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Policy Coherence and the Transition to a Bioeconomy: The Case of Ireland

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Abstract: Advancing a bioeconomy requires that policymakers understand how the design and coherence of public policy can contribute, or create barriers, to its development. Ireland's first National Policy Statement on the Bioeconomy (February 2018) recognized the significance of policy coherence as a critical factor in a successful transition to a bioeconomy. Qualitative document analysis was employed to assess the level of coherence across a range of relevant policy documents. As is the case with most other countries the key sub-sectors related to the bioeconomy in Ireland have independent policy documents for their own developmental process, with obvious potential for conflict. The results of the analysis indicated inconsistency across sectors, highlighting the requirement to update certain strategy documents in order to raise the level of cross-sectoral coherence. This process is essential in both avoiding a 'silo' mentality and enabling the concept of the bioeconomy and its associated objectives to become mainstreamed. The methodology employed in this research is easily transferable and should prove useful for other countries in transition to a bioeconomy to assess the strengths and weaknesses of relevant documents and identify where change is required.

Keywords: bioeconomy; policy coherence; policy alignment; transition

1. Introduction

The economic, social and environmental challenges associated with climate change and the role played by a dependency on fossil resources are global in scope. Finite natural resources will result in heightened competition for the use of such resources in the decades ahead. A new economic model that recognizes the environmental damage caused by continued consumption of dwindling fossil-based resources is necessary [1]. New production methods involving alternatives to fossil-based fuels and derivatives are required; the innovative use of bioresources in what is termed the bioeconomy or bio-based economy has a pivotal role in any transition to a low carbon economy [2,3].

A conclusive definition of the bioeconomy has not yet been established [4]. However, there is a growing body of both policy literature and academic research that has attempted to provide greater clarity to this concept [5–7]. In February 2012, the European Commission (EC) launched its first bioeconomy strategy and action plan. It provided a broad context for the bioeconomy, which included "the production of renewable biological resources and the conversion of these resources and waste streams into value added products, such as food, feed, bio-based products and bioenergy" (p. 9) [8]. This strategy was updated in October 2018 with the bioeconomy defined as covering "all sectors and systems that rely on biological resources (animals, plants, micro-organisms and derived biomass,

including organic waste), their functions and principles" (p. 4) [9]. It includes and interlinks not only the agriculture and food industries but also extends to forestry, fisheries and aquaculture as well parts of the chemical, biotechnological and energy industries [9].

Bugge et al. [10] undertook an extensive literature review in an attempt to define the bioeconomy. Their findings presented an understanding of the concept as multi-faceted in terms of origins and sectors and also in terms of its underlying values and drivers. Their frequently cited review resulted in the delineation of three visions of the bioeconomy: a bio-technology vision that highlights the importance of biotechnology research and its application across different sectors; a bio-resource vision that focuses on the development of new value chains that process and upgrade biological raw material; and a bio-ecology vision that highlights sustainability and ecological processes. In addition, the bioeconomy has been presented as an all embracing multi-sectoral sustainable solution to a range of societal problems across Europe, in particular food security, natural resource security, fossil resource dependence and climate change [8].

The complexity of the bioeconomy in turn means that it is particularly challenging from a policy perspective [11]. Its development is dependent on efforts across a spectrum of policy spheres [12]. Indeed, while the transition to a bioeconomy presents advantages and opportunities, [9] it is not necessarily sustainable [13,14]. There are inherent risks that should be considered in developing relevant policies [15,16]. A central issue is the trade-offs necessary to mitigate conflict that might arise between relevant policies [17]. Another issue is the need for policy makers to be cognizant not only of developing a bioeconomy but also maintaining a sustainable balance in terms of issues such as biodiversity loss, deforestation and labor migration [18]. Appropriate policy development and regulation is therefore central to the achievement of a successful process of transition across the spectrum of sectors related to the bioeconomy.

The 2012 EC Bioeconomy Strategy was structured around three pillars: investments in research, innovation and skills; enhancement of markets and competitiveness; and reinforced policy co-ordination and stakeholder engagement. A 2017 EC review found that significant achievements had been completed particularly in terms of research and innovation. However, it indicated that a greater level of policy co-ordination and stakeholder engagement is still required [12]. The requirement of greater policy coherence among relevant sectors was highlighted in the updated EC Bioeconomy Strategy of October 2018. Advancing a bioeconomy requires that policymakers understand how the design and coherence of public policy can contribute, or create barriers, to the development of a bio-based market in the wider economy [9,13]. This paper contributes to this awareness in the context of one nation state—Ireland—by exploring the degrees to which there is coherence between sectoral strategies that impact on the bioeconomy in Ireland.

2. The Bioeconomy in Ireland

Ireland's first National Policy Statement on the Bioeconomy (NPSB) was released in February 2018. Prior to its publication there had been increasing political attention to development of the bioeconomy, evidenced through the establishment of a bioeconomy Inter-Departmental Group at the government level and specific mention of bioeconomic related opportunities in a range of national plans and strategies (2016 National Action Plan for Jobs; 2017 National Mitigation Plan for decarbonization; 2017 National Action Plan for Rural Development) [19]. Although not a pioneer in terms of bioeconomy strategy development, lessons learned from experience elsewhere meant that the significance of policy coherence and effectiveness was recognized as critical in the design of the NPSB [19]. Based on a global review of country-specific characteristics Ireland was recently categorized as having a high-tech bioeconomy [14].

The political importance of a transition to a bioeconomy in Ireland is highlighted in the Taoiseach's (Prime Minister) foreword to the NPSB in which he identified as a central concern not only the promotion of more efficient use of renewable resources but the necessity of supporting economic development and employment in rural Ireland [20].

The document outlines the potential of the bioeconomy in Ireland through four Strategic Policy Objectives (SPOs). A summary of each SPO and its potential benefits is provided in Table 1.

Table 1. Ireland National Bioeconomy Statement Policy Objectives (SPOs) and potential benefits.

Objective 1: A sustainable economy and society—envisions the growth of the bioeconomy as a pathway towards putting Ireland's economy on a more sustainable footing by more efficient use and re-use of resources and materials.
Objective 2: Decarbonization of the economy—sees the crucial role of the bioeconomy in helping, to lower greenhouse gas emissions by more efficient innovatory practices in agriculture and forestry. Bio-based alternatives can replace carbon intensive products such as concrete, steel and plastics.
Objective 3: Jobs and competitiveness—given that many of the inputs for the bioeconomy are sourced in Ireland, its development has distinct advantages over other economic areas that are more import reliant. The looming spectre of Brexit and its threat, particularly to Ireland's agri-food and marine sectors, means that the opportunities for diversification provided by expanding the bioeconomy could not be more inviting.
Objective 4: Creation of regional prosperity—as many of the businesses associated with development of the bioeconomy are located in rural and coastal areas, which are in great need of an injection of new vigor and economic growth. Any expansion of knowledge workers locating to the countryside will have obvious economic benefits.

Source: Government of Ireland, 2018.

Although the NPSB stresses Ireland's natural advantages as an actor in the European bioeconomy (such as its fertile soil and one of the largest seabed territories in Europe) it does not present specific targets for the Irish bioeconomy. However, it does delineate seven key actions designed to help deliver a successful bioeconomy. Table 2 illustrates how the seven key actions are structured around the three pillars stated in the EC 2012 Strategy.

Currently, the key sub-sectors related to the bioeconomy in Ireland have independent policy documents for their own developmental process with obvious potential for conflict. Being aware of the strengths and weaknesses of these documents in relation to the transition to a bioeconomy may identify where change is required, in addition to providing nuanced information about each document [21]. Accordingly, this paper reports on the findings of a qualitative document analysis (QDA) based on three clear objectives:

1. To identify the nature and extent of awareness of the bioeconomy process across sectoral documents that impact on the bioeconomy in Ireland;
2. To assess the current level of coherence between relevant sectoral objectives and the Strategic Policy Objectives of the National Policy Statement on the Bioeconomy;
3. To assess current policy coherence across sectoral documents that impact on the bioeconomy in Ireland.

The remainder of this paper is structured as follows. Section 3 discusses different definitions of policy coherence in the literature, highlighting key conceptual frameworks for its analysis. Section 4 presents a rationale for the methodology employed in this study. It goes on to specify three key questions for research and the policy documents selected for inclusion in the analysis. Sections 5 and 6 provide results and discussions of the policy coherence analysis. The final section outlines key limitations and scope for further study.

Table 2. Summary of key actions in Ireland's National Policy Statement on the Bioeconomy and related EU Bioeconomy Strategic Pillars.

