are currently six projects within IrBEA, namely THREE C Project, Small Biogas Demonstration Project (SBDP), RE-DIRECT, H2AD Project, Biogas 3 and Biomass Trade centres Project.

Small Biogas Demonstration project (SBDP) aims to demonstrate the potential for deployment of small-scale biogas production at a farm level. Research in the project will assist in understanding how biogas can drive sustainability improvements at farm level to address the need of agriculture to reduce its emissions impact on local global environment.

THREE C project which is a three-year Interreg North West Europe funded project is looking for further development of economically viable value chains based on charcoal raw materials from waste biomass. It is a successor project

to the RE-DIRECT project which investigated viability of establishing biochar and activated carbon production from technical, social, economic and environmental aspect.

While Biogas3 project is another program under IrBEA which started a two-year program to investigate potential for small scale anaerobic digestion and promote its use in agri-food market. It brings together interested parties through workshops, training sessions, field trips and web-based seminars.

H2AD project involves using micro-technology for the treatment of micro-scale industrial and agricultural waste.

Biomass Trade Centre II project aims to use wood biomass for increasing production and use of energy by organizing motivation events that brings investors to biomass business and logistics and trade centres in 9 EU counties including Austria, Croatia, Germany, Greece, Ireland, Italy, Romania, Slovenia and Spain. It aims to bring right people by providing necessary information that help them enter the market.

Irish Bioindustry Association (IBIA) is a leading representative body for Biotechnology Industry in Ireland consisting of over 50 member companies. It promotes further development of Biotech sector in Ireland and aims to promote research and development, business environment, increase stakeholder benefits, and participate in rest of the EU biotech Industry.

Forest Machine Operator Training Programme:

Renewable Gas forum Ireland vision is to setup a large-scale renewable gas Industry in Ireland, Indigenous and sustainable, producing at least 12% of current gas demand as renewable gas by 2030. Its members include:

Renewable Gas Forum Ireland Members List	**Danone, Diageo, Dairygold co-operative, Nestle Wyeth Nutrition, Lakeland Dairies, Naturgy, Nova UCD, Aurivo, Renewable energy Ireland(MaREI), and Gas Network Ireland (GNI), etc**

It aims to develop a sustainable indigenous biomethane Industry in Ireland on a phased basis by 2030, which will simulate the rural economy and save over 2.6 m tonnes of CO_2 emissions per annum.

RGFI has several projects running under it like Graze, REGATRACE, BioWill, Irish Green Gas Certification scheme, etc. AGRIBIOCNG is also an initiative led by RGFI involving development of a cluster of 6-8 anaerobic digestion (AD), biomethane plant in Munster, as a showcase plant. RGFI is working towards generating regional solutions to reduce carbon emissions in agriculture, manufacturing, processing and transport by collaborating between industries, co-operatives and farmers.

Irish Forestry and Forest Product Association (IFFPA) was established to represent the broad forest and forest-based business sector. It provides mechanisms for collaboration on a sector-wide basis. Its council meets on a quarterly basis to develop and promote strategic goals and develop a work programme.

IFFPA has a training program centre based in Teagasc Ballyhaise College, County Cavan. It is located 220 hectares of grassland and is a leading provider of training in Agriculture and Forestry. It has close links with local institute of Technology in Dundalk (DKIT). Over 1000 students are registered at Ballyhaise college.

Irish Farmer Association (IFA) is Irelands largest farming representative organisation. IFA has a democratic structure organised into branches, county executives and national committees. Each IFA branch elects up to 4 members to represent branch. There are 29 county executives to canvass the views of members and branches on policy and other issues and provide link between national level and members on ground in each county.

IFA is divided into multiple farm sectors including cattle, Dairy, Grain, Sheep, Liquid Milk, Pigs, Horticulture, Potato, Forestry, Poultry, FMP, Aquaculture, Horses, IHNSA etc. In Addition, there are several campaigns run by IFA along with farm schemes like Greening, Basic Payment, Young

farmer & national reserve, Protein Aid Scheme and Rural Development schemes like GLAS scheme, Area of Natural Constraint (ANCs), Sheep Welfare Scheme, BDGP, TAMS, Targeted Agri-Environment Schemes, Organic farming scheme.

Bio Connect

Bio Connect Ireland which is a network of Biotech in Ireland and is led by Enterprise Ireland is an informal, open and independent networking organization in biotechnology, life science and medical devices sector in Ireland, North and South. It was founded in 2001 to promote interaction and exchange amongst all in this field.

Bio Connect meeting are a great way for collaboration where meetings are conducted at regular intervals on the core themes followed by a Q&A session by 70-150 people from academic institutions, bio-industry, service providers in consulting, legal and technical areas and state agencies or civil service. They also have open mike 3-minute session where any participant is allowed to share ideas, needs, products and services. Each meeting ends with a networking session and refreshment to encourage interaction between participants.

Knowledge transfer

Knowledge transfer Ireland is central point of reference for industry-academia partnership and research commercialization.

KTIs mission is to support business and research base by getting technology, ideas and expertise into the hands of business to extract maximum innovation capabilities from state funded research for benefit of public and economy. KTI works with businesses, investors, research funders and TTOs to review, recommend, and implement changes to the way in which Ireland approaches managing IP and contracting.

KTI is co-funded by Enterprise Ireland and Irish university Association (IUA). It is accountable to Department of Enterprise, Trade and Employment (DETE). It is advised by experienced people from industry (SMEs, multi-national, Irish and Overseas).

KTI engages with broader KT community through KT stakeholder forum of representatives Irish HEIs, research funders and government agencies.

Irelands Technology Transfer strengthening Initiatives (TTSI)

TTSI3 builds on TTSI2 and TTSI1 funding program that kick-started technology transfer across Irish universities and Institute of technology (IoTs).

The objectives of TTSI3 include the development of a fast, flexible response to industry's requests for access to

intellectual property and research expertise.
TTSI3 maintains regional clusters (consortia) of research performing organisations, which share resources and expertise, with the expected delivery of an enhanced service for industry in Ireland. The consortia are as follows.

Dublin City University (DCU) working with **Dundalk Institute of Technology (DKIT)** .

TU Dublin (formerly DIT, ITB, ITTD) working with, **Dun Laoghaire Institute of Art, Design and Technology (IADT)**, **National College of Ireland (NCI)** and **The Dublin Institute for Advanced Studies (DIAS)**.

National University of Ireland Galway (NUIG) working with **Galway-Mayo Institute of Technology (GMIT)**, **Institute of Technology Sligo (ITS)**, **Letterkenny Institute of Technology (LYIT)**.

Maynooth University (MU) working with **Athlone Institute of Technology (AIT)**, **Institute of Technology Carlow (ITC)**, **Waterford Institute of Technology (WIT)**.

University College Cork (UCC) working with **Munster Technological University (MTU Cork)**(formerly CIT), **Teagasc**, **Munster Technological University (MTU Kerry)** (formerly ITT).

University of Limerick (UL) working with **Limerick Institute of Technology (LIT)**.

University College Dublin (UCD) working with **National College of Art and Design (NCAD)** (*now a college of UCD*).

WEST IRELAND RESEARCH

Trinity College Dublin (TCD) working with the **Royal College of Surgeons of Ireland (RCSI).**

WEST IRELAND CONNECTED HUBS

HUBS	LINK
ConnectedHubs.ie	https://connectedhubs.ie/
PorterShed	https://portershed.com/
CoWorking Europe	https://coworkingeurope.net/

Universities -> National University of Ireland, Galway

University of Limerick, Clare

Munster Technological University, Kerry

Munster Technological University, Cork

University College Cork

National Institutes -> Marine Institute, Galway

Tyndall National Institute, Cork

NIBRT - National Institute for Bioprocessing Research & Training, Dublin

ICHEC - Irish Centre for High-End Computing, Dublin

Teagasc Food Research Centre - Ashtown & Moorepark

HRB - Health Research Board, Dublin

Institute of Technology -> Letterkenny Institute of Technology (LYIT) TTO, Donegal

Institute of Technology Sligo TTO

Galway-Mayo Institute of Technology (GMIT) TTO

Limerick Institute of Technology (LIT) TTO, Clare

Waterford Institute of Technology (WIT) TTO, Kilkenny

Institute of Technology, Carlow

Dun Laoghaire Institute of Art, Design & Technology (IADT) TTO, Dublin

DIAS - The Dublin Institute for Advanced Studies (TTO), Dublin

Athlone Institute of Technology (AIT) TTO

EI/IDA Technology Center -> MCCI - Microelectronics – Cork

Pharmaceutical Manufacturing (PMTC) – Limerick

FHI - Food for Health Ireland – Dublin

IMR - Irish Manufacturing Research – Mullingar

MTI - Meat Technology Ireland, Dublin

IVI - IT Innovation – Dublin

Learnovate Centre – Dublin

EI Technology Gateway -> Wireless Sensor Technologies, LetterKenny

Precision Engineering, Materials and Manufacturing research – Sligo

WiSAR Lab - Wireless Sensor Technologies – Letterkenny

CREDIT - Centre for Renewables and Energy – Dundalk

MiCRA - Microsensors for Clinical Research and Analysis – Dublin

CREST - Centre for Research in Engineering Surface Technology – Dublin

Design and Applied Design Technology Gateway – Carlow

Shannon ABC - Nutraceuticals Research - Tralee/ Limerick

MET Gateway - Medical & Engineering Technology – Galway

IMaR - Intelligent Mechatronics and RFID – Tralee

NIMBUS - Embedded Computing and Software Systems – Cork

TSSG - Telecommunications Software & Systems Gateway

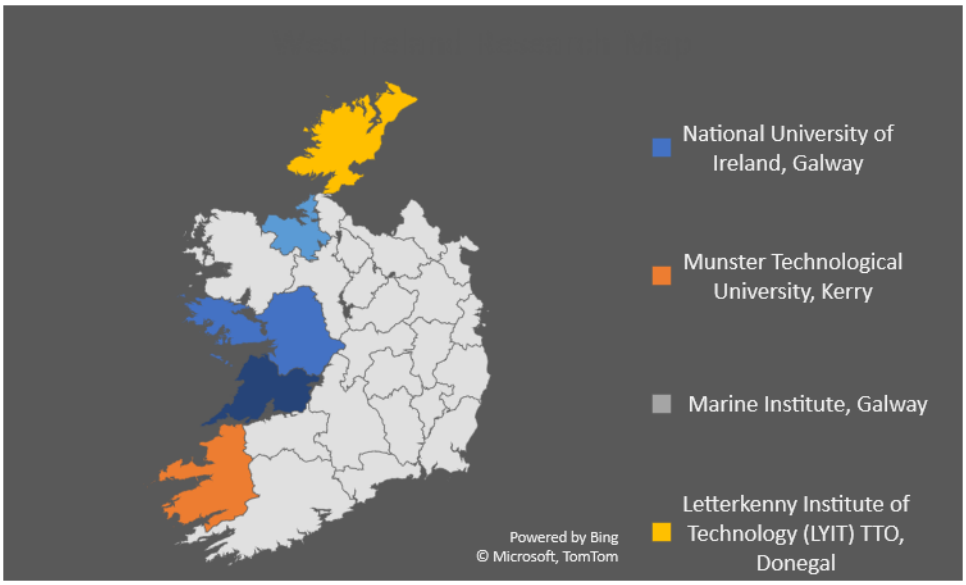

Figure 9-West Ireland Research Map

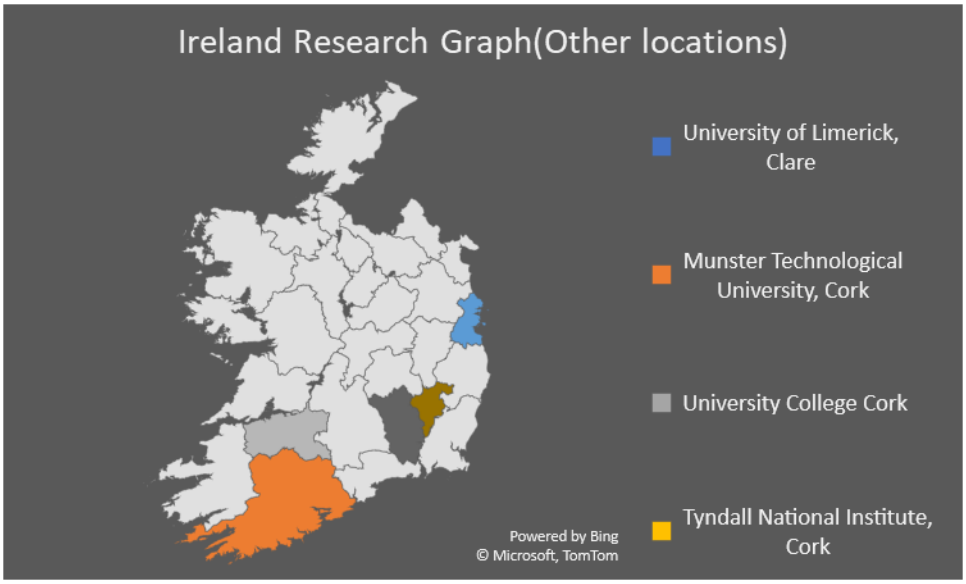

Figure 10: West Ireland Bioeconomy Research Universities

C. Results:

The results from the analysis show that there are many different types of input in terms of resources and activities, within and between the helices.

From a governmental perspective, it is shown that the government provides funding from many different levels of government (local, regional, and national). This involvement of different governments seems to create value by providing innovative output in the form of new products and firms which create jobs. In addition, it is interesting to note that Robotdalen also facilitates collaborations that usually do not take place between government units, for example, between the different regions. Moreover, 'soft infra-structure' for the helix models such as networking and collaboration over geographical borders that do not usually collaborate can have a positive impact on a RIS.

INDUSTRY:

Both large and established firms, as well as small and new firms, collaborate with Robotdalen.

Robotdalen and its extensive network help the firms to find new relationships that can lead to potential collaboration and knowledge transfers

Interestingly and somewhat surprising, our results show that for the startups and small firms, it has at times been critical that Robotdalen has been able to quickly contribute with small, but critical funding that has helped the firms to keep afloat.

ACADEMIA:

Research centres have been found to be able to achieve higher results when collaborating closely with industry and can depend on how central the research centre is in the network. In addition to research and education at the universities, Robotdalen also assists the universities with the commercialization process of robotics, a complex task in a university setting.

University Centers and Research Institutes

Universities	• **NUI Galway**, Ryan Institute for Environment, Marine and Energy Research • **University College Cork** (UCC), Sustainable Energy Research Group • **University College Dublin** (UCD), Energy Research Group • **Dundalk IT**, Centre for Renewable Energy • Institute of Technology Carlow • Galway Mayo Institute of Technology
Research Institutes	**Shannon ABC** (Applied Biotechnology Centre) • **Teagasc** • **Marine Institute**
Research Centre's across Institutes	• **BEACON** research centre, co-ordinated by UCD • **MaREI Marine and Renewable Energy** **Research Centre** co-ordinated by UCC • **Dairy Processing Technology Centre** (DPTC)

Table 3: Bioeconomy Universities and Research Institutes across Ireland

1. Distribution of Innovation Ecosystems across sectors for Bio-economy in West Ireland

West Ireland consist of nine counties as shown below:

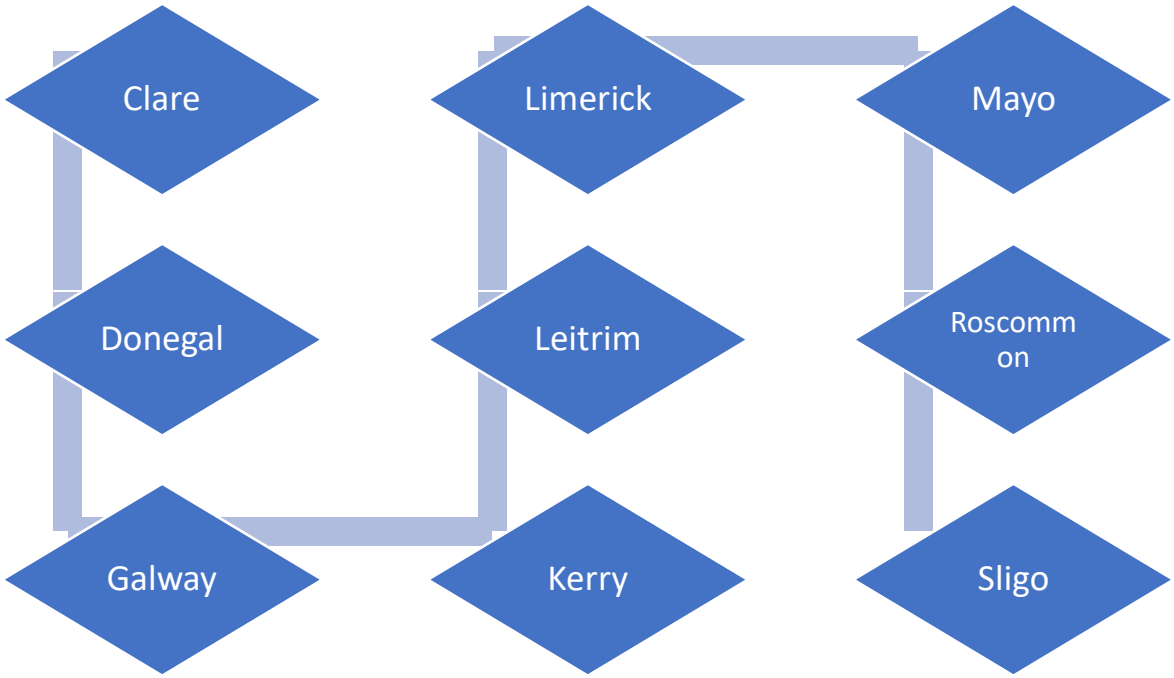

Figure 11:West Ireland Counties

2. West Ireland Agri-food sector Bio-economy Actors Distribution:

West-Ireland-Bio-economy cluster	Industry/large organizations	Educational Institutes	Government		Finance stakeholders
Agri-food		BHSL Hydro-Co. Limerick Contract laboratory solution-	GMIT - Mayo, IT Sligo, LYIT-Donegal, Ulster	Department of Agriculture, food and Marine	SFI Research center

Table 4: West Ireland Agri-food Bioeconomy Key Players

Comparative Analysis: Case Study- Agri-Food

Thierry Stadler, Jean-Marie Chauvet, 2018, New innovative ecosystems in France to develop the Bio-economy

The Industries and Agri-Resources cluster (IAR), based in France is completely dedicated to the French bio-economy. IAR works along full value chain of bio-economy by including all actors along the full value chain. It has facilitated public private partnership by creating new platforms for innovation in Bio-economy. Pomacle Biorefinery is a good example of this approach. Role of national and regional partners is essential to succeed in this long-term strategy and support.

Since 2005, Grand Est and Hauts-de-France regions are a leader in France for agricultural productions with 5.1 million hectors of agricultural lands producing wheat, sugar, beets, barley, potatoes, hemp etc. and a strong agro-industry producing sugars, proteins and other ingredients. In their smart strategy specialisation, they strongly support research and innovation in this field investing tens of millions of euros, making bio-economy as priority.

a) The main objective of IAR enhance collaborative projects on renewable carbon uses and bio-based products and technologies with four strategic axes:

- **Ingredients for food and feed.**
- **Bio-based chemicals (bio lubricants, glues, building blocks, bio surfactants)**
- **Bioenergy with biofuels and biogas production.**
- **Bio-based raw material for transport and construction sector.**

It promotes sustainable use of renewable resources from land, fisheries and forest and convert them into food, feed, fibres, bio-based products and bio-energy while growing jobs in industries.

2. Reducing barriers between actors along the value chain

It brings together stakeholders (approx. 350) from farmer cooperatives, research org. and universities to VCs, start-

ups, SMEs and large industries including end-users with a common goal through biorefining.

Since 2005, IAR has supported 219 research and innovation projects for an investment of 1.525 billion euros (1/3 public support, 2/3 private investments) with the active involvement from farmers and end-users in agricultural production. A network of experimental farms in Grand Est region, have converted an air base to work on full size intermediate crops, biofertilizers, new crops and new agricultural practices with the goal of reducing environmental footprint of agricultural production and hence tackling climate change.

3. BRI (Bioraffinerie Recherches and Innovation) : an open innovation platform within biorefinery of Bazancourt- Pomacle focused on Industrial biotechnologies.

IB (Industrial biotechnologies) play an important role in future of bio-economy in Europe and all around the world. Vast progress has been achieved in the field of biology, which made possible to produce by fermentation and large range of products for food, chemicals and energy and even produce biohydrocarbons, all this has been possible due to huge progress in biology.

Figure 12: Jean-Marie Chauvet, 2018, Stakeholder Value Chain

ARD (Agroindustrie Recherches & Developments) which has been recognized in 2009 as an open innovation platform focused on IB from the French ministry of Industry. ARD has regional expertise in development of fermentation process either to produce biofuels, chemicals or ingredients for cosmetics.

With support of local authorities, French engineering schools with local business schools and regional university have combined forces to setup CEBB (Centre Europeen de Biotechnologies et de Bioeconomie). CEBB deals with academic part of platform BRI located at site of biorefinery. BRI is competent for labs or institutes having competencies in field of new strains and development.

4. PPP (Public-private partnership) has gone beyond competition to invest in collective research and demonstration tools.