Key Actions in Ireland's National Policy Statement on the Bioeconomy (2018)	EC Bioeconomy Strategy—Strategic Pillars (2012)
1. Ensure that there is coherence between all sectoral strategies that impact on the bioeconomy.	Reinforced policy co-ordination and stakeholder engagement
2. Establish a network comprised of representatives of commercial entities operating within the bio-economy and relevant public bodies to inform the future development of the bioeconomy.	Enhancement of markets and competitiveness
3. Encourage the translation of research into real world applications through promoting collaboration between research institutions (academia) and industry.	Investment in research, innovation and skills
4. Assess the current legislative definition of waste and recommend whether a redesignation is necessary for residual waste flows to be successfully managed for use in the bioeconomy.	Reinforced policy co-ordination and stakeholder engagement
5. Ensure greater sectoral coherence within the bioeconomy through the development of risk assessment and management protocols regarding the use of by-products.	Reinforced policy co-ordination and stakeholder engagement
6. Progress the leading value chain propositions identified in the Bio-Eire project by establishing the conditions required for their commercial viability.	Enhancement of markets and competitiveness
7. Examine how greater primary producer, public and consumer awareness of the bioeconomy and its products could be built up.	Enhancement of markets and competitiveness

Sources: EC, 2012; Government of Ireland, 2018.

3. Policy Coherence: Definitions and Measurement

Similar to the bioeconomy, there has been a growing body of research on policy coherence, which has contributed to an evolving range of definitions of the concept [22]. Gauttier [23] stressed the central importance of the achievement of a synergy between policies, while May et al. [24] considered it a relative term that relates to the degree of integration of relevant components.

In broad terms, policy coherence should provide better efficiency and reduce competition for budgets and resources [25]. Policy incoherence can arise as a result of conflict between legitimate interests and inadequate awareness of the wider effects of policy decisions [26]. More recent research undertaken assessing policy coherence from the perspective of climate change policy integration has asserted the need for governments "to actively embrace longer term cross-sectoral planning … to foster greater policy coherence" (p. 1) [27].

A number of conceptual frameworks have been developed to measure policy coherence. Analysis of policy coherence can be undertaken both vertically and horizontally. The former refers to coherence between different levels of government [28]. The latter refers to coherence between policy areas across one level [29].

The significance of coherence in the design, objectives, implementation and outcomes of policies is recognized by Nilsson et al. [29]. They also identify that as public policies seek to address specific, concrete problems, officials tend to focus on the impact of a given policy, perhaps without consideration of other external effects. As Cejudo and Michel [30] point out " … it may erroneously be assumed that a series of well-designed and properly implemented public policies is equivalent to a set of complementary and self-reinforcing policies that are able to jointly address complex problems" (p. 755). They go on to outline an approach by which policy makers could bring about coherence between a set of policies developed in an attempt to solve multi-faceted problems. Similar to Nilsson et al. [29], they refer to coherence in terms of policies' objectives and instruments. Huttunen et al. [31] also assert that policy coherence requires consistency between goals, instruments and implementation procedures in order to promote synergies, and also to mitigate conflicts, between and within different sectors, in order to achieve intended objectives.

Despite a number of articles addressing the bioeconomy concept from the perspective of policy strategy [15,32,33] and policy discourse [34,35] there has been limited application of analysis specifically related to policy coherence. Previous relevant studies have included assessment of policy coherence from the perspective of bio-gas production [31], forest based bio-energy [36] and of environmental and climate policies, e.g., [29,37]. A common theme across each of the studies has been a top-down assessment of the interaction of policies within policy domains from policy objectives to measures and implementation. A caveat regarding the 'top-down' nature of the approach advocated by Nilsson et al. [29] is expressed by Huttunen et al. [31] who advocates a more 'bottom-up' perspective with the perceptions of local and regional actors introduced to the process of establishing policy coherence.

4. Methodology

This research utilized a case-study approach in order to assess the level of coherence across a range of policy documents impacting the transition to a bioeconomy in Ireland. To achieve this a horizontal-level policy coherence analysis of relevant sectoral strategy documents from the Irish state's Department of Agriculture, Food and the Marine (DAFM) was undertaken. Case studies are a method that provides for depth rather than breadth in research, and enables researchers to examine data at the micro level [38]. They are a useful tool for research at the preliminary stage [39,40] and have been used previously in studies related to the bioeconomy within a number of countries [41–43]. Despite a number of recognized limitations to the case study method [44], particularly the caveat that they can sometimes provide little basis for generalization [45], the lessons learnt from this particular research should prove transferable to the many regions across Europe that have recently or are currently in the process of developing their own bioeconomy policy statements or strategies.

The DAFM was chosen as the case study due to its pivotal role in the transition to a bioeconomy in Ireland. In 2015, the DAFM funded the BioEire project, which was responsible for evaluating growth opportunities, policies and initiatives in Ireland's transition to a bioeconomy. The findings were used as a knowledge base in the development of the NPSB. DAFM also continues to co-chair the Government mandated Bioeconomy Implementation Group and the declared mission of the department to lead the sustainable development of a competitive, consumer focused agri-food sector and to contribute to a vibrant rural economy and society is in close alignment with the Strategic Policy Objectives (SPO) outlined in the NPSB (see Table 1).

In order to establish robust analysis of the relevant policy documents a qualitative document analysis (QDA) was adopted. QDA systematically analyzes the meaning and implications of text in relevant documents rather than simply the presence of key words [27,46,47]. Our approach examined the meaning and implications of relevant sections of documents and utilized a subjective scoring system in a top-down assessment [29]. We systematically analyzed the level of awareness and coherence between the policy documents across three research questions:

(i) Research Question 1: To what extent does each policy document take account of the bioeconomy and related key bio-concepts;
(ii) Research Question 2: What is the level of coherence between each sectoral policy document and the four Strategic Policy Objectives of the Irish Bioeconomy National Statement;
(iii) Research Question 3: What is the level of coherence between each of the sectoral policy documents and other sectors related to the bioeconomy in Ireland.

The results could provide insights into the objectives and policy measures currently implemented by each sector and act as a platform for important discussion as Ireland transitions to a bioeconomy.

A limitation of the case study approach can be a perceived lack of rigor [45]. In this research several clearly defined stages were incorporated into the process to improve both rigor and consistency. Table 3 provides a methodological summary guide to the process involved in completing this research. Each of the steps is described in detail below.

Table 3. Methodological summary guide.

(a)	Setting criteria for the selection of documents;
(b)	Obtaining documents;
(c)	Analyzing the documents;
(d)	Synthesizing the results.

4.1. Selecting and Obtaining Documents

The key criteria in the selection of documents were: those sectors within the DAFM which were most relevant; the nature of the documents to be analyzed; and the publication dates for the documents.

Key sectors contained within the DAFM were identified from the NPSB. Contact was then made with the Bioeconomy Implementation Group to identify the most relevant sectoral policy documents for analysis. Following a meeting with DAFM the documents were agreed on and supplied.

It was also decided to include the Irish Government's new overarching national spatial and economic development plan, Project Ireland 2040, in the analysis. This was included in order to assess the levels of coherence and awareness of the bioeconomy inherent in the Government's overall vision for the future.

Project 2040 was launched in February 2018, the same month as the NPSB. The key aim of this overarching policy initiative is to improve the country's long-term economic, environmental and social progress through the attainment of ten strategic outcomes, which substantively aligned with the bioeconomy SPOs. This initiative is comprised of two key complementary documents: National Development Plan (NDP), a 10-year €116 billion capital investment plan; and a new National Planning Framework (NPF). Both Project 2040 documents were downloaded from the project website (https://www.gov.ie/en/collection/580a9d-project-2040-documents/).

Table 4 details the final documents selected for analysis. The dates of publication of each document are detailed to enable a chronology of policy development as recommended by England et al. [27].

Table 4. Policy documents selected for analysis.

Document Title	Sector	Year Published
Forest Research Ireland (FORI)	Forestry	May 2012
Harnessing our Ocean Wealth (HOW)	Marine	July 2012
Food Wise 2025 (FW)	Food	July 2015
National Farmed Animal Health Strategy (NFAHS)	Agriculture	July 2017
National Development Plan 2018-2027	Project Ireland 2040	February 2018
National Planning Framework	Project Ireland 2040	February 2018

4.2. Analysis of Selected Document

Each policy document was then systematically analyzed in line with methodological guidance, using a three-stage approach combining elements of content analysis and thematic analysis [27,48,49]. Content analysis in the context of this research refers to the process of identifying and collating meaningful sections of text in each policy document, containing specific key words and terms; thematic analysis was used to assess the emergence of more implicit themes within and between the policy documents. General scoring criteria to assess research question specific levels of coherence ranging from 0 (no coherence) to 3 (high coherence) were employed at each stage (see Table 5). The three stages of analysis are discussed in detail below. For the purpose of this research each document was given equal weight during analysis.

Table 5. General scoring criteria to assess level of coherence (adapted from Le Gouais and Wach 2013; England et al., 2018 [21,27]).

High Coherence = 3	Policy document aligns strongly with relevant "Bio-Concept", "Strategic Policy Objective" or "Sector". Includes a range of detailed associated measures in order to achieve coherence.
Partial coherence = 2	Policy document supports alignment with relevant "Bio-Concept", "Strategic Policy Objective" or "Sector". Limited details on associated measures provided. it is less clear and distinct as to how coherence could be achieved.
Limited coherence = 1	Policy document recognizes "Bio-Concept", "Strategic Policy Objective" or "Sector" (particularly in the form of general statements). No details on associated measures are provided.
No coherence = 0	No evidence of co-ordination or alignment

In Stage 1 each of the policy documents was assessed to establish both awareness of the bioeconomy and related key bio-concepts and the extent to which relevant measures were detailed. This involved a directed content analysis, i.e., developing a coding scheme prior to beginning to analyze the documents. Taking into account the diversity of the term in different countries [12] in order to identify key concepts and terms related to the bioeconomy in Ireland, the National Statement on the Bioeconomy was reviewed in detail. This led to identification of a series of key bio-concepts specific to the bioeconomy in Ireland (See Table 6).