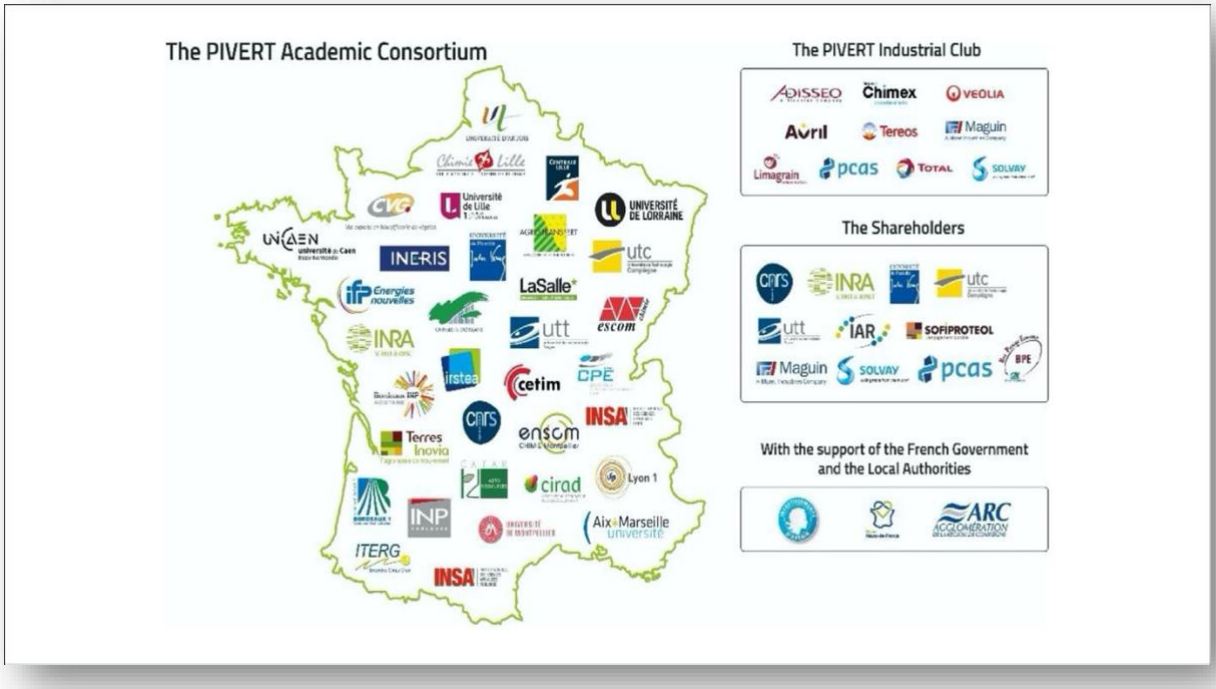

Figure 13 : Jean-Marie Chauvet, 2018, PIVERT ecosystem and Shareholders

5. Regional, national and European policy have a strong leverage effect.

IAR provides the link to optimize synergies for the development of bio-economy.

5.1 National Level: French economy supports development of Agriculture supporting 936000 jobs and a turnover of 78.4 billion euros. Bio-based chemistry concerns development of 25000 direct jobs with strong agro industry.

Bio-based chemistry and Biorefinery proposed national priorities for research and innovation including plant-based chemistry considering national policy since 2009.

5.2 Regional Level: There is emphasis on research strategy on bio-economy in the frame of smart specialization strategy(S3). Two previous regions Picardie and Champagne-Ardenne have therefore been able to get European funds for research and development programs and platform investments.

5.3. European level: Biorefinery Euro-view has been coordinated by IAR. A European project aimed at formulating recommendations to EU commission to boost biorefinery developments in Europe. State of the art biorefineries in Europe with their economic analysis for development has been provided to EU commission.

6. Complete demonstrators' ecosystem to boost bio-based products development has been built.

It is decided to build Complete ecosystem of platforms to prove industrial feasibility and bridge innovation valley of death. Plant components include proteins, oils and carbohydrates, technologies include biotechnology, biogas production, second generation biofuels (bioethanol by biotechnology, biodiesel with gasification), fermentation, plant fractionation. This

policy is built in collaboration with regional, and national level.

7. Conclusion: Challenges for future

Low price oil has slowed development of new bio-based products based on biotechnology and bio-based chemistry. Many public-private partnerships have been done but business model of open innovation platforms has to evolve to new economic situations. In meantime, there is need for long term policy for supporting national and European level to reassure investors and start-ups. Public-private partnership is best way to embrace future. To fulfil a roadmap, next step is to build market development and new bio-based products in Europe.

3. West Ireland Forest Bio-economy Actor Distribution:

West-Ireland-Bio-eco	Industry/large organizations	SMEs	Educational Institutes	Government	Finance stakeholders
Forest	Teagasc	• Patrick Murray, Murrays Timber Group Ltd	University College Dublin	COFORD • Forest Sector Development (DAFM) • Forest Service (DAFM) • Research, Food & CODEX Co-	Enterprise Ireland

Table 5: West Ireland Forest Bioeconomy Key Players

The implementation of Forest Research of Ireland, require interaction between various stakeholders, building collaboration between institutions, industry, academia, nationally and internationally, between funding initiatives of government and agencies. Critical elements include knowledge transfer, program and project monitoring and overview of critical elements.

Key Actions include:

1. Stakeholder Involvement
2. Collaboration
3. Knowledge transfer
4. Measuring success

Some of the key issues for research performing organizations (PROs) is to develop the need to:

1. **Strengthen collaboration between RPOs and maximize exploitation of findings from research.**
2. **Enhance encouragement and active involvement between stakeholders as active project participants.**
3. **Facilitating collaboration so that maximum value is gained from investments.**

Disseminating findings from research is an essential element and it includes activities like seminars, field events and publications, both scientific and technically focused such as COFORD connects series which is a valuable resource of information for foresters, forest owners, industry and wider stakeholders over the years.

The CCFRWG ensures research findings are made available through appropriate research audience, but also through results will help inform funding support and ongoing research support.

There are three main parties involved:

1. **DAFM – Research Division and CODEX division**
2. **COFORD council**
3. **CCFRWG – Council Forest Research Working Group**

Ireland is trying to develop a world class research system to drive innovation and economic success. Research divisions and DAFM plays an important role in vision for Agri-food

and Forestry sector, via its publicly funded research programs. The three primary public good research programs run by DAFM research division are:

1. **Food Institutional Research Measure (FIRM)**
2. **Research Stimulus Fund (RSF) and the**
3. **Program of competitive Forest Research for development (CoFoRD)**

DAFM facilitate its involvement in Horizon 2020 by one of its national delegate and a national contact point.

National delegate attends relevant program committee meetings whereas the national contact point increases Irish participation and success in Horizon 2020 program.

DEVELOPING THE STRATEGIC RESEARCH AGENDA

CCFRWG (COFORD council Forest research working group) develops a strategic agenda for Irish forest research in consultation with DAFM/Forest service. It takes care of two important issues, namely long-term nature of some aspects of forest research and issues arising and secondly on bio-economy.

The primary objectives of national strategic agenda for forest sector includes:

1. **Deliver, from state investment in forestry research, sustainable economic return from the sector through enterprise development, growth of sustainable employment and improved competitiveness.**

2. Ensure protection of natural capital and address binding environment requirements for climate change, water and other natural resource management, with reference to
    a) Current national and EU forest policy, legislative, market and external environmental drivers, previous national and EU forest policy initiatives, previous and current COFORD and other forest research programs, work of forest policy review group, food harvest 2020.

The work will include:

1. Consideration of policy, legislative, market and environmental drivers and potential drivers that will influence research needs and priorities.
2. Documentation of existing publicly funded (national and EU) forest research conducted in Ireland over recent years.
3. Documentation of national forest related research capability and infrastructure.
4. Documentation of national forest related research capability and infrastructure.
5. Documentation of funding modalities at national and European level.

6. **Identification and prioritization of national research needs to address the state drivers.**
7. **Recommendation to the COFORD council, DAFM and other relevant departments and/or funding agencies on national research needs and related matters.**

According to the proposed working arrangements and timeframes:
Membership of the CCFRWG are drawn from council while other members are drawn from wider sector. The group may wish to establish sub groups and may decide to consult with others outside the council or group membership.

The groups may invite presentations or submissions to guide its work.

SECRETARIAT

DAFM research and Codex division will act as secretariat to convene and record the outcome of meetings, draft material for inclusion in strategy and prepare final report. Meeting/timeframes should be expected to be completed at specific times.
Group meetings needs to be held at DAFM headquarters. In addition,

1. **It should seek submissions from sectoral interest**

2. It should seek details of competencies in Irish forest research and universities and other third level institutions.
3. A presentation of potential impact of climate change on existing and potential forest and possible adaptive aspects of climate change needs to be given to the group.
4. Attention to issues related to market needs and consult directly with a number of processors.
5. A formal consultation process needs to be placed on DAFM website.
6. The COFORD council should have a number of working groups in relation to different aspects of the sector.
7. A brief submission of priorities on forest research related to above should be done.
8. While proceeding, three sub groups needs to be formed to address specific areas:
    a. Inside the gate
    b. Outside the gate
    c. Ecosystem services

Comparative Analysis: Case Study-Forest

Stefanie Linser and Markus Lier, 2020, The Contribution of Sustainable Development Goals and Forest-Related Indicators to National Bio-economy Progress Monitoring

SDGs include policy aims such as the decarbonization of energy markets, lower greenhouse gas emissions, sustainable management of natural resources, the reduction of social inequality, and meeting the food security demands of a growing global population.

Sustainable and circular bio-economy covers all sectors and systems that rely on biological resources (animals, plants, micro-organisms and derived biomass, including organic waste), their functions and principles. It includes and interlinks: land and marine ecosystems and the services they provide; all primary production sectors that use and produce biological resources (agriculture, forestry, fisheries and aquaculture); and all economic and industrial sectors that use biological resources and processes to produce food, feed, bio-based products, energy and services.

The review of the eight-national bio-economy indicators is provided by this study. Its focus was on exclusively on the indicators studied for bio-economy and not on related sub-aspects like biomass or green growth. It identified three bio-economy studies based on key indicators for forest bio-

economy, synthesis on bio-economy monitoring systems in EU member states and the frameworks for measuring size and development of bio-economy with a list and detailed description of bio-economy indicators. The indicator list refers to the bio monitor project related to bio-economy sectors and most suitable indicators.

Table 1. Overview of systematically analyzed national bioeconomy strategies [25,46–52] containing indicators for progress monitoring and assessment, listed according year of publication.

Year of Publication	Country	National Bioeconomy Strategy
2012	USA	National Bioeconomy Blueprint—Indicators [25]
2013	South Africa	Bio-economy Strategy, South Africa—Indicators of critical factors [46]
2014	Finland	Finnish Bioeconomy Strategy—Key indicators [47]
2015	Malaysia	Bioeconomy Transformation Programme—Bioeconomy Contribution Index [48]
2016	Spain	Spanish Bioeconomy Strategy 2030 Horizon—Evaluation Index [49]
2018	Denmark	Strategy for Circular Economy—Indicators [50]
2018	United Kingdom	A national bioeconomy strategy to 2030—Indicators [51]
2018	Italy	A new bioeconomy strategy for a sustainable Italy—Key Performance Indicators [52]

Figure 14: Stefanie Linser, The Contribution of sustainable development goals, 2012

List of Bio-economy indicators for the sustainable forest management for SDG 12

Sustainable Development Goals [44]	**SDG Targets** [44]	**SDG Indicators** [44]	**Keywords** for screening of SDG related wording	Strategy for Circular Economy 2018 in **Denmark** - *Indicators* [50]	Strategy for Circular Economy 2018 in **Denmark** - *SDG related wording* [50]	The **Spanish** Bioeconomy Strategy 2030 Horizon - *Indicators* [49]	The **Spanish** Bioeconomy Strategy 2030 Horizon - *SDG related wording* [49]
7. Ensure access to affordable, reliable, sustainable and modern energy for all	7.2 By 2030, increase substantially the share of renewable energy in the global energy mix	7.2.1 Renewable energy share in the total final energy consumption	energy, renewable energy, energy efficiency, energy intensity	Renewable energy, share of total energy consumption	"embedded energy for new buildings can constitute up to 50 percent of the energy consumption over the entire life of the building", p. 35	-Production of renewable energy of biological origin -Production of biofuels	"marketing of new ways of synthesising biofuel using thermochemical or biochemical technologies, and with waste, by-products or algal biomass as raw material", p. 27
	7.3 By 2030, double the global rate of improvement in energy efficiency	7.3.1 Energy intensity measured in terms of primary energy and GDP			"The government works for a coherent product policy in the EU, setting requirements for both energy efficiency and circular economy for all product groups for which an overall assessment indicates a considerable improvement potential", p. 24		
8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all	8.1 Sustain per capita economic growth in accordance with national circumstances and, in particular, at least 7 per cent gross domestic product growth per annum in the least developed countries	8.1.1 Annual growth rate of real GDP per capita	employment, unemployment, economic growth, economic productivity, resource efficiency, consumption, production, innovation, tourism	GDP	"sharing economy must contribute to growth in a sustainable and smart manner", p. 21	-Economic importance of the bioeconomy sector -Agriculture value added	"Transformation of timber, cork, resin, production of paper and of other industrial products, and extracting bioenergy and other bioproducts, uses and services linked to ecosystems, ranging from harvesting activities to tourism and leisure. These productive processes, with great potential for generating employment and added value, involving major amounts of biomass which can be exploited", p. 12

Figure 15: Stefanie Linser, Sustainable Development Goals

Jaana Korhonen, Alexandru Giurca, et. al, Actors and Politics in Finland's Forest-Based Bio-economy Network – This study is an exploratory analysis of Finland's forest-based bio-economy. Actors participation depends on their perception, choice of approaches and their interest and beliefs and the network they operate in. It aimed to understand the interests of the actors involved and how effective the policy coalition and structures are for promoting innovation.