Table 6. Key bio-concepts identified from National Policy Statement on the Bioeconomy.

Bioeconomy	Biotechnology
Bioresources	Biodiversity
Biomass	Bioenergy
Biofuels	Biomaterial
Biodegradable	Biobase
Biopharmaceutical	Bioprocessing

Nvivo software was used to identify each of the bio-concept terms within the policy documents. Total mentions were recorded and used as an initial basic indication of awareness. Each mention was assessed based on the content of the sentence or paragraph in which they were included, providing sector-specific background context and insights. Utilizing a categorization matrix [50], a qualitative score was applied to the level of coherence, ranging from 3 (high coherence) to 0 (no coherence) for each policy document in relation to awareness of each of the 12 bio-concepts and extent of relevant measures (see Table 7). For example, a document demonstrating both a high level of awareness in terms of bioeconomy mentions and in addition specific measures related to the bioeconomy was seen as exhibiting 'high coherence' in relation to the bioeconomy, while a document showing awareness of the bioeconomy but no measures was seen as exhibiting 'limited coherence'. An average coherence score was generated for each policy document (see Table 7).

Table 7. Coherence of policy documents with the bioeconomy and related key bio-concepts (coherence score 0–3).

	Forest Research Ireland (FORI) 2012	Harnessing our Ocean Wealth (HOW) 2012	Food Wise 2025 (FW) 2015	National Farmed Animal Health Strategy (NFAHS) 2017	Project Ireland 2040 (NDP and NPF) 2018
Bioeconomy	24 Mentions (2)	0 Mentions (0)	2 Mentions (1)	0 Mentions (0)	3 Mentions (1)
Biotechnology	1 Mention (0)	12 Mentions (2)	5 Mentions (2)	1 Mention (1)	3 Mentions (1)
Bioresources	1 Mention (1)	0 Mentions (0)	0 Mentions (0)	0 Mentions (0)	0 Mentions (0)
Biodiversity	13 Mentions (2)	8 Mentions (3)	12 Mentions (3)	0 Mentions (0)	26 Mentions (3)
Biomass	16 Mentions (3)	0 Mentions (0)	5 Mentions (1)	0 Mentions (0)	12 Mentions (2)
Bioenergy	5 Mentions (1)	0 Mentions (0)	3 Mentions (2)	0 Mentions (0)	3 Mentions (2)
Biofuels	1 Mention (1)	0 Mentions (0)	0 Mentions (0)	0 Mentions (0)	0 Mentions (0)
Mean Score	1.42	0.71	1.14	0.14	1.14

Biodegradable, Biomaterial, Biobase, Biopharmaceutical and Bioprocessing were also included in the analysis but received no explicit mention in any of the sectoral policy documents and were therefore omitted from Table 7. Scoring criteria to assess level of coherence (adapted from Le Gouais and Wach 2013; England et al. [21,27]). High coherence = 3: the policy document exhibits a high level of awareness of bio-concept. Policy document devotes specific attention to bio-concept. It includes numerous and detailed complementary measures. Partial coherence = 2: the policy document shows general awareness of bio-concept. Although acknowledging its importance there are limited details and measures included within the policy document. Limited coherence = 1: the policy document recognizes the bio-concept. No details on associated measures are provided. No coherence = 0: there is no evidence in the policy to suggest awareness of the bio-concept.

The second stage also involved a directed content analysis to assess the level of coherence of each policy document in relation to the four Strategic Policy Objectives (SPOs) stated in the NPSB (see Table 1). In this case a thematic framework for analysis of the policy documents was generated by using the four SPOs (sustainable economy and society; decarbonization of the economy; jobs and competitiveness; and regional prosperity) as themes. Each policy document was then thematically coded in Nvivo based on the rules outlined in Table 8. Careful reading of each document was required to determine how closely each policy document aligned either explicitly or implicitly with each theme. Again a categorization matrix was generated and a qualitative score was applied to the level of coherence, ranging from 3 (high coherence) to 0 (no coherence) for each policy document in relation to alignment with each of the SPOs and extent of related measures to achieve it (see Table 7). For example, a document demonstrating a clear alignment with regional prosperity and in addition outlining specific measures to achieve it was seen as exhibiting 'high coherence' in relation to that SPO while a document that supported the aspirations of regional prosperity but contained no measures was seen as exhibiting 'limited coherence'. An average coherence score was generated for each policy document (see Table 9).

Table 8. Sub-themes and coding rules.

Jobs and competitiveness	Focus on opportunities for diversification provided by the expansion of the bioeconomy.
Regional prosperity	Focus on the role of the bioeconomy in contributing to innovative development and economic growth in rural and coastal areas.
Sustainable economy and society	Focus on the significance of development of the bioeconomy as a means by which Ireland's national economy can be established on a more sustainable platform.
Decarbonization of the economy	Focus on efficient, innovatory practices by which the bioeconomy can lower greenhouse gas emissions, and also the role of bio-based alternatives to carbon-intensive products and services.

Table 9. Coherence of policy documents with Strategic Policy Objectives of the Bioeconomy National Statement.

	Forest Research Ireland (FORI) 2012	Harnessing our Ocean Wealth (HOW) 2012	Food Wise 2025 (FW) 2015	National Farmed Animal Health Strategy (NFAHS) 2017	Project Ireland 2040 (NDP and NPF) 2018
Jobs and Competiveness	1	3	3	1	3
Regional Prosperity	3	3	3	3	3
Sustainable Economy and Society	3	3	3	1	3
Decarbonization of the Economy	2	0	1	3	3
Mean Score	**2.25**	**2.25**	**2.50**	**2.00**	**3.00**

Scoring criteria to assess level of coherence (adapted from Le Gouais and Wach 2013; England et al. [21,27]). High coherence = 3: the policy document aligns substantively with the NPSB "Strategic Policy Objective". There is clear identification of its significance. Detailed and specific related measures for advancement are included in the document. Partial coherence = 2: the policy document supports the NPSB "Strategic Policy Objective", although it is less definitive. Relatively limited measures for advancement are included within the policy document. Limited coherence = 1: the policy acknowledges the aspirations the NPSB "Strategic Policy Objective" in a general statement. No measures for advancement are included within the policy document. No coherence = 0: there is no evidence in the policy to suggest alignment.

The third stage involved assessing the level of coherence between each policy document and the key DAFM sectors related to Ireland's bioeconomy: agriculture; food; forestry; and marine. In this case each document was reviewed carefully to identify when each of the other sectors was either explicitly mentioned or implicitly considered. In particular, how each document's stated objectives and listed measures recognize and might impact upon the other sectors was examined through the use of a categorization matrix. Again, a qualitative score was applied to the level of coherence, ranging from 3 (high coherence) to 0 (no coherence) for each policy document in relation to both acknowledgement of each of the other sectors and the extent of complementary or coordinated measures (see Table 10). For example, the forestry document demonstrated a clear acknowledgement of the agriculture sector and contained specific complementary measures; it was seen as exhibiting 'high coherence' with the agriculture sector. The same document contained a general acknowledgement of the marine sector but had no complementary or coordinated measures and was therefore recorded as exhibiting 'limited coherence' with this sector. An average coherence score was generated for each policy document (see Table 10).

Table 10. Coherence of policy documents with sectors related to the bioeconomy in Ireland.

	Forest Research Ireland (FORI) 2012	Harnessing our Ocean Wealth (HOW) 2012	Food Wise 2025 (FW) 2015	National Farmed Animal Health Strategy (NFAHS) 2017	Project Ireland 2040 (NDP and NPF) 2018
Agriculture	2	0	3	-	3
Food	2	3	-	3	3
Forestry	-	0	2	0	1
Marine	1	-	3	1	2
Mean Score	**1.66**	**1.00**	**2.66**	**1.33**	**2.25**

Scoring criteria to assess level of coherence (adapted from Le Gouais and Wach 2013; England et al. [21,27]). High coherence = 3: the policy document aligns strongly with other sector. Policy document devotes specific attention to alignments with other sector. It includes numerous and detailed complementary measures for achieving that. Partial coherence = 2: the policy document supports other sector, although it is less clear and distinct as to how it could be achieved. Relatively limited details and measures are included within the policy document. Limited coherence = 1: the policy document recognizes other sector. No details on associated measures are provided. No coherence = 0: there is no evidence in the policy to suggest alignment with other sector.

4.3. Synthesis of Results

The final stage of the process—the synthesis of findings—was described and discussed in Sections 5 and 6. Although external coder reliability was not undertaken on the data, internal validation analysis was conducted according to recommendations from Elo and Kyngäs [50] with the authors discussing and agreeing on coding issues and refinement of themes. In Section 5 we present a summary of the three categorization matrices showing how each document scores in respect to the research questions. Recognizing the need for transparency when reporting content analysis data full detailed matrices are provided in the appendices.

5. Results

The results of this analysis are presented in three subsections. First, we show the results of the bio-concepts analysis. Then, we present coherence levels between the selected policy documents and the Strategic Policy Objectives of the Bioeconomy National Statement. Finally, we examine the level of coherence between the selected policy documents and other sectors related to the bioeconomy.

5.1. Research Question 1: To What Extent is Each Policy Document Aware of the Bioeconomy and Related Key Bio-Concepts

Awareness of the bioeconomy and related bio-concepts is summarized in Table 7. A full categorization matrix detailing the levels of coherence in evidence in each of the documents, including specific related measures, is included in Table A1. Although, there is a degree of overlap between some of the bio-concepts, for example biofuels and bioenergy, for the purpose of this research each of the bio-concept coherence scores was given equal weighting. Seven of the bio-concepts, including bioeconomy, were identified in the policy documents and included in the analysis. Neither of the Harnessing our Ocean Wealth (HOW; 2012) and National Farmed Animal Health Strategy (NFAHS; 2017) mentioned the bioeconomy at all. In terms of all the bio-concepts analyzed the Forest Research Ireland (FORI; 2012) document demonstrates the highest level of awareness (1.42) with the NFAHS 2017 revealing the lowest level (0.14). The following section provides a narrative of the findings per sectoral document.

Forest Research Ireland (FORI) document:

Despite being published in May 2012, six years prior to the NSPB, The Strategic Agenda for Forest Research Ireland (FORI) illustrates an awareness of the concept of the bioeconomy throughout the document. It states that "Forestry has always been a bioeconomy, converting wood, a renewable biological material, into bio-based products and bioenergy" (p. 21). It recognizes the challenges that will occur if the forestry sector is to be used as a renewable energy source, particularly regarding

potential supply problems. Although the document stresses the need to assess potential opportunities for the Forestry sector within a sustainable European bioeconomy, specific details are not included.

The most frequently mentioned bio-concepts throughout the document were biomass and biodiversity. In particular, the importance of the development of supply chain mechanisms to ensure biomass crops are brought to market and full returns realized is emphasized. A requirement for opportunities to enhance sustainable biomass production and to optimize its use, especially for energy production, is highlighted. Furthermore, the significance of biorefinery research in developing the potential of the forest-based sector to extract higher value innovative biomass based products for changing markets is outlined.

In relation to biodiversity, the document states that forestry management has the potential to deliver a range of ecosystem services. The significance of appropriate planning and management of forest plantations for biodiversity receives emphasis. However, although a number of current schemes are mentioned the policy is limited in relation to specific measures. Biofuels, bioenergy and bioresources are recognized in general statements without specific details of intended measures for development.

Harnessing our Ocean Wealth (HOW) document:

There is no specific mention of the "Bioeconomy" in the Harnessing our Ocean Wealth document published in June 2012. It does, however, recognize the significance of the then emerging ocean industry of marine "biotechnology". Although stressing the importance of development of an integrated enterprise strategy to generate momentum in specific emerging market opportunities, including biotechnology, no specific details are included.

Biodiversity is especially emphasized with clear recognition of its importance in the planning and management of marine resources. The document advocates promotion of further research into economic values of marine diversity to ensure best practice in the planning and management of ocean resources. While a number of specific measures for the achievement of an overarching vision are included, none of the other bio-concepts are mentioned.

Food Wise 2025 (FW) document:

The Food Wise 2025 document published in March 2015 mentions the bioeconomy only twice in the entire document. It simply states that the food sector " ... is also increasingly a platform for supporting other sectors of the economy including pharma, tourism, bioeconomy, biotechnology, bioenergy, health and wellness ... ". However, it does recommend that agri-food research funding be made available to provide scientific advice and to inform policy decisions on the benefits of bioeconomy solutions.

The document recognizes the need for appreciation of synergies between agri-food sectors and biotechnology, specifying in particular the marine biotechnology field. It identifies the 'Harnessing our Ocean Wealth' document, which highlights the market potential of biotechnology, although without specifying relevant approaches.

The necessity for a coordinated response to minimize any threat to biodiversity while providing optimal efficiency in food production is highlighted in the policy. It goes on to identify and evaluate a range of tailored measures that will have a positive impact on biodiversity.

While there is recognition of the importance of themitigation benefits of forest-based biomass and affirmation of support for measures including optimization of market potential, specific detailed measures are not in evidence. The policy also notes the synergy of the agriculture and forestry sectors in bioenergy production, mentioning some measures for improvement.

National Farmed Animal Health Strategy (NFAHS) document:

Although the National Farmed Animal Health Strategy document, published in July 2017, outlines in detail the role of the agri-industry in the context of the national economy there is no mention of the bioeconomy in the document. Indeed, there is only one mention of "biotechnology" contained

as part of a general statement that a "system will be in place to identify, evaluate and effectively manage all potential threats to animal health arising from infrastructural change, new biotechnology, novel husbandry systems".

While there are no references to any of the other "Bio-concepts" in the document, the economic value and practicalities of farm level bio-security are highlighted.

Project Ireland 2040 (NDP and NPF) documents:

Published in February 2018, in total both Project 2040 documents contain only three mentions of the bioeconomy, simply noting in the NDP that the Irish Bioeconomy Foundation in Tipperary is amongst the recipients of funding under the Regional Enterprise Development. Although, the NPF document includes a short description of the components of the bioeconomy and acknowledges the significance of a successful transition, no specific details are included.

The NPF document includes a general statement on the importance of biotechnology in relation to the optimal development of Ireland's Maritime Economy. While containing no specific measures it highlights the role of biotechnology as included in the HOW (2012) and FW (2015) documents.

In relation to the other "Bio-concepts" there is a particular emphasis on Biodiversity and to a lesser degree Biomass and Bioenergy. The documents recognize the necessity for focused investment in settings for biodiversity. The protection and enhancement of the state's biodiversity is included in a substantive ten-year plan. This vision stresses the dependence of the tourism and recreational sectors on Ireland's natural heritage and biodiversity. Specific investment in the National Biodiversity Action Plan 2017–2021 is highlighted.

5.2. Research Question 2: What is the Level of Coherence between Each Sectoral Policy Document and the Four Strategic Policy Objectives of the Irish Bioeconomy National Statement?

The coherence of the policy documents in terms of alignment with each of the NPSB Strategic Policy Objectives (SPOs) is summarized in Table 9. More detailed evidence is provided in the matrix included in the Table A2. The Project 2040 documents demonstrate complete alignment (3.00), followed by FW (2015) (2.50) and to a slightly lesser extent, FORI (2012) and HOW (2012), (2.25 respectively). Alignment with the SPO regional prosperity was demonstrated at a maximum level across all documents while least alignment was with the SPO decarbonization of the economy. To reveal a more expansive perspective, the following section provides a narrative of the findings with the SPOs as focal points.

Jobs and competitiveness:

Although jobs and competitiveness is included, either explicitly or implicitly, in all of the policy documents, FORI (2012) provides minimal reference to this SPO with its central concern focusing on sustainability. However, the HOW (2012) document is more explicit in referring to "a skilled and experienced workforce which adapts to changing requirements and new opportunities" (p. iii) as representing an essential component in the achievement of its vision. It also includes specific key measures for success. The FW (2015) document recognizes that "there are a range of skills gaps which could constrain the industry's growth" (p. 48) at both producer and processing levels in the food sector. It includes specific measures, including incorporating Teagasc expertise in knowledge transfer, to achieve the required standards. In a section devoted to competitiveness, it is recognized that Irish family farms have particular challenges "related to the scale of their operations and the fragmentation and structure at farm level" (p. 51). In contrast the NFAHS (2017) contains little explicit evidence of focus on jobs and competitiveness. However, it does mention the importance of supporting access to international markets.

The NPF, closely aligned with NDP in Project 2040, has a particular emphasis on the competitiveness dimension of the SPO where it identifies high quality international connectivity as one of its shared goals: "This is crucial for overall international competitiveness and addressing opportunities and challenges from Brexit" (p. 14). The NDP, acknowledging the NPF statement of an additional 660,000

at work in Ireland in 2040, stresses the importance of the "sustainability of existing employment and supporting employment opportunities" (p. 9).

Regional prosperity:

By the very nature of the location of businesses in the forestry sector, the Strategic Research Agenda outlined in the FORI (2012) document is focused on the innovative development and economic growth in rural areas. Specific measures for advancement in a range of issues relating to regional prosperity in the forestry domain includes expansion of resources, productivity and resource utilization. Unsurprisingly, coastal development receives direct focus in the three goals of the HOW (2012) document which are concerned with a "thriving maritime economy", "healthy ecosystems" and "engagement with the sea". Clear targets ("double the value of our ocean wealth to 2.4% of GDP by 2030) and innovative thinking ("Irish ports are important nodes where future renewable and off-shore energy projects be based") are included along with specified measures for enablement.

Regional prosperity is observed implicitly in the FW (2015) document in terms of the location of the primary producers and in the identification of growth opportunities. These opportunities range across the rural industries associated with agri-food, including the dairy, beef and prepared consumer food sectors, while also specifying seafood development in coastal areas. Specific measures in pursuit of the stated opportunities are outlined in the policy. Economic prosperity is one of the key issues highlighted in the context to the NFAHS (2017). A range of strategic policy objectives are designed to maximize the contribution of the farming sector to regional prosperity. These include increased farm-level productivity, improved processor outcomes and improved market access. Detailed measures are specified.