Qualitative social network analysis techniques were used to investigate emerging social network structure at two levels: 1. Overall structural features of the network. 2. Actor level measures detailing the position and roles of specific actors within the network.

(i) Network-level measures included cohesion, density, or centralization, which can be used to characterize the network as a whole.

(ii) Actor-level measures, such as "betweenness" and "degree centrality", focus on the roles of individual nodes in the network. "Degree centrality" refers to the number of nodes that an organization is connected to. This measure considers both out-degree (the number of connections going to other nodes) and in-degree (the number of incoming edges). Organizations with a high degree of centrality can be considered "well connected".

The data can organized in the NodeXL Excel Template (https://nodexl.codeplex.com/) and Sustainability 2018, 10, x FOR PEER REVIEW 6 of 19

further analysed and visualized with the open source and free visualization and exploration software Gephi 0.9.2 (https://gephi.org/).

As a result of the analysis, 67 organizations and 359 (edges) connections. example is research dominated, 36% participation from research organizations, 12% from government, 22% from Industry, 10% from non-industry, 5% from environmental non-governmental organizations (ENGOs) and remaining 15% from other types including

(consultancies, industry association, or network organizations).

It was identified that the current network structure centred around governmental bodies and traditional forest-based industries with less participation from other actors and stakeholders could hamper knowledge transfer in networks. It has been suggested that transition towards BE require breaking silos of forest-based industry and stimulating hybrid connection. Technological innovations are more dominant in finish forest-based industry and stimulate hybrid collaboration. Inclusion of diverse stakeholders like entrepreneurs, forest owners, citizens etc is a more flexible way to increase quality and acceptance of technological innovations.

Based on the analysis, key aspects and drivers support two alternative paths in forest-based BE: "Business as usual" development (BAU) or a more radical change ("transformative"). BAU path is geared by strong industrial and governmental coalition. Furthermore, a closed network structure increases the risk of further segregation in emerging BE network hampering knowledge transfer between diverse actors. Based on strategic paths forest sector business will diversify network structure and open new opportunities for small scale businesses.

For Instance, policy incentives could focus on strengthening responsible research and innovation (RRI) by opening the network for diverse societal actors (e.g.,

researchers, citizens, policy makers, business, NGOs, etc.). This implies there is co-production during the whole research and innovation process with a wider sense of societal actors to better align both the process and its outcomes with the values, needs and expectations of BE stakeholders.

4. West Ireland Fishing Bio-economy Actors Distribution:

West-Ireland-Bio-economy cluster	Industry /large organizations	SMEs	Educational Institutes	Government	Finance stakeholders
Fishing	BIM INFOMAR	**AquaTT -** **http://www.aquatt.ie/**	Ryan Institute-NUI Galway,	Department of Agriculture, Food and the	SFI and Marine Institute
	The Geological Survey Ireland and	**Bantry Marine Research Station -** **http://www.bmrs.ie/** **Bio-marine Ingredients Ireland Ltd**	Galway-Mayo Institute of Technology	Marine Survey Office (MSO), Bord	European Maritime and Fisheries Fund
	Sea ++ , PWC,	**Cyber Colloids Ltd. -** **http://www.cybercolloids.net/** **Dolmen Design and Innovation -** **http://www.dolmen.ie**	Host Institute: University college cork,	Sea Fisheries Protection Authorit	BIM Ireland's seafood development

			ESRI, NUIM, MTU, NUI Galway,	Directorate General Fisheries of the	
			Irish Fisheries Science Research	Intrafish	

Table 6: West Ireland Fishing Bioeconomy Key Players

Comparative Analysis: Case Study- Fishing

M.T Johnson, L.J Johnson, et. al., 2020, The Marine Knowledge Exchange Network: Insights from an Innovative Regional-to-National Scale Academic-Led Knowledge-to-Impact Network and Recommendations for Future Initiatives, https://www.tandfonline.com/doi/abs/10.1080/08920753.2020.1781513?journalCode=ucmg20

ANALYSIS:

The research by M.T Johnson on marine knowledge exchange network, has taken the approach of a regionally focused initiative to increase coastal marine and marine research impact in east England by providing a knowledge exchange (KE) platform.

A review of activities is presented here generating tangible impact from research. Some of the key research questions identified in KE literature, reflecting strength and weakness of M-KEN.

M-KEN's network-based impact of model first identifies needs then co-creates an event or project followed by outputs feed directly to users within network and finally grows the network.

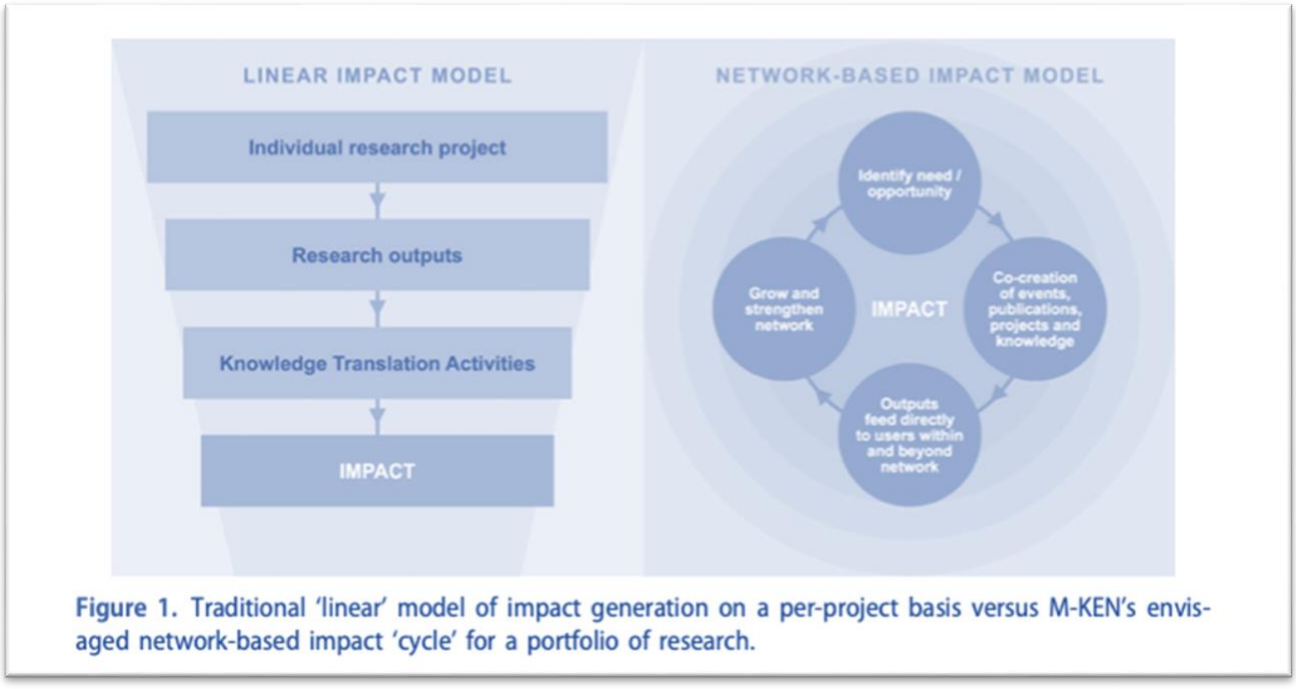

Figure 1. Traditional 'linear' model of impact generation on a per-project basis versus M-KEN's envisaged network-based impact 'cycle' for a portfolio of research.

Figure 16: M.T Johnson,2020, marine knowledge Exchange Network

Marine knowledge exchange network 2014–2018

The M-KEN is intended for building on the nation-wide research agenda, translate knowledge from research into policy and to raise reputation for marine leadership and coastal science and management.

It aims to achieve this by bringing together network of members representing different sectors like business, policy, local government and NGO, practitioners and charities together through webinars, meetings, workshops and conferences through digital media (websites, videos, social media platforms) The social network would then generate new opportunities for translating existing and ongoing research into truly co-designed research projects as the network evolves.

M-KEN from its outset is dedicated to develop a visual communication tool that is a key part of research translation effort and to build capacity in graphic design sector to deliver science rich outputs. Visualization of data, methods and concepts is an important concept of research impact cycle (eg: McInerny et al. 2014). M-KEN puts visual research at the fore including infographics, data visualizations, posters, videos, live-presentations etc/

The processes and actions that create value and build impact from research activity is useful in providing alternative ways to assess impact generation processes:

Below is the list of key traits during the discovery, engagement, implementation, uptake and impact phase as defined by this study.

Table 1. Impact readiness levels for social sciences and health research (SSH) by DANDELION 2018, adapted here for broader application by removal of references to SSH. Descriptor for each IRL (Discovery, Engagement, Implementation, Uptake, Impact) defined and added by the current study.

IRL1	IRL 2	IRL 3	IRL 4	IRL 5
Discovery **KEY TRAITS:** - Mapping & analysis of the stakeholders landscape in order to grasp the value chain of the envisioned research outputs - Definition of instruments and strategic planning of outreach activities in order to create value - Successful communication of research to key target audiences at a medium/late stage of the project - Research agenda and process are co-designed with the potential stakeholders	***Engagement*** **KEY TRAITS:** - Organization of / participation in multi-stakeholder events with a common agenda - Successful outreach and systematic, planned involvement of various media channels - Scientific knowledge circulates along various channels in a stakeholder-sensitive language - Early systematic exploration with specific stakeholders about requirements, barriers, opportunities for potential application	***Implementation*** **KEY TRAITS:** - The basis for research application is established through an iterative co-creation process - Consolidation and validation of 'actionable' results of research by stakeholders in practice - First implementation efforts can be demonstrated as single one-off events in a concrete societal context of application - Societal stake-holders are engaged in research evaluation and support learning feedback loops for researchers	***Uptake*** **KEY TRAITS:** - Demonstrable uptake of research results and their advancement through entering a for-profit/ not-for-profit enduring partnership with stakeholders - Sustainability of the multi-stakeholder process is planned for in previous stages and appears highly probably - Beneficial outcomes on target stakeholder groups are verifiable - Research triggers a change in funding institutions and their schemes, and also in the visibility and the positioning of the societal dimensions of 'Third Mission' in PROs and RTOs	***Impact*** **KEY TRAITS:** - Demonstrable scale-up and follow-ups both in regional and sectoral terms; emergence of SSH spinoffs - The initiators/ researchers are recognized as innovators and are consulted for advice for replication of good practices - The application of research in different contexts generates additional demand with funding organizations for further innovative research - Beneficial outcomes are measurable and introduce not merely a change in practice but moreover a sustainable change in mindsets, culture, regulation

Figure 17: M.T Johnson,2020, IRL Descriptors

The following important observation has been drawn upon M-KEN development and activities:

M-KEN prior to its creation, inspite of good existing individual relationships between researchers and regional stakeholders in policy, local government, commercial and NGO sector, the level of activity amongst research community and research users 'divide' was very poor. Important step by M-KEN was 'knowledge and impact discovery' i.e using knowledge amongst research users about the existing research expertise in the region and

across the network and where there were opportunities that can make a difference.

Summary of the insights M-KEN has brought to the core topics is given below:

1. Research impact and knowledge exchange can facilitate a long term, multi stakeholder approach. M-KEN ignited and fostered cross-sectorial stakeholder relationships to influence regional marine research agenda. These developments facilitate dialogue and collaboration across knowledge action interface.

2. M-KEN operates as a semi-independent mediation org between knowledge and end users. It provides the framework for knowledge exchange activity and has the ability to maximize the delivery of knowledge exchange through direct academic leadership, due to multiple foci of academic role and in particular need to progress one's own research agenda than broader portfolio of interest.

3. Utilizing dedicated knowledge brokers to facilitate multi-stakeholder knowledge exchange. This has led to the development of network leading to truly interdisciplinary research, knowledge production and impact.

4. Ability to provide focused and effective knowledge exchange outputs from the research outcomes. It suggests a regional and topical focus of M-KEN generated via stakeholder interest along with engagement. Visual communication of research outputs involved using infographics was particularly effective.

5. Long term assessment and monitoring of KEA: The M-KEN model supported domain specific knowledge exchange beyond the funding of a particular research project. It applied cross network collaboration to develop and secure funding for innovation, knowledge exchange and research activities and building capacity to deliver infographic services as stated in point 4.

6. knowledge exchange activities being incentivised within research context.

Literature suggest that full potential of M-KEN was not realized due to time and budgetary concerns of the academic roles of M-KEN leads despite significant financial support from host institutions, considerable time was required to develop and maintain M-KEN to evaluate academic roles.

therefore, it was suggested that if KE activity is formally recognised as a core element in typical academic role then researchers would have more opportunity to expedite communication of knowledge to individual research users.

RECOMMENDATIONS FOR FUTURE ENDEAVOURS

According to the above research, supporting securely and well-funded "Ocean knowledge exchange network ("Ocean-KEN") with national nodes around the world. It suggests a hybrid model for hierarchy of "nested" networks facilitating flow of knowledge, making decisions and best

practice innovations through both national and international coordination activities. As proven by M-KEN the value of regional focus was to build strong network of actors who share common challenges with overlap in work and that of others and therefore can provide significant professional benefits to active participation as shown below with the hierarchy.

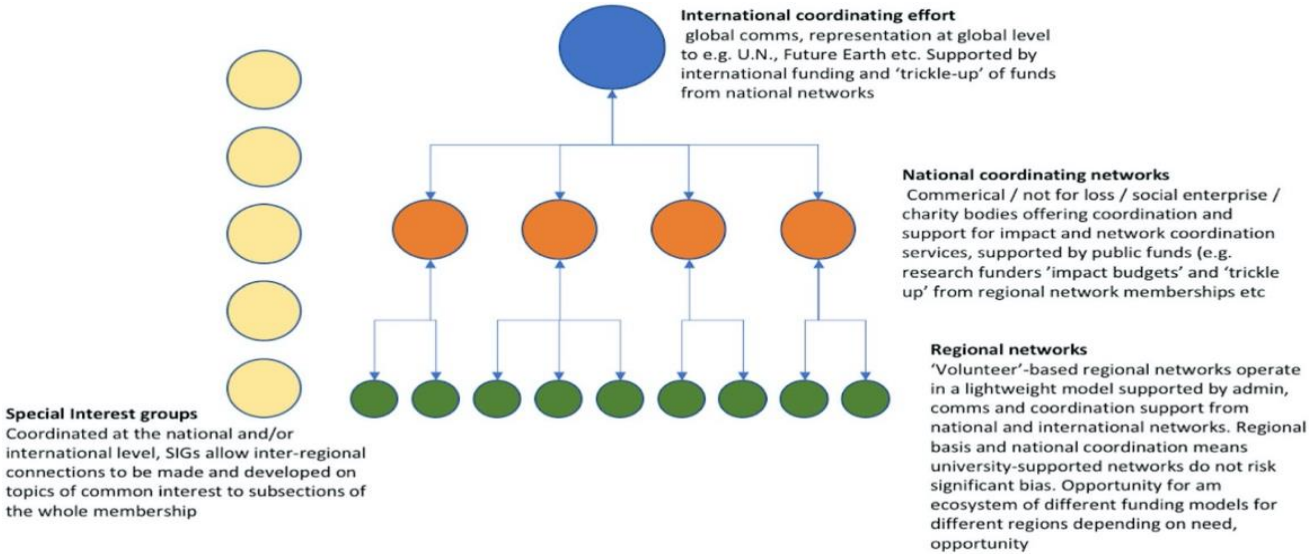

Figure 18: M.T Johnson, 2020, M-KEN coordination effort

As demonstrated through M-KEN, there are sufficient funds available in the research impact ecosystem from funders, beneficiaries of research network and through membership fee. Therefore, national nodes can be run fully independently for commercial activities, not-for-profit social enterprises or charities depending upon national conditions.

The maritime alliance BlueTech cluster(https://www.tmabluetech.org/) based in san Diego California is an internationally growing network of research

and commercial organisation under shared vision to promote sustainable science-based ocean and water industries. It aims to develop regional "BlueTech clusters" of marine industry. Engaging with and supporting such initiatives is an important part of bringing together what is called the patchwork of marine network and clusters under a common banner

The "nationally-supported, internationally coordinated, regional KE network" model may therefore provide a solution to a multiplicity of challenges in making science work for societal good:

All actors in the system are benefitting their own interests as well as the 'common good', but independent management at national level ensures no bias toward particular knowledge producers or commercial interests.

- Impacts and outcomes can be traced and documented, benefitting research institutions and research funders.
- Stakeholder fatigue and the 'multiplication of engagement' are avoided. Whilst we have focused here (as M-KEN did) on policy and business impacts, we argue that other societal interactions such as education and community engagement could also be achieved through the same hierarchy of networks.

BTCA has 8 other member clusters:

1. Cornwall Marine Network
2. Forum OCEANO
3. GCE Ocean Technology

4. Irish Maritime Development Office
5. Oceansadvance
6. PLOCAN
7. Polemer Mediterranean or
   Polemer Bretagne Atlantique
8. Marine Southeast

D. Challenges:

According to a case research on "Bio-economy Campus, Central Finland" by **Anneli Ylimartimo,** 2016 There is no single recipe to follow to develop Regional ecosystems that can meet the needs of all the different kinds of clusters, but there is a list of actions to choose from:

1. **Understand and benchmark regional economies.**
2. **Engage different actors.**
3. **Deliver and organize services by cluster, teams, external connections.**
4. **Build a specialized workforce.**
5. **Stimulate innovation and entrepreneurship by supporting and investing in innovations, start-ups, cluster-based incubators and technology hubs and networks.**
6. **Allocate and attract resources and investments.**
7. **Promote marketing and branding in a region.**

The **key assets** Identified in the BERST analysis involved in Bio-economy clusters are knowledge Institutes, those with close

contacts with other knowledge Institutes and RDI organizations. The Institutes in West Ireland like Ryan Institute- NUI Galway, Mayo Institute of Technology – Galway, Munster Technological University, University College Cork (UCC)- Sustainable Energy Research Group, University College Dublin (UCD)- Energy Research Group, Dundalk IT- Centre for Renewable Energy have linkages to several fields of study in Bio-economy which enables integration of different expertise for creating new innovations for developments of bio-economy. The RDI cooperation with research centers of Ireland as well as with Marine Institute, Teagasc and Shannon ABC strengthen the RDI competence, technical know-how and resources at bio-economy campuses.

BIM Ireland's seafood development Agency, Enterprise Ireland, and Marine Institute offers a strong scientific knowledge base for generating new ideas and bio-economy businesses. From the initial stages political and financial support from regional and local authorities should be strong and consistent for the development of Bio-economy.

Other assets that contribute in bio-economy clusters are policies and measures: legislative and policy framework conditions affecting introduction of products made from biomass including measures relating to legislation, policies, standards, labels, certification, and public procurement.

Political climate in west Ireland is favorable for development of ecosystem for Bio-economy. There is strong political will to support development of bio-economy in the region and support development of bio-economy businesses and high value bio-

products. The present strategy of west Ireland including plan for province, identifies three focal economic activities around which capabilities, target markets, and strategic development priorities are shaped: bio-economy, digital economy, and knowledge-based economy. The strategy for its part has facilitated the allocation of public funds for bio-economy RDI projects carried out at various research centers and research Institutes such as SFI Research Centre for Energy, Climate and Marine and Department of Agriculture, Food and Marine.

Beaudry and Breschi have shown that clustering itself is not conducive of firm's innovation performance. It has concluded that though firm's innovation activities are positively affected by clustering, but the likelihood of innovation arises only from co-location with existing population of innovation companies.

According to the European Commission's smart guide to clustering notes that cluster and cluster initiatives are important part of innovation ecosystem. Innovation ecosystem are a combination of two distinct economies: the research economy, driven by fundamental research and the commercial economy which is driven by the marketplace. In other words, when the innovation induced profit increase exceeds the R&D investment, the innovation ecosystem is growing.

Potter's (1998) clusters has expanded the idea of local clustering, open innovation expands the scope of potential participants of the innovation process from internal actors of R&D to numerous additional co-creators and co-innovators outside organizations.

For an ecosystem to be innovative, a continuous cross pollination of ideas, questions, knowledge and technology between

research, development and application is necessary, but many barriers prevent innovation as described by Lindqvist.

Lindqvist et al. presented "The Gap Model" which describes the gaps that prevent innovation, describing the five innovation gaps within the cluster and two external gaps, one between the cluster and other clusters and another between the cluster and global markets as described below:

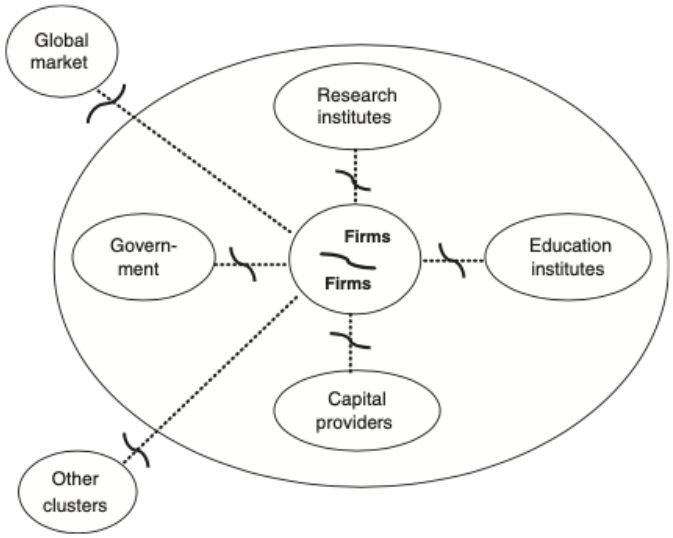

Figure 2. The Gap Model by Lindqvist *et al*.[8] depicting the seven innovation gaps. The figure has been modified from Fig. 4.2 in Lindqvist *et al*.[8]

Figure 19: Lindqvist et al. Gap Model

According to Jackson, who examined the gap between academia and commercial marketplace in an innovation ecosystem. He found, In academia, there is concentration of government investment in fundamental research while industry investment concentrates on product development in commercial marketplace. In between, there is gap in resources for technology demonstration and development called Valley of Death – as for those actors who are involved in moving through the

commercialization of innovations from their discovery, like the actors- academia, small businesses, investor community, and commercial industry. It is this valley that many innovations die.