The two policies associated with Project 2040 provide evidence of clear alignment with regional prosperity. Key strategic outcomes included in the NPF include "Enhanced Regional Accessibility" and "Strengthened Rural Economies and Communities". The NDP expands upon the former by identifying investment actions. Specifically including the establishment of A Rural Regeneration and Development Fund with €1 billion budget. Furthermore, a National Broadband Plan intervention will focus on "communities in rural areas in every county in Ireland" (p. 48).

Sustainable economy and society:

Exhibiting awareness of the importance of a sustainable economy and society the FORI (2012) document identifies two of its seven thematic research areas as "Expansion of the Forest Resource through sustainable increases in productive area" and "Productivity – sustainable improvements in crop productivity and quality" (p. 8). A range of key measures is included. Aligned also with this SPO, the HOW (2012) document focuses on the complementary synergy between the achievement of economic recovery and sustainable growth in a thriving maritime economy. Its vision of "Enabling our Sustainable Future" is supported by a detailed range of 39 key actions.

The FW (2015) document addresses the key issues of economic competitiveness and sustainability with clarity, stating that they are "equal and complementary: one will not be achieved at the expense of the other" (p. 4). In a comprehensive section dedicated to sustainability, the document identifies its strategy of focusing "on developing technologies and process which suggest a vision of sustainable intensification" (p. 24). A series of progressive recommendations are outlined, underpinned by specific measures for achievement. Although the NFAHS (2017) Strategy makes a general acknowledgement of environmental sustainability as a required strategic outcome, it is less specific on associated measures.

Clearly identified goals, which align with this SPO, within the NPF (2018) include "Sustainable Mobility" "Compact Growth" and "Sustainable Management of Water, Waste and Environmental Resources". Specific investment actions linked to maintenance and renewal are outlined in the NDP document.

Decarbonization of the economy:

Forestry's role in the mitigation of climate change through carbon sequestration and the potential to replace fossil fuels is acknowledged in the FORI (2012) document with reference to resource utilization. However, there is no direct mention of decarbonization in the HOW (2012) document.

The urgent requirement of a reduction in the rate of greenhouse gas emissions associated with the farming sector is recognized in the FW (2015) document and measures such as leveraging the benefits of "genomic technology to help maintain the rate of genetic improvements . . . to lower emissions" (p. 69) are advocated. However, this strategic objective does not receive equal emphasis with sustainability and regional prosperity.

In contrast, the NFAHS (2017) is uncompromising in its acceptance that "in comparison with many of our international competitors, emissions from animal based production make-up a disproportionate percentage of greenhouse gas emissions produced within Ireland" (p. 9). A range of detailed measures for the improvement in animal health are proposed as this is recognized as a significant factor in Ireland's response to reduction targets for emissions.

The NPF contains a goal "Transition to a Low Carbon and Climate Resilient Society", which specifies the "transition to a competitive, low-carbon, climate-resilient . . . economy by 2050" (p. 15). Detailed measures are also included in the complementary Project 2040 policy, the NDP.

5.3. Research Question 3: What is the level of coherence between each of the sectoral policy documents and other sectors related to the bioeconomy in Ireland

The level of coherence of each policy document in relation to the other key DAFM sectors associated with the bioeconomy is summarized in Table 10. A full matrix detailing the levels of alignment, including specific measures for attainment is included in Table A3. The FW (2015) document revealed the highest level of coherence (2.66) with HOW (2012) the lowest (1.00). The following section provides a narrative of the findings for each policy document.

The most prominent "other" sectoral emphasis in the FORI (2012) document focuses on the agricultural sector. The document posits the necessity for an assessment of the synergies between trees and agricultural practices when it stresses the significance of continuing to " . . . research the ability of forestry to sequester carbon and the extent to which it can help to reduce Ireland's greenhouse gas emissions from agriculture . . . ". FORI (2012) notes the potential conflict in the conversion of land from agriculture to forestry in the context of the requirements of increased food production envisaged under FoodHarvest 2020. Although reference to the marine sector is limited the document does address the role of forestry in lake recovery from acidification.

The HOW (2012) document addresses the food sector with particular reference to specific measures to advance sustainable production and processing in alignment with an increased target for seafood provision as specified within FoodHarvest 2020 requirements. Neither the forestry nor agriculture sectors are explicitly mentioned in the policy.

The significance of the agriculture sector in the FW (2015) document is clearly recognized particularly where the necessity for production enhancement aligned with sustainability issues is emphasized. Specific measures for advancement that acknowledge the challenges of climate change are provided " . . . investment in the development of new technologies that create more sustainable production systems must be a cornerstone of achieving future growth at primary production level". Focus on the marine sector is also comprehensive with a range of measures included, for example, "Deliver enhanced stock knowledge and sustainability through the €40m funding allocated to marine science . . . ". FW (2015) is clear on the significance of the forestry sector although much more descriptive than prescriptive in its coverage.

The NFAHS (2017) shows most comprehensive alignment with the food sector. A potentially transformative approach to agriculture is outlined which stresses the need for risk identification and communication strategies. Furthermore, the scope of the strategy in relation to ensuring the integrity of the food supply chain is clear with specific measures provided. The marine sector receives limited inclusion through general statements on its importance. The forestry sector is not included.

The multi-dimensional range of the Project2040 documents presents some level of alignment across all sectors, particularly in relation to agriculture and food, with emphasis on optimal, sustainable production in the former and linkage with Food Wise 2025 in the latter. Specific measures regarding both sectors are included. Although not as prominent, the marine sector is also recognized with particular reference to coastal and island communities and measures related to marine research investment outlined. Although the role of forests in climate change mitigation is recognized in a general statement there are no specific details regarding measures to be adopted. Some specific details regarding approaches and measures are provided for the marine sector but are not evident in relation to forestry.

6. Discussion

In this study, we analyzed coherence, particularly in terms of objectives and measures, between a range of sectors that may impact upon the delivery of a successful bioeconomy in Ireland. By undertaking a three-stage analysis we attempted to establish the level of policy coherence and awareness of the significance of the bioeconomy across current sectoral policy documents.

6.1. Key Findings

The findings indicate inconsistency across sectors in relation to the nature and extent of awareness of the bioeconomy and related bio-concepts. For example, explicit mention of the term 'Bioeconomy' was included in just three of the policies examined. Notably, only the earliest document FORI (2012), published six years before the NPSB (2018), contained more than a general statement recognizing its significance. Surprisingly, considering the importance of innovative technological advancement in the transition to a flourishing bioeconomy, 'Biotechnology' as a concept received attention in only three of the documents, none of which provided specific measures for its development. Additionally, another of the visions of the bioeconomy advocated by Bugge et al. [10], 'Bioresources', was mentioned only in FORI (2012), and then only as a general statement on research strategy with no detailed measures included.

In terms of the other bio-concepts identified from the NPSB, the management of 'Biodiversity' was highest on the agenda with four of the policies demonstrating at least appropriate recognition in terms of objectives for its protection supported by specific measures. Indeed, recognition of the significance of the protection and enhancement of biodiversity in Ireland was clearly evident through a substantive ten-year plan included in the Project 2040 documents. The analysis concluded that overall FORI (2012), FW (2015) and the Project 2040 documents were most aware of the entire range of bio-concepts. The most recently published of the DAFM documents—the NFAHS (2017)—demonstrated almost no awareness of any of the bio-concepts while any update to the HOW (2012) should include greater awareness of the range of bio-concepts besides its current particular concern with protecting and conserving Ireland's rich marine 'Biodiversity'.

In terms of alignment between the four Strategic Policy Objectives of the National Policy Statement on the Bioeconomy (2018) and the selected documents, the results for Research Question 2 again indicate a degree of inconsistency. Furthermore, there was no correlation between these results and the mean awareness scores generated for Research Question 1. Encouragingly, awareness of the significance of 'Regional Prosperity' was consistently high across all sectors with the inclusion of clear goals and substantive measures for its achievement. This level of alignment was broadly matched in terms of the goals and measures advocated in each of the policy documents in order to enable the transition to a 'Sustainable Economy and Society', with the exception being the NFAHS (2017). Although substantive measures that focused on the reduction of greenhouse gas emissions were delineated in the more recently published Project Ireland 2040 (2018) and NFAHS (2017) documents, much less attention to the 'decarbonization of the economy' was evident in the earlier sectoral policies, particularly related to food and marine. It would be anticipated that this particular objective would receive greater prominence when updated policies are released. Project Ireland 2040 (2018) was the

only document to register maximum alignment scores with all four SPOs. This result is unsurprising as when launched this document was promoted as an important shift from previous approaches to long-term planning and investment by the Irish Government. It sought to implement a holistic approach by which the various government departments, agencies, state owned enterprises and local authorities shared a set of strategic objectives for rural, regional and urban development (Government of Ireland, 2018).