Among the challenges towards development of bio-cluster in west Ireland is the firm structure, especially in bioenergy sector. Forest fuel production enterprises in the cluster are relatively small scale- while this has advantages such as competition and local employment -it also brings challenges.

Networking and interaction among these enterprises is complex and can be slow moving. Also, reaching the participants for example with training initiatives is difficult. The rate of creation of start-ups by entrepreneurs is relatively slow. Further, new investment in road infrastructure are required to support further development of cluster activities. Furthermore, diversity of bio-based market sectors increases the complexity for technological transfer. Diversity also makes scaling up of new conversion pathways and commercialization of new bio-based product more complex.

The fragmented nature of the various bio-based economy sectors prohibits the fast design and uptake of cross sector targets and the subsequent sectorial policy alignment. Also, the complexity of data required alongside with the large datasets needed causes delays in providing evidence and information policy formation. Finally, reinforcement of trans-regional and international perspectives would expand business development prospects.

The main barrier perceived are the insufficient link between decision makers and stakeholders from the bio-economy and the insufficient links between policies related to the bio-economy.

E. Action Plan and Roadmap:

The Bio-economy action Plan:

According to the action plan described by the commission for the implementation of Bio-economy strategy objectives, following are the major investments in research, innovation and skills:

1. **Ensure substantial EU and national funding.**
2. **Increase the share of multi-disciplinary and cross-sectorial research and innovation.**
3. **Promote the uptake and diffusion of innovation in bio-economy sectors.**
4. **Build the human capacity required to support growth and further integration of bio-economy sectors by organizing university.**

Secondly, Support for Research actions necessary for implementation of bioeconomy by the following:

1. **Support research into industrial applications.**
2. **Foster industrial involvement in research and innovation projects.**

Thirdly, support for better engagement of society and foster social innovation in the bioeconomy by the following:

1. **Enhance actions related to communication and dissemination of information on the advantages and risks of bio-economy.**
2. **Improve information on bio-based products for consumers.**

IMPORTANCE OF INTERACTION BETWEEN LOCAL FIRMS AND EXTERNAL ONES:

One of the main actors of the quadruple helix is regional government. Power of the regional government is of substantial important while making decisions at regional level, which varies from region to region. The cooperation between regional and external firm facilitates innovation, in that continuous exchange of knowledge, and spillovers leads to knowledge being accumulated in the region. Thus, it is critically important that innovation actors develop absorptive capacity to obtain knowledge from advanced knowledge sources.

As RIS benefits from the interaction between local firms as well as external ones. Therefore, those firms that interact with regional, national and international firms and institutions benefits from gained skills and know-how, which facilitates regional innovation.

Given this, one way of developing an RIS is to reduce dependence on central government while adopting a more regional decision-making approach.

As the actors of the quadruple helix are having overlapping functional roles in an RIS. Therefore, there is a need for enhanced mutual cooperation among the actors. Cultural and environmental factors affect the stability of quadruple helix systems thus, the construction of careful balance between differentiation and integration among the three functions

determines the innovation environments for a region (Leydesdorff, 2000, p. 1441).

Open clusters are an important way for firms to gain knowledge and develop innovations. Intermediary organizations that can support the firms and mostly SMEs in developing internationalization.

International connections and the regional research institutes have played a key role in knowledge acquisition and resultant innovations by the local firms.

There is a need for a gateway at academic Institutes for students to collaborate with students of other Institutes and having learnt the skills, apply them to local Industries while for the researchers in capacity they should be able to collaborate with local Industries which allows them to gain valuable contacts in an untapped market.

Research centers acts as a vital bridge between the universities and local firms for commercializing scientific research outcomes and inventions.

For example, they allow the firms to make use of the research outputs they conduct through soliciting private-sector financing and helping researchers to join firm's projects. In these exchange schemes researchers can be directly employed by the local firms, thus benefiting from the knowledge exchange. They can use all the laboratory facilities and infrastructure at the disposal of the research center during their employment, giving firms easy access to scientific research activities and out- comes. This provides R&D resource-constrained local small and medium-sized enterprises (SMEs) (e.g., constrained in terms of human capital and

technological knowledge) with learning opportunities for upgrading their internal R&D capabilities and enhancing their absorptive capacity.

The universities can develop ties with Industrial Associations not only for internships but also for cooperation of PHD students with firms.

National potential – resources, actors and development opportunities

To facilitate conversion to a bio-based economy, it is necessary that various actors- universities, colleges and research institutes, as well as regions, municipalities and commerce collaborate, this may also require individual research, inter disciplinary research, trans disciplinary research projects where researchers and users collaborate and exchange knowledge.

Research and innovation strategies are jointly formed by regional and municipal authorities with commercial enterprises for more effective utilization of resources. The ability of colleges, universities etc. to act together with surrounding society and to be at the cutting edge in terms of knowledge is of great importance. Research institutes collaborate with Industry in several relevant projects for bio-economy development.

Other important actors in the area are *small innovation-driven companies,* which may be offshoots from universities and colleges. Another important role contextually is the *consumer* choice of goods and services in creating demand that can contribute to converting to a bio-economy.

RESEARCH AND DEVELOPMENT STRATEGY

A new approach that can promote the development of bioeconomy should consist of both long term and short-term plan. An important pre-requisite for this is the collaboration between state, commercial enterprise and research performers. An analysis of knowledge requirements of society is a good starting point to implement the existing plan. Based on this there is a need for focus of research, development and innovation initiatives across the entire biomass value chain starting from production, refining and consumption.

Achieving bio-based economy will require demonstration and innovation initiative measures besides research and development. Access to biomass material can be changed by improving access to new ecosystem for biomass production. Some of the areas that have the potential for improvement are:

- Marine and Aquatic systems – Sustainable production techniques development using aquatic animals.
- Enhancing green areas in the cities for improving urban environment for biomass production.
- Sustainable usage of peat- using better peat extraction methods, production and post processing technologies and consequence analysis.

NEED FOR COLLABORATION BETWEEN RESEARCH FUNDING BODIES AND RESEARCHERS

Implementing research and innovation strategy for bioeconomy needs collaboration. There should be distinct and clear division of roles and responsibilities. Using collaboration agreement is a more developed form of collaboration between agencies.

There are currently many different forms of collaboration between agencies. One is co-funded collaboration, where participants participate with other funding bodies. It uses strategic areas to coordinate investment. Creating synergistic effects in initiatives and following the concerted effects on bio-based economy. Existing framework of resources is applied to carry out the work but for any new major initiative additional resources are required.

It also needs to establish a user forum consisting of representatives of users like agencies, companies and community members and other national and international stakeholders.

LEADING THE STRATEGY

To be able to achieve change, all sectors comprising public, private, businesses and civil society must work together towards a vision. This requires a new model of leadership. Dynamic leadership model can be used for achieving strategic vision and goals where goal setting, implementation, evaluation and development are all carried out as a single process. During this process, initially a vision is defined. Subsequently, key areas where structure needs to be changed are identified simultaneously to reach the goal.

Figure 2. *The strategy's systemic and dynamic leadership model.*

Figure 20: Dynamic Leadership Model

The main characteristics of this strategy is the need to recognise barriers, conduct experiment and learn iteratively.

Following steps are part of strategic leadership model:

1. Preparation of an agenda for an action plan for implementing the strategy. A set of programs are needed to realize the goal. For each program, groups will be setup to implement steps towards change.

2. Extensive debate and publicity campaign is needed initially for the strategic work. This role is played by media and non-governmental organizations.

The first phase of reaching the goal will include identifying the necessary steps which include creating proposals concerning the actors who will implement the necessary change. Firstly, authorities should first bring the necessary actors who will act together to plan the development of projects and define who will participate in the work. Other listed actors should take part in implementation as described below:

a. **Bio-expertise and business activities:** Expertise on creating environmentally sustainable business activities that can produce high added value should be developed. Organic raw material sources should be identified.

b. **Biorefineries:** New techniques and Business Models for promoting utilization of diverse raw materials should be developed through regional networks. New logistic chains for biomaterial procurement and purification techniques should be developed and tested.

c. **Improving control over material cycle:** Systems should be devised to support the efficient material flow and methods and measures should be developed to express use of natural resources giving due consideration to logistic chain.

d. **Services based on non-material natural resources:** Services based on non-material natural resources and related innovation, marketing and business activities should be promoted. Knowledge base and business models should be developed to

support trade related to natural value, recreational amenity value should be developed.

e. **Interaction between rural areas and growth centers:** Awareness regarding the importance of rural natural resources at nation level should be improved. New Innovation potential and expertise should be created by promoting rural and growth centers interactions.

f. **International measures and rules:** The use of natural resource should be adopted as per international sustainability criteria and standards. Common international rules should be developed. Trade policies and other market-based mechanisms should be designed to integrate all the cost related to natural resource use. Common International rules should be developed.

g. **International Natural Resource Policies:** International natural resource policies that promote global sustainability, justice, security and a level playing field for business.

Administrative regulations, work-sharing, and co-operation: The ministries responsible for natural resource issues should assess the responsibilities of different administrative sectors, work sharing between different authorities so as to support natural resource strategy. Legislative and administrative barriers hindering development of bio-economy should be examined. The goals should be duly considered when new legislation is drafted. Use of natural resource should be planned with longer time frame at national and regional level.

h. **Natural resource accounting and economic incentives:** New models for evaluation that can combine natural resource accounting methods as part of national accounting system and assess environmental impacts within the national economy. Their

adoption should be tested at commercial and administrative levels. This strategy goal should be driven by economic incentives and revised taxation policy for everyday consumers.

i. **Forecasting and integrated expertise:** Networks forecasting natural resource issues should be developed. There is a need for collecting knowledge in this field and bringing together international expertise supporting natural resource strategy. Research and training should be organized around wider aspects of natural resource issues. Structural and institutional changes should be made and supported by networking and coordination. Network of expertise and strategic centers of science, technology and information focused on natural resource strategy and its goals should be encouraged.

j. **Training for decision makers:** Key decision makers should be trained within society covering natural resource issues on the basis of national strategy.

The Strategy can be formulated through wide ranging collaboration involving politicians, administrators, researchers, organizations, business representatives and media. To support transfer of information through seminars and through internet is necessary for strategic acquisition. Open Web based tools should be used for the creation of natural resource strategy that compiles respondent suggestions regarding issues to be addressed and how. Communications campaigns organized jointly by various sectors is also utilized.