In the third stage of analysis, unsurprisingly, the most recent of the selected policies, the Project 2040 (2018) documents, demonstrated the highest level of alignment across all sectors. Interestingly, however, the depth of recognition was not consistent across all sectors with expansive coverage including specific measures for agriculture and food and more limited details provided for the forestry sector. It is worth acknowledging that agri-food is Ireland's largest indigenous business and 64% of its land is devoted to agricultural use. Conversely, only 11% of Ireland is under forests. This is a very low percentage in comparative terms with most other European countries [51]. The FW (2015) document also had a consistently high level of coherence. It demonstrated not only an appropriate recognition of the linkage between the sectors but also provided specific measures for development of objectives, particularly in relation to agriculture and the marine. Conversely, the earlier HOW (2012) contained no explicit mention of any of the other sectors apart from food. However, on this it did provide detailed action plans for coordinating policy with the food sector with emphasis on sustainable food production and processing. It should be recognized that for long term bioeconomic growth to be sustainable it will need the benefits and risks of any bioeconomic innovation and policy implementation to be subject to an intensive process of evaluative scrutiny [14].

Surprisingly, there was no focus on the challenge presented by plastic waste and the opportunities for bio-plastics. Again, this is something that would be expected to change with any subsequent strategies. In terms of sustainability, Ireland, which could be termed a "High-Tech Bioeconomy", must accept the importance of decreasing its environmental footprint in both domestic and international contexts [14].

6.2. Importance of the Findings

These findings are significant in terms of the transition to a successful bioeconomy in Ireland because the sectoral policy analyses provide a perspective on which to reflect upon the necessity for more expansive collaboration and closer co-ordination between the actors involved in its development.

They highlight the requirement to update certain strategy documents to raise the level of cross-sectoral coherence, which is essential in avoiding a 'silo' mentality and enabling the concept of the bioeconomy and its associated objectives to become mainstreamed. For this to occur the variable range of scores revealed in the levels of coherence across the sectoral documents points to a need to create an awareness and appreciation of the value of consistent alignment. This could be achieved through coordinated consultation at the horizontal level [29]. Birch [7] argues that in order to promote and support transition to a coherent policy framework a single bioeconomic vision, which a majority of policy stakeholders can adhere to, is a fundamental requisite. As noted previously, Ireland has already established a Bioeconomy Implementation Group (BIG) to deliver the key actions delineated in the NPSB including ensuring that there is coherence between all sectoral strategies that impact on the bioeconomy in Ireland (see Table 2). The findings of this research further reinforce the importance of that group strengthening engagement among relevant stakeholders to ensure that there is greater coherence between the many sectors of the bioeconomy. Significant difficulties are presented for policy makers attempting to manage the impact and outcome of scientific research and innovation [7]. A mutually supportive policy framework across the relevant sectors should be constructed, with the benefits of increased synergies, mitigation of conflict and the sustainable management of natural resources, which are inherent in the transition to a robust national bioeconomy.

The importance of public consultations in policy development is now accepted as a means by which to facilitate the widest range of responses to the work of government. A caveat of which the

BIG should be aware is that facilitating such a diffuse approach, particularly in a multi-sectoral and relatively new concept such as the bioeconomy, may militate against achieving optimal coherence. Clarification of who controls the agenda is crucial to policy coherence. Importantly, with the lack of a robust evidence base, defining who the bioeconomy experts are is a particularly complex and difficult decision [52]. Awareness of potential stakeholder conflicts and competing interests is also essential [13]. The methodology employed in this research should help them recognize not only their own interests but also mutual responsibilities.

6.3. Limitations and Further Research

This paper presented the findings of a horizontal-level policy coherence analysis of relevant sectoral documents from the Irish state's Department of Agriculture, Food and the Marine (DAFM). While they are instructive regarding the policy documents at the period of publication (2012–2018), it should be acknowledged that the range of documents is related to the DAFM and Project Ireland 2040 only, and as such omitted analyzing the significance of energy, the responsibility of the Department of Communications, Climate Action and the Environment (DCCAE), as a sector within the bioeconomy.

Furthermore, written documents may encompass only one facet of policy; perhaps not including funding requirements. Moreover, policy as stated in written documents does not necessarily correlate with action. Implementation may not equate with the measures designed to realize clearly outlined and valid objectives. For a holistic assessment of policy coherence, what is further required is to identify and track flows of related public expenditure, and make an assessment of how this relates to the various policy objectives in each plan [53].

Further research would not only broaden the scope of the documents included but also undertake analysis in relation to vertical policy coherence. Evaluation criteria could be used to analyze policy objectives and implementation across different levels of government (national, regional and local) in Ireland, see [40]. This would align with the consistent emphasis on the importance of the deployment of local bioeconomies outlined in the 2018 EC Bioeconomy Strategy (EC, 2018)

Finally, the results could be triangulated with other sources, particularly interviews with independent experts [21]. Barriers against appropriate implementation of policy include: "lack of dissemination; lack of skill and knowledge; resistance to change" [21]. Therefore, it is important to recognize that the findings from this "top-down" QDA on bioeconomy policies could be enhanced by consultation with relevant stakeholders/actors in order to provide further "bottom-up" insights into sectoral policies and practices [31] bearing in mind the caveat mentioned in the previous section.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Matrix 1 Coherence of Policy Documents with the Bioeconomy and Related Key Bio-Concepts (Coherence Score 0–3).

	Forest Research Ireland (FORI) 2012	**Harnessing our Ocean Wealth (HOW) 2012**	**Food Wise 2025 (FW) 2015**	**National Farmed Animal Health Strategy (NFAHS) 2017**	**Project Ireland 2040 (NDP and NPF) 2018**
Bioeconomy	24 Mentions. Recognizes bioeconomy concept. Acknowledges the need to assess potential opportunities and challenges for forestry in Ireland within sustainable European bioeconomy. More specific detail is not included. (2)	No explicit mention of Bioeconomy. No plans detailed. (0)	2 Mentions. General statements on significance and recommendation for funding to be made available. No detailed activities specified. (1)	No explicit mention of Bioeconomy. No plans detailed. (0)	3 Mentions. Irish Bioeconomy Foundation is recognized in the list of recipients of funding. Significance of Ireland's transition to a bioeconomy is recognized. No Specific details provided. (1)
Biotechnology	1 Mention. Recognition of Food, Agriculture, Fisheries and Bio-technology Forestry Commission. No specific details included. (0)	12 Mentions. Recognizes significance of marine biotechnology and contains "Action" stressing importance of its development. No specific details are included. (2)	5 Mentions. Recognizes need for appreciation of synergies between agri-food sectors and biotechnology. Identifies other policy documents on market potential of biotechnology without specifying relevant approaches. (2)	1 Mention. General statement recognizing potential threats to animal health arising from new biotechnology. (1)	3 Mentions. General statement on importance of biotechnology in relation to the optimal development of Ireland's maritime economy. Highlights also the role of biotechnology in relation to Harnessing our Ocean Wealth and Food Wise 2025 documents. No detailed activities specified. (1)
Bioresources	1 Mention. General statement related to research strategy on sustainable biomass utilization and processing. No specific details included. (1)	No explicit mention of Bioresources. No plans detailed. (0)	No explicit mention of Bioresources. No plans detailed. (0)	No explicit mention of Bioresources. No plans detailed. (0)	No explicit mention of Bioresources. No plans detailed. (0)

Table A1. *Cont.*

	Forest Research Ireland (FORI) 2012	**Harnessing our Ocean Wealth (HOW) 2012**	**Food Wise 2025 (FW) 2015**	**National Farmed Animal Health Strategy (NFAHS) 2017**	**Project Ireland 2040 (NDP and NPF) 2018**
Biodiversity	13 Mentions. Recognizes appropriate planning and management of forest plantations can contribute significantly to biodiversity. A few current schemes are mentioned. (2)	8 Mentions. Recognizes goal of protecting and conserving Ireland's rich marine biodiversity. Advocates promotion of further research and details number of specific approaches to achievement of overarching vision. (3)	12 Mentions. Stresses importance of arresting biodiversity losses. Advocates a centrally coordinated response to threat to biodiversity. Includes number of approaches and measures to achieve this aim. (3)	No explicit mention of Biodiversity. No plans detailed. (0)	26 Mentions. Recognizes necessity for focused investment. Protection and enhancement of State's biodiversity is included in a substantive ten year plan. Specific investment in Plan 2017–2021 highlighted. (3)
Biomass	16 Mentions. Recognizes importance of development of supply chain mechanisms. Stresses significance of biorefinery research in developing potential for forest-based sector to extract higher value innovative products. (3)	No explicit mention of Biomass. No plans detailed. (0)	5 Mentions. Recognizes importance of mitigation benefits of forest-based biomass. No specific details mentioned. (1)	No explicit mention of Biomass. No plans detailed. (0)	12 Mentions. Recognizes importance of biomass in less intensive/low carbon energy production and heating solutions. Some specific details are included. (2)
Bioenergy	5 Mentions. Recognizes that forestry research on bioenergy has enhanced knowledge about utilization of biomass to meet present and future energy needs sustainably. No specific details mentioned. (1)	No explicit mention of Bioenergy. No plans detailed. (0)	3 Mentions. Recognizes synergy of agriculture and forestry sectors within production of bioenergy. Affirms DAFM support for innovative use of animal by-products for energy production. (2)	No explicit mention of Bioenergy. No plans detailed. (0)	3 Mentions. Recognizes need for identification of suitable locations for bioenergy production. Some specific details included regarding importance of innovation and improved techniques to enhance bioenergy production. (2)
Biofuels	1 Mention. General statement that waste streams associated with forestry have been converted into biofuels. No specific details mentioned. (1)	No explicit mention of Biofuel. No plans detailed. (0)	No explicit mention of Biofuel. No plans detailed. (0)	No explicit mention of Biofuel. No plans detailed. (0)	No explicit mention of Biofuel. No plans detailed. (0)

Table A2. Matrix 2 Coherence of Policy Documents with Strategic Policy Objectives of the Bioeconomy National Statement—Full Details.

	Forest Research Ireland (FORI) 2012	**Harnessing our Ocean Wealth (HOW) 2012**	**Food Wise 2025 (FW) 2015**	**National Farmed Animal Health Strategy (NFAHS) 2017**	**Project Ireland 2040 (NDP and NPF) 2018**
Jobs and Competiveness	Limited evidence of alignment with SPO. Minimal range of measures for attainment included. 1	Clear evidence of alignment with the SPO and awareness of its importance. Detailed recommendations/actions are specified across a range of proposed measures for attainment. 3	Clear evidence of alignment with the SPO and acknowledgment of its importance. Detailed recommendations/actions are specified across a range of proposed measures for attainment. 3	Limited evidence of alignment the SPO. No detailed measures specified in the policy document. 1	Clear evidence of alignment with the SPO and acknowledgement of its importance. Detailed recommendations/actions are specified across a range of proposed measures for attainment. 3
Regional Prosperity	Significant, if implicit, evidence of alignment with the SPO. Detailed recommendations/actions are specified across a range of proposed measures for attainment. 3	Clear evidence of alignment with the SPO and awareness of its importance. Detailed recommendations/actions are specified across a range of proposed measures for attainment. 3	Significant, if implicit, evidence of alignment with the SPO and awareness of its importance. Detailed recommendations/actions are specified across a range of proposed measures for attainment. 3	Clear evidence of alignment with the SPO and awareness of its importance. Detailed recommendations/actions are specified across a range of proposed measures for attainment. 3	Clear evidence of alignment with the SPO and acknowledgement of its importance. Detailed recommendations/actions are specified across a range of proposed measures for attainment. 3
Sustainable Economy and Society	Clear evidence of alignment with the SPO and acknowledgement of its importance. Detailed recommendations/actions are specified across a range of proposed measures for attainment. 3	Clear evidence of alignment with the SPO and awareness of its importance. Detailed recommendations/actions are specified across a range of proposed measures for attainment. 3	Clear evidence of alignment with the SPO and acknowledgement of its importance. Detailed recommendations/actions are specified across a range of proposed measures for attainment. 3	Evidence of general alignment with significance of the SPO. Limited re specific measures for attainment. 1	Clear evidence of alignment with the SPO and acknowledgement of its importance. Detailed recommendations/actions are specified across a range of proposed measures for attainment. 3
Decarbonization of the Economy	Clear evidence of alignment with the SPO and acknowledgement of its importance. Appropriate Resource Utilization measures included. 2	No evidence provided of alignment with the SPO. 0	Evidence of general alignment with the significance of the SPO. However, limited re range of measures for attainment. 1	Clear evidence of alignment with the SPO and acknowledgement of its importance. Detailed recommendations/actions are specified across a range of proposed measures for attainment. 3	Clear evidence of alignment with the SPO and acknowledgement of its importance. Detailed recommendations/actions are specified across a range of proposed measures for attainment. 3
Mean Score	2.25	2.25	2.50	2.00	3.00

National Statement—full details.

Table A3. Matrix 3 Coherence of Policy Documents with Sectors related to the Bioeconomy in Ireland—Full Details.

	Forest Research Ireland (FORI) 2012	**Harnessing our Ocean Wealth (HOW) 2012**	**Food Wise 2025 (FW) 2015**	**National Farmed Animal Health Strategy (NFAHS) 2017**	**Project Ireland 2040 (NDP and NPF) 2018**
Agriculture	Highlights acceptance that land utilization cannot be considered in isolation from agriculture policy. Stresses importance of research into extent to which forestry can help to reduce greenhouse gas emissions from agriculture. Addresses need to assess synergies between trees and agricultural practices. (2)	No explicit mention of Agriculture sector. No plans detailed (0)	Stresses importance of development of future markets and challenges imposed by climate change. Innovative approaches required for enhancing productivity and sustainability are recognized with specific actions for growth clarified. (3)	-	Highlights importance of policy objectives seeking carbon neutrality in sector while not compromising optimal, sustainable production. Recognizes crucial significance of cross-sectoral coherence and strong co-ordination in approaches and measures in order that Ireland meets climate targets. Specific strategies included. (3)
Food	The 'food energy and environment' trilomna is acknowledged as is potential conflict inherent in farmers converting land from agriculture to forestry in context of increased demands of Food Harvest 2020. Research re drivers (both economic and behavioral) in land-use change decisions is advocated although specific details are not included.(2)	Provides overarching vision that stresses importance of Ireland's 'clean, green image' in promotion of marine products. Stresses need for more holistic management to avoid potential conflict of interest among government bodies. Advocates effective co-ordination between relevant agencies and identifies current and future action plans relating to sustainable food production and processing, taking cognizance of Food Harvest 2020 proposals. (3)	-	Highlights importance of sustained optimal health to future profitability and sustainability of farming industry and maintenance of a competitive position in international agri-food market place. Recognizes need to take cognizance of development plans outlined in Food Wise 2025. Stresses impact of optimal animal health on food quality, consistency and security. Specific details regarding actors and actions in implementation of objectives included. (3)	Recognizes crucial importance of sustainable food production. Linkage with aspirations of Food Wise 2025 is stressed in terms of sustainable development of the sector through public capital investment. Specific details regarding research initiatives and potential technological innovation provided. (3)

Table A3. *Cont.*

	Forest Research Ireland (FORI) 2012	Harnessing our Ocean Wealth (HOW) 2012	Food Wise 2025 (FW) 2015	National Farmed Animal Health Strategy (NFAHS) 2017	Project Ireland 2040 (NDP and NPF) 2018
Forestry	-	No explicit mention of Forestry sector. No plans detailed (0)	Recognizes sector contribution to renewable energy and to carbon sequestration. Importance of RDI emphasized as is innovative investment mechanisms. Descriptive rather than prescriptive regarding specific details regarding measures to combat production and environmental threats. (2)	No explicit mention of Forestry sector. No plans detailed (0)	General statement recognizing role of forests in climate change mitigation through carbon sequestration and provision of renewable fuels to reduce dependence on fossil fuels. Specific details regarding approaches and measures to be adopted not included. (1)
Marine	General statement regarding possible role of forestry in recovery of lakes from acidification. No detail included. (1)	-	Recognizes importance of sector in increased production of food but also providing an opportunity for strategic advantage in field of marine technology. Specific plans are specified in a range of planned activities for achieving success. (3)	General statement regarding importance of sector in providing stimulus to employment opportunities in rural and coastal area. No detail included. (1)	General statement on requirement to support growth and development of maritime economy in coastal and island communities. Some specific details regarding marine research investment. (2)