F. Findings:

Agri-food companies	County name
Doherty Coleman Architects and Project Managers Limited	Mayo
Abbey Frozen Foods Limited	Sligo
Inishowen Frozen Foods Limited	Donegal
Yeats Country Foods Limited	Sligo
Taravale Foods Limited	Galway
Snack Sales Limited	Donegal
Iman Casings Ireland Limited	Mayo
Clare Foods Limited	Clare
B. & B. Foods Limited	Mayo
Persses Galway Whiskey Limited	Galway
L & N Fast Foods Limited	Galway
Bofey Quinn (Corofin) Limited	Clare
Country Cooking Co. Limited	Leitrim
Cuinneog Limited	Mayo
Bia Con Limited	Leitrim
Peaches and Cream Limited	Galway
A. & N. Tempany Limited	Sligo
The Clare Jam Company Limited	Clare

Doherty Fresh Food Shop Limited	Donegal
The Mid-West Food Safety Company Limited	Clare
Tom Freeman Agri-Services Limited	Galway
Roscrea Fresh Foods Limited	Mayo
Momentum Educate + Innovate Limited	Leitrim
City Villa (Galway) Limited	Galway
John Holmes Limited	Mayo
Aurivo https://www.aurivo.ie/	Sligo
Irish Nature and Hill Farmers Association (INHFA) http://inhfa.ie/work.html	Sligo
Ei Electronics https://www.eielectronics.com/	Clare
https://cls.ie/ complete Laboratory Solutions	Galway

Table 7: List of Agri-food companies in West Ireland Counties

Biotech	Location
https://slcontrols.com/industries/industries-technology/	Galway, Sligo
https://www.sigmarrecruitment.com/galway	Galway
https://www.frsrecruitment.com/office-locations/	Galway, Cork. Kilkenny

https://www.ttmhealthcare.ie/	Clare
https://www.arrotek.com/	Sligo
https://www.ie.abbott/about-us.html	Donegal, Sligo
https://www.lindalgroup.com/	Sligo
https://www.nordson.com/en/our-company/about-us	Roscommon

Table 8: List of BioTech Companies in West Ireland Counties

Innovation Centres in West Ireland – (Connectedhubs.ie)	Location
Arbutus Innovation Centre	Roscommon
The Spool Factory	Roscommon
Tulsk Digi-Hub	Roscommon
The Malbay Hub	Clare
The Kilrush Hub	Clare
The Kilkee Hub	Clare

The Business Hub	Donegal
CoWork Plus Stranorlar	Donegal
Mevagh Family Resource Centre	Donegal
Cill Charthaigh	Donegal
Ballinasloe Enterprise Centre	Galway
Beechtree Enterprise Centre	Galway
Forge Works	Galway
Galway Technology Centre	Galway
iHub Galway	Galway
NUI Galway Business Innovation Centre	Galway
Portershed	Galway
Future Cast Hub	Leitrim
Kinlough Hub	Leitrim

ManorHub	Leitrim
Mohill Enterprise Centre	Leitrim
The Hive	Leitrim
Bodhi Innovation Centre	Mayo
Cairn Enterprise Hub	Mayo
Leeson Enterprise Centre	Mayo
The Building Block	Sligo
The Hub @CMD group	Sligo
South Sligo Enterprise Centre	Sligo

Table 9: List of Innovation Centres in West Ireland Counties

6. Limitations of the study

Like any other research, this research has some limitations. Firstly, It is difficult to take into account all aspects of Bio-economy and Regional Innovation Systems. There could be other factors that

affect Regional Innovation Ecosystems other than those specified by the quadruple helix framework like international connections and others. We recommend that future research take into account other dimensions of Regional Innovation Ecosystems and further develop on this research.

Another aspect of considering all universities, Industries, government organization of nine counties cannot be completed in this study as it is difficult to find all universities and firms that might be working towards developing knowledge and performing research on bio-economy in active collaboration with Institutes and organizations outside the boundaries of West Ireland and even internationally. We recommend researching these international institutes that can be used to bring their knowledge on implementing Bio-economy and understanding their interaction mechanisms.

We conducted interview with a limited number of knowledgeable individuals. Although they are key representatives, but their view may differ on specific points from other representatives therefore, the information provided should be interpreted with care. To resolve this, further studies should be conducted using qualitative and quantitative analysis and collecting data on different countries that have already implemented similar bio-economy frameworks.

H. Conclusion:

The Strategy required for developing West Ireland Regional Innovation ecosystem should consist of following:

- Innovation
- International Expansion
- New West Ireland Project funding sources
- New ways of Marketing
- New ways of cooperation

VIII. Business Recommendations and Impacts:

Formation of clusters for Agri-food, Forest and Fishing sectors aimed at implementing cooperation with other EU countries or Ireland counties from East, North and other regions and partnerships, clusters and cross-sectoral cooperation. To accelerate the development of Agriculture Bio-economy, the aim of the cluster is to strengthen the capacity of the industry in an inter disciplinary way.

1. **Strategy:**
    a. **Innovation**
    b. **International Expansion**
    c. **New West Ireland Projects funding sources**
    d. **New ways of Marketing**
    e. **New ways of Cooperation**

2. Partnering the SMEs and Corporate Members from West Ireland counties with **MPowerBio** for seeking support on assessing investment readiness of SMEs. It will also provide

training for clusters across the bio economy, covering most of Europe through its online platform. It trains clusters and support SMEs. Also, Joining the **Irish Bio economy foundations** (bio-economyfoundation.com/bio economy-ventures/) project which aims to build the reference platform for bio economy-based startup and spin-offs seeking to gain access to finance and become the main meeting point in EU bio economy.

3. Need for the development of Digital Innovation Hub for Biomass value chain in West Ireland. The competence center should provide access to best knowledge, information and technology to integrate industries into biomass supply chain to lead the way towards more sustainable production of chemicals. It should bring together leading experts and support networks to develop the hub.

Action Plan:

The aim is to bring together maximum participants with a shared interest in a greener economy and facilitate networking, dialogue and partnership among the region's bio-based researchers, innovators and supply chain. Support with the development of an ecosystem for bio-based products, processes and services and promote the region nationally and internationally as a place to do bio-based business and R&D.

1. Building Community of Public and Private entities:

Building a community of 80-100 public and private entities (including institutes, research centers, companies and training institutes) that will share their ideas, skills, tools, resources to support sustainable development and transition to regional economy towards a system of reduced use of fossil energy sources, lesser impact on environment and favoring circular economy approach in supply chain. It aims to build a low carbon economy by promoting use of low carbon technologies and innovative solutions for increasing energy efficiency and support the development of renewable energy sources (electricity, thermal and biofuels) at regional level and their integration in climate change.

2. Need for Development Agency:

To develop a competent workforce as per the need of the labor market with a mission to develop models with concrete instruments and tools for improving business environment and developing a competitive economy by employing educated people in different sectors - general affairs, entrepreneurship support, development and project management sectors and departments- center for Investors and Business Competence centers.

3. Need for an Interdisciplinary Instrument:

For Agri-food bioeconomy, there is a need to bring together enterprises, local government administration, research and scientific institutes and business environment institutions from West Ireland and stimulate cross-sector, inter-cluster and international cooperation with the strategic goals outlined below:

1. **Need for integration** between science, business and administration by combining their potential by creating interrelationships supporting emergence of innovation.

2. Supported by Innovations it should be able to create competitive advantage for its members.

3. **Internationalization**- promoting international cooperation by helping to enter the foreign markets and supporting the members on the international level by development of export and networking.

4. **Identifying New Projects -** Need for cooperation amongst the members to solve the problems jointly and identifying new EU projects and sources of funding enabling development of its members.

5. **Marketing** - Supporting the activities through marketing for promotion and development of its activities.

4. Need for a digital transformation Hub:

Digital Innovation Hub that can bring together stakeholders in research, business and public for digital transformation in agriculture and marine sector. With a mission to create a smart and sustainable digital future for European agriculture and rural

areas and strengthen the national and technological infrastructure. Linking stakeholders with the initiative to provide support in research, development and tech innovations.

5. Need for Bioindustry Association:

Linking together the regional, national and European legislative bodies as well as the social organizations that are committed to using biotechnology to improve citizens quality of life, environmental sustainability, economic development and skilled job creation. Bringing together companies, associations, foundations, universities, technology and research centers that work in biotechnology in west Ireland.

6. SMEs/Cluster Needs:

Understanding needs of members

Transversal Competencies and skills

Understanding market trends in bio-based value chains.

SME assessment tools

Technology readiness levels by mapping innovation

Investment readiness of SMEs or cluster in relation to bio-based industry projects.

Train clusters and SMEs through online training modules and regional trainer's events to build capacity and give them best possibilities for preparing and presenting high quality projects to investors.

7. Need for Platform:

The platform that provides for the carrying out of the activities through working groups (WG) open to the participation of all interested parties.

The WGs work on the most important issues of the Regional Innovation Ecosystem, selected on the basis of suggestions from members of the platform.

1. Research and Knowledge transition amongst universities.
2. Technology Readiness of Industries.
3. Investment and funding from government.
4. Identifying Bio-based projects.
5. Policy and governance
6. Assessment Tools
7. Promotion and Communication
8. Training of working groups

Impact:

- As Ireland Bio-economic sectors have most of their inputs in Ireland and they employ relatively more people per unit of output, increase in sectoral sales especially their exports generate greater impact on the economy. Bioeconomy has a particularly deeper impact on rural jobs.

  Bio-economy Input Output Model (BIO) which is developed to assess the output and employment multipliers of public policy initiatives (a joint initiative by teagasc and NUI Galway) has given following tables and analysis for their macroeconomic Impacts for Dairy and aquaculture sectors for a proposed development:

- Base Case Scenario- €1.7 bn farm level investment resulted in total output increase of €4 bn
- Base case scenario delivers 31,466 jobs while base case+ scenario delivers 40,751 jobs.

- It is projected that expansion in sector would support direct and indirect employment of over 1600 people.

- With an overall economic impact of approx. €379 million per annum in wider fish economy.

IX. References:

Loet Leydesdorff , 2011, The Triple Helix, Quadruple Helix, ..., and an N-Tuple of Helices: Explanatory Models for Analysing the Knowledge-Based Economy?

Tévécia Ronzon * and Robert M'Barek , 2018, Socioeconomic Indicators to Monitor the EU's Bio-economy in Transition, Molecular Diversity Preservation International.