References

1. Martins, F.; Felgueiras, C.; Smitkova, M.; Caetano, N. Analysis of Fossil Fuel Energy Consumption and Environmental Impacts in European Countries. *Energies* **2019**, *12*, 964. [CrossRef]
2. Hausknost, D.; Schriefl, E.; Lauk, C.; Kalt, G. A Transition to Which Bioeconomy? An Exploration of Diverging Techno-Political Choices. *Sustainability* **2017**, *9*, 669. [CrossRef]
3. Wreford, A.; Bayne, K.; Edwards, P.; Renwick, A. Enabling a transformation to a bioeconomy in New Zealand. *Environ. Innov. Soc. Transit.* **2019**, *31*, 184–199. [CrossRef]
4. Birner, R. Bioeconomy concepts. In *Bioeconomy*; Springer: Cham, Germany, 2018.
5. Meyer, R. Bioeconomy strategies: Contexts, visions, Guiding implementation principles and resulting debates. *Sustainability* **2017**, *9*, 1031. [CrossRef]
6. Stern, T.; Ploll, U.; Spies, R.; Schwarzbauer, P.; Hesser, F.; Ranacher, L. Understanding perceptions of the bioeconomy in Austria—An explorative case study. *Sustainability* **2018**, *10*, 4142. [CrossRef]
7. Birch, K. Emergent imaginaries and fragmented policy frameworks in the canadian bio-economy. *Sustainability* **2016**, *8*, 1007. [CrossRef]
8. European Commission, D.-G.f.R.a.I.E. *Innovating for Sustainable Growth: A Bioeconomy for Europe*; European Commission: Brussels, Belgium, 2012.
9. European Commission, D.-G.f.R.a.I.E. *A Sustainable Bioeconomy for Europestrengthening the Connection between Economy, Society and the Environment: Updated Bioeconomy Strategy*; European Commission: Brussels, Belgium, 2018.
10. Bugge, M.; Hansen, T.; Klitkou, A. What is the bioeconomy? A review of the literature. *Sustainability* **2016**, *8*, 691. [CrossRef]
11. Devaney, L.; Henchion, M. Consensus, caveats and conditions: International learnings for bioeconomy development. *J. Clean. Prod.* **2018**, *174*, 1400–1411. [CrossRef]
12. European Commission, D.-G.f.R.a.I.E. *Review of the EU bioeconomy strategy and its action plan. Expert group report - Study*; European Commission: Brussels, Belgium, 2017.
13. Laibach, N.; Börner, J.; Bröring, S. Exploring the future of the bioeconomy: An expert-based scoping study examining key enabling technology fields with potential to foster the transition toward a bio-based economy. *Technol. Soc.* **2019**, *58*, 101118. [CrossRef]
14. Biber-Freudenberger, L.; Basukala, A.; Bruckner, M.; Börner, J. Sustainability performance of national bio-economies. *Sustainability* **2018**, *10*, 2705. [CrossRef]
15. Dietz, T.; Börner, J.; Förster, J.; von Braun, J. Governance of the Bioeconomy: A Global Comparative Study of National Bioeconomy Strategies. Available online: https://www.mdpi.com/2071-1050/10/9/3190 (accessed on 16 December 2019).
16. Priefer, C.; Jörissen, J.; Frör, O. Pathways to shape the bioeconomy. *Resource* **2017**, *6*, 10. [CrossRef]
17. Gawel, E.; Pannicke, N.; Hagemann, N. A Path Transition towards a Bioeconomy—The Crucial Role of Sustainability. Available online: http://www.fao.org/3/I9580EN/i9580en.pdf (accessed on 16 December 2019).
18. Assessing the Contribution of Bioeconomy to Countries' Economy. 2018. Available online: https://www.mdpi.com/2071-1050/10/9/3190 (accessed on 16 December 2019).
19. Devaney, L.A.; Henchion, M. If opportunity doesn't knock, build a door: Reflecting on a bioeconomy policy agenda for Ireland. *Econ. Soc. Rev.* **2017**, *48*, 207.
20. National Policy Statement on the Bioeconomy. 2018. Available online: https://www.mdpi.com/2071-1050/11/11/3005 (accessed on 16 December 2019).
21. Gouais, A.L.; Wach, E. A qualitative analysis of rural water sector policy documents. *Water Altern.* **2013**, *6*, 439–461.
22. Harahap, F.; Silveira, S.; Khatiwada, D. Land allocation to meet sectoral goals in Indonesia—An analysis of policy coherence. *Land Use Policy* **2017**, *61*, 451–465. [CrossRef]
23. Gauttier, P. Horizontal coherence and the external competences of the European Union. *Eur. Law J.* **2004**, *10*, 23–41. [CrossRef]
24. May, P.; Sapotichne, J.; Workman, S. Policy Coherence and Policy Domains. *Policy Stud. J.* **2006**, *34*, 381–403. [CrossRef]

25. Akhtar-Schuster, M.; Thomas, R.J.; Stringer, L.C.; Chasek, P.; Seely, M. Improving the enabling environment to combat land degradation: Institutional, financial, legal and science-policy challenges and solutions. *Land Degrad. Dev.* **2011**, *22*, 299–312. [CrossRef]
26. Siitonen, L. Theorising politics behind policy coherence for development (PCD). *Eur. J. Dev. Res.* **2016**, *28*, 1–12. [CrossRef]
27. England, M.I.; Dougill, A.J.; Stringer, L.C.; Vincent, K.E.; Pardoe, J.; Kalaba, F.K.; Mkwambisi, D.D.; Namaganda, E.; Afionis, S. Climate change adaptation and cross-sectoral policy coherence in southern Africa. *Reg. Environ. Chang.* **2018**, *18*, 2059–2071. [CrossRef]
28. Geerlings, H.; Stead, D. The integration of land use planning, transport and environment in European policy and research. *Transp. Policy* **2003**, *10*, 187–196. [CrossRef]
29. Nilsson, M.; Zamparutti, T.; Petersen, J.E.; Nykvist, B.; Rudberg, P.; McGuinn, J.; Stockholms, u.; Stockholm Environment, I.; Stockholm Resilience, C. Understanding Policy Coherence: Analytical Framework and Examples of Sector–Environment Policy Interactions in the EU. *Environ. Policy Gov.* **2012**, *22*, 395–423. [CrossRef]
30. Cejudo, G.M.; Michel, C.L. Addressing fragmented government action: coordination, coherence, and integration. *Policy Sci.* **2017**, *50*, 745–767. [CrossRef]
31. Huttunen, S.; Kivimaa, P.; Virkamäki, V. The need for policy coherence to trigger a transition to biogas production. *Environ. Innov. Soc. Transit.* **2014**, *12*, 14–30. [CrossRef]
32. Imbert, E.; Ladu, L.; Morone, P.; Quitzow, R. Comparing policy strategies for a transition to a bioeconomy in Europe: The case of Italy and Germany. *Energy Res. Soc. Sci.* **2017**, *33*, 70–81. [CrossRef]
33. Lainez, M.; González, J.M.; Aguilar, A.; Vela, C. Spanish strategy on bioeconomy: Towards a knowledge based sustainable innovation. *New Biotechnol.* **2018**, *40*, 87–95. [CrossRef] [PubMed]
34. Ramcilovic-Suominen, S.; Pülzl, H. Sustainable development – A 'selling point' of the emerging EU bioeconomy policy framework? *J. Clean. Prod.* **2018**, *172*, 4170–4180. [CrossRef]
35. Kleinschmit, D.; Arts, B.; Giurca, A.; Mustalahti, I.; Sergent, A.; Pülzl, H. Environmental concerns in political bioeconomy discourses. *Int. For. Rev.* **2017**, *19*, 2017–2018. [CrossRef]
36. Lindstad, B.H.; Pistorius, T.; Ferranti, F.; Dominguez, G.; Gorriz-Mifsud, E.; Kurttila, M.; Leban, V.; Navarro, P.; Peters, D.M.; Pezdevsek Malovrh, S.; et al. Forest-based bioenergy policies in five European countries: An explorative study of interactions with national and EU policies. *Biomass Bioenergy* **2015**, *80*, 102–113. [CrossRef]
37. Climate Policy Integration, Coherence and Governance. 2009. Available online: https://www.peer.eu/publications/climate-policy-integration-coherence-and-governance/ (accessed on 16 December 2019).
38. Suresh, D. Case Study: Research Method for Social Sciences. 2015. Available online: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2684644 (accessed on 16 December 2019).
39. Rowley, J. Using case studies in research. *Manag. Res. News* **2002**, *25*, 16–27. [CrossRef]
40. Shahab, S.; Clinch, J.P.; O'Neill, E. An analysis of the factors influencing transaction costs in transferable development rights programmes. *Ecological Econ.* **2019**, *156*, 409–419. [CrossRef]
41. Ylimartimo, A. Case study on bioeconomy campus, central Finland. *Biofuels, Bioprod. Biorefining* **2018**, *12*, 177–186. [CrossRef]
42. Bosman, R.; Rotmans, J. Transition Governance towards a Bioeconomy: A comparison of finland and the netherlands. *Sustainability* **2016**, *8*, 1017. [CrossRef]
43. Lehtonen, O.; Okkonen, L. Regional socio-economic impacts of decentralised bioeconomy: A case of Suutela wooden village, Finland. *Environ. Dev. Sustain.* **2013**, *15*, 245–256. [CrossRef]
44. Thomas, R.; Bertolini, L. Beyond the case study dilemma in urban planning: Using a meta-matrix to distil critical success factors in transit-oriented development. *Urban Policy Res.* **2014**, *32*, 219–237. [CrossRef]
45. Yin, R.K. *Case Study Research: Design and Methods*, 3rd ed.; Sage Publications: London, UK, 2003.
46. Altheide, D. *Process of Qualitative Document Analysis In Qualititive Media Analysis*; Sage Publications: Newbury Park, CA, USA, 1996.
47. Wesley, J. Observing the Political World: Quantitative and Qualititative Approaches and Explorations: A Navigator's Guide to Research. In *Explorations: A Navigator's Guide to Quantitative Research in Canadian Political Science*; Nelson Canada Publishing: Toronto, Canada, 2011.
48. Bowen, G.A. Document analysis as a qualitative research method. *Qual. Res. J.* **2009**, *9*, 27–40. [CrossRef]
49. Stemler, S. An overview of content analysis. *Pract. Assess. Res. Eval.* **2001**, *7*, 1–6.

50. Elo, S.; Kyngäs, H. The qualitative content analysis process. *J. Adv. Nurs.* **2015**, *62*, 107–115. [CrossRef]
51. Central Intelligence Agency. The World Factbook. 2018. Available online: https://www.cia.gov/library/publications/the-world-factbook/ (accessed on 16 December 2019).
52. Devaney, L.; Henchion, M. Who is a Delphi 'expert'? Reflections on a bioeconomy expert selection procedure from Ireland. *Futures* **2018**, *99*, 45–55. [CrossRef]
53. Bullock, C.; Morrison, R. *A National Biodiversity Review for Ireland*; University College Dublin: Dublin, Ireland, 2018.