M.T. Johnsona,b,c, L.J. Johnsond,e, G.A. Bayliss-Brownf, V. Daninof, S. Daya, I. Dunnettg, J. Forsterh, et. Al., 2020, Vol 48, The Marine Knowledge Exchange Network: Insights from an Innovative Regional-to-National Scale Academic-Led Knowledge-to-Impact Network and Recommendations for Future Initiatives, 308-335, https://doi.org/10.1080/08920753.2020.1781513

Thierry Stadler[a,*], Jean-Marie Chauvet[b], 2018, New innovative ecosystems in France to develop the Bioeconomy , New BioTechnology, 113-118, http://dx.doi.org/10.1016/j.nbt.2017.07.009

Stefanie Linser 1,2,* and Markus Lier 3 , Apr 2020, The Contribution of Sustainable Development Goals and Forest-Related Indicators to National Bioeconomy Progress Monitoring, sustainability, mdpi.com

Elias G. Carayannis1, Evangelos Grigoroudis2 ,et. Al, 2017, The ecosystem as helix: an exploratory theory-building study of regional co-opetitive entrepreneurial ecosystems as Quadruple/Quintuple Helix Innovation Models, R&D management

Nina Hasche, Linda Höglund & Gabriel Linton, Quadruple helix as a network of relationships: creating value within a Swedish regional innovation system, Journal of Small Business & Entrepreneurship, https://www.tandfonline.com/loi/rsbe20

Yong Kyu Lew1, Zaheer Khan2 and Sara Cozzio3, Gravitating toward the quadruple helix: international connections for the enhancement of a regional innovation system in Northeast Italy, R&D Management

Linda H€oglund1 and Gabriel Linton2, 2017, Smart specialization in regional innovation systems: a quadruple helix perspective , R&D Management

Sara Tsog, Johanna Haunschild[1] and Ronald Orth et. Al, 2018, Towards Sustainable Evolution of Bioeconomy: The Role of Technology and Innovation Management

Mariusz Sołtysik 1, Maria Urbaniec ,2019, Innovation for Sustainable Entrepreneurship: Empirical Evidence from the Bioeconomy Sector in Poland, mdpi.com

Stefanie Linser [1,2,*] and Markus Lier [3] , 2020, The Contribution of Sustainable Development Goals and Forest-Related Indicators to National Bioeconomy Progress Monitoring, mdpi.com

Matteo de Besi and Kes McCormick, Towards a Bioeconomy in Europe: National, Regional and Industrial Strategies, 2015, sustainability, mdpi.com

Rick Bosman * and Jan Rotmans , Oct 2016, Transition Governance towards a Bioeconomy: A Comparison of Finland and The Netherlands, sustainability, MDPI

Lillian Hansen * and Hilde Bjørkhaug, Feb 2017, Visions and Expectations for the Norwegian Bioeconomy, sustainability, MDPI.com

Tévécia Ronzon * and Robert M'Barek, May 2018, Socioeconomic Indicators to Monitor the EU's Bioeconomy in Transition, sustainability, MDPI.com

National Policy Statement on the Bioeconomy, Government of Ireland

Needs and challenges of companies in the bioeconomy in NW Europe , European Regional Development Fund, http://www.biobasenwe.org/media/96429/BBNWE-analysis-report-on-bottlenecks-SMEs- encounter-in-bioeconomy_final.pdf

Jaana Korhonen [1,2,*], Alexandru Giurca [3], Maria Brockhaus , Actors and Politics in Finland's Forest-Based Bioeconomy Network, sustainability, mdpi.com

Anneli Ylimartimo, JAMK University of Applied Sciences, Tarvaala, Finland, 2018, Case study on Bioeconomy Campus, Central Finland, john wiley and sons ltd

*Virginija Kargytė[1], Rando Värnik[2], Vilija Aleknevičienė[3] , 2018, ASSESSMENT OF BIOECONOMY DEVELOPMENT POTENTIAL FROM THE PERSPECTIVE OF INNOVATION ECONOMICS IN EUROPEAN REGIONS, 492-513, Management Theory and Studies for Rural Business and Infrastructure Development

Louise Staffas 1,*, Mathias Gustavsson 2 and Kes McCormick 3 , 2013, Strategies and Policies for the Bioeconomy and Bio-Based Economy: An Analysis of Official National Approaches, http://www.mdpi.com/journal/sustainability

Matteo de Besi and Kes McCormick * , 2015, Towards a Bioeconomy in Europe: National, Regional and Industrial Strategies , http://www.mdpi.com/journal/sustainability

A. Bibliography:

Forest Research Ireland (FORI) - A Strategic Agenda for Forest Research in Ireland ,2014 Department of Agriculture, Food and the Marine

Growing the Irish Bioeconomy, COFORD, COFORD Bioeconomy Report 2017-2018

Developing the Green Economy in Ireland- Key Actions, 2012, Report of the high level group on Green Enterprise

Department of the Environment, Climate and Communication, gov.ie, Whole of Government Circular Economy Strategy 2021-2022, Government of Ireland

A natural resource strategy for Finland, Using natural resources intelligently- A vision for 2030

Other Links Utilized for Research:
https://www.mria.ie
https://emff.marine.ie/marine-biodiversity/baseline-habitat-and-biodiversity-information
https://www.iooa.ie/irelands-offshore/#the-irish-offshore-seabed
https://marine-ireland.ie/directory?field_sectors_target_id=All&field_categories_target_id=67
https://www.bbi.europa.eu/projects?field_project_year_tid=All&field_project_category_tid=All&field_project_classification_tid=All&combine=
https://www.iffpa.ie
https://www.enterprise-ireland.com/en/events/associated-events/bioconnect-ireland.html
https://www.knowledgetransferireland.com/Research_in_Ireland/Research-Map-of-Ireland/

B. Appendices:

1. Appendix A – Marine Org and Institutes:

1	**Marine Projects**	SFI and Marine Institute to co-fund Project **Blue-Bio-economy**		
2	Marine Institute	Department of Agriculture, food and Marine		
3	Research Areas	Marine Biotechnology and aqua food		

4	Ocean Wealth Summit Partners	PWC	Ireland's EU structural and Investment funds programs- 2014-2020 European Maritime and Fisheries Fund Department of Agriculture, food and Marine Department of foreign affairs and trade BIM Ireland's seafood development Agency Enterprise Ireland Marine Institute Cork Chamber Cork city council SEAFEST	

5	Irish Marine SMEs Marine Biotechnology and Bio product		SME Directory: https://marine-ireland.ie/directory?field_sectors_target_id=36&field_categories_target_id=All **AquaTT - http://www.aquatt.ie/** **Bantry Marine Research Station - http://www.bmrs.ie/** **Bio-marine Ingredients Ireland Ltd - http://www.biomarine.ie/** **Capstone Business Advisors Ltd - https://www.capstonedublin.com/** **CyberColloids Ltd. - http://www.cybercolloids.net/**	

			Dolmen Design and Innovation - http://www.dolmen.ie/ **ERINN Innovation - https://www.erinn.eu/** **Flagship Management – http://www.flagshipmgt.com/about-us/** **FRKELLY – https://www.frkelly.com/** **La Tene Maps - http://www.latenemaps.com/**	

6	Marine Organizations -Ireland	**Marine Renewable Energy Association** Volvo ocean race Offshore Oil and Gas Association European commission	https://www.mria.ie https://www.theoceanrace.com/en/sustainability.html https://www.iooa.ie/irelands-offshore/#the-irish-offshore-seabed https://ec.europa.eu/info/research-and-innovation_en	

7	Marine Organizations -Ireland	IBM Ireland BlueWise Marine	https://www.ibm.com/ibm/history/ibm100/us/en/icons/smarterwater/ https://bluewisemarine.ie Bluewise Marine is GMIT Institute clients. It supports development, management and promotion of marine and offshore renewable projects and initiatives.	

8	Government department and other agencies	Department of Agriculture, Food and the Marine (DAFM) Marine Survey Office (MSO) Bord Iascaigh Mhara (BIM) Sea Fisheries Protection Authority (SFPA) Marine Institute (MI) International Council for Exploration of the Sea (ICES) International Commission for the Conservation of the Atlantic Tuna (ICCAT) European Union (EU) Directorate General Fisheries of the European Commission (DG MARE) Irish Offshore Operator's Association (IOOA) Intrafish The Skipper Marine Times Inshore Ireland	https://www.agriculture.gov.ie http://www.transport.ie/maritime/contacts/marine-survey-office http://www.bim.ie https://www.sfpa.ie http://www.marine.ie https://www.ices.dk http://www.iccat.es http://www.europa.eu.int http://www.europa.eu.int/fisheries	

		Enterprise Ireland IDA Ireland **Údarás na Gaeltachta**	http://www.iooa.ie http://www.intrafish.com https://theskipper.ie https://www.marinetimes.ie https://inshore-ireland.com https://www.enterprise-ireland.com/en/ http://www.idaireland.com/ http://www.udaras.ie/	

9	Academia- Ireland Sea Bio-economy contributor-knowledge sharing	National Maritime college of Ireland	https://www.nmci.ie/commercial	
10	SFI Research Centre for Energy, Climate and Marine Research and Innovation.		https://www.marei.ie Blue Economy Project Host Institute: University college cork, Ireland Partner Institute: DCU(Dublin city university), DIAS(Dublin Institute for Advance Studies), DUNDALK-Institute of Technology, ESRI, NUI-Maynooth, Munster Technological university, NUI Galway, Trinity College Dublin, Technological university Dublin, Tyndall National Institute, UCD Dublin, University of Limerick	

Appendix A: Marine Institutes , Research centres and Projects

2. Appendix B: Interviews

INTERVIEW QUESTIONS LIST 1:

1. Role of provincial government in innovation.
2. Provincial-level innovation policy
3. Support for local firms
4. Role of intermediary research organizations, R&D centers, role of universities in the region.
5. University-Industry linkages and innovation performance, public and private collaborations for Innovation
6. Specific incentives for firms to attend international events.

INTERVIEW QUESTIONS LIST 2:

Bioeconomy Clusters in the region: universities, Institutes, and other entities involved?

Industrial R&D in Bioeconomy?

- How is University Bioeconomy research **financed/funded** by the provincial government?
- Bioeconomy Project Example and mechanism of Interactions?
- Is there any **support for international networking** of firms by the government? Any compensation for the cost of participation in international trade fairs or overseas commercial events.
- Any **additional compensation** by provisional government like cost of international marketing, consulting service fee, business analysis, human resource development and hiring of new graduates in universities.
- Any support from **provisional government** in the development of **innovation culture.**
- Funding's for both academic and private sector level by the public sector.

- West Ireland Universities that help in the **mobility of PHD students in EU through projects** like Marie Curie or any other projects.
- Bioeconomy PHD programs for student's association with the firms.

PROFILES OF INTERVIEWS CONTACTED:

Type	Job Title
Provincial Government	- Head of department of knowledge for west Ireland - Director of Innovation and Development Department – provincial government agency
Regional Firm	- CEO of a cluster, comprising of multiple firms
University/Research center	- Head of scientific research and transfer of technology of NUI Galway/Mayo Institute - Director of the technological unit of a regional research center

SAMPLE INTERVIEW TRANSCRIPT:

- What are your opinions about the bioeconomy and MaREI role in it? MaREI is the national centre for research and innovation in the broad thematic areas of Energy, Climate and the Blue Economy. The bioeconomy is very significant generally in terms of sustainability, of key importance to MaREI. The bioeconomy is very significant to specific

research areas like Coastal and Marine Systems/ advanced fuels in the circular economy.

- Clusters in the region: Universities, institutes and other entities involved? Irish Bioeconomy Foundation (UCD, MTU, UCC and others involved) Circular Bioeconomy South West Cluster (MTU)
- Industrial R&D? MaREI has 75 industry partners involved in collaborative research across a range of areas
- How does the government fund the research? MaREI is government funded through Science Foundation Ireland and non-exchequer funded through industry partnerships
- Support for international networking of firms by the govt? Clusters are typically at least part funded through government sources. International networking happens through clusters and also through government organisations like Enterprise Ireland https://www.enterprise-ireland.com/en/
- Govt role in innovation culture? Enterprise Ireland is the government agency tasked with supporting the creating of jobs and generating exports out of Ireland. It supports numerous programmes that foster an innovation culture. Science Foundation Ireland fund significant research.
- How are marine-related start-ups supported? I am the National Marine Incubation Manager, funded by Enterprise Ireland, and tasked with supporting all Marine/ Maritime/ Blue Tech start ups in Ireland. I provide start ups with one to one support on their journey and make introductions to the various other supports available to start ups in Ireland and beyond – through organisations like the Local Enterprise Offices, Enterprise Ireland, Intertrade Ireland, European Innovation Council, Horizon Europe Programme, Green Deal etc.
- How does MaREI plan on increasing the knowledge of the local people and the SME's? Employment roles for the locals? MaREI places

significant emphasis on Public Engagement activities to deliver both economic and social impacts locally https://www.marei.ie/empowering-society/education-and-outreach/

- What are the challenges faced dealing with the locals? See above
- Is there any such platform available for organisations to interact with? See above