

Article

Mapping and Analysis of Biomass Supply Chains in Andalusia and the Republic of Ireland

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Abstract: The bioeconomy can play a critical role in helping countries to find alternative sustainable sources of products and energy. Countries with diverse terrestrial and marine ecosystems will see diverging feedstock opportunities to develop these new value chains. Understanding the sources, composition, and regional availability of these biomass feedstocks is an essential first step in developing new sustainable bio-based value chains. In this paper, an assessment and analysis of regional biomass availability was conducted in the diverse regions of Andalusia and Ireland using a bioresource mapping model. The model provides regional stakeholders with a first glance at the regional opportunities with regards to feedstock availability and an estimate of the transportation costs associated with moving the feedstock to a different modelled location/region for the envisioned biorefinery plant. The analysis found that there were more than 30 million tonnes of (wet weight) biomass arisings from Ireland (84,000 km²) with only around 4.8 million tonnes from the Andalusian region (87,000 km²). The study found that Cork in Ireland stood out as the main contributor of biomass feedstock in the Irish region, with animal manures making the largest contribution. Meanwhile, the areas of Almería, Jaén, and Córdoba were the main contributors of biomass in the Andalusia region, with olive residues identified as the most abundant biomass resource. This analysis also found that, while considerable feedstock divergence existed within the regions, the mapping model could act as an effective tool for collecting and interpreting the regional data on a transnational basis.

Keywords: biomass; mapping; bioresources; circular economy; bioeconomy; waste; modelling; bio-based; biorefinery

1. Introduction

Availability of biomass is essential to the successful implementation of the bioeconomy across Europe. The European Union (EU) has set a target of 32% renewable energy by 2030 under Renewable Energy Directive II, while the Bio-based Industries Consortium has also set out ambitious targets for bio-based products, including 30% of all materials and chemicals produced from bio-based sources by 2030 [1]. Being able to map available biomass supply and match it with demand will be an

essential aspect of meeting these targets. A recent study suggested that 34 MMT (million metric tonnes) of biomass per annum would be required to replace 20% of chemical and oil-based products in Europe with bio-based products by 2020, with at least 50 MMT required to replace 30% by 2030 [2]. Meanwhile, an additional 48 MMT of biomass will be required to produce conventional biofuels, with up to 80 MMT required to produce bio-based power and heat [2]. Total existing EU biomass utilisation for food, feed, and materials is 1100 MMT. A recent report by the European Commission's Joint Research Centre (JRC) into biomass production, supply, uses, and flows in the European Union showed that, overall, Europe is a net importer of biomass in order to meet its biomass use requirements [3]. Ensuring that the growing demand for biomass in Europe can be met by local supply is challenging. In addition, costs of feedstock are often higher in Europe than in other jurisdictions due to regulations, climatic conditions, and/or higher labour and operating costs [4]. Importing biomass is being considered in some cases in order to meet our bioeconomy and bioenergy targets. Imported solid biofuels, for example, mainly composed of wood pellets, accounted for around 7% of all primary energy production from solid biofuels in the EU-28 in 2013 (JRC). With increasing demand for biomass within the EU but also in other parts of the world such as Japan, South Korea, and India, additional domestic and imported resources will be needed [5]. There is also a risk that innovative European bio-based companies may relocate to Southeast Asia or South America, where biomass is a lower cost and more abundantly available. Although the EU is investing heavily in the research and development of fermentation-based building blocks, the majority of new facilities are being built outside Europe, mainly in Asia and Brazil, in part due to availability of low-cost sugars [6].

The innovation being developed in the framework of the BBI JU (Bio-Based Industries Joint Undertaking) is creating a clear path and competitive advantage for the European bioeconomy in the future [1]. Hence, it is vitally important that this is not compromised by supply chain uncertainty. The European Union is responding to this challenge, investing in projects which work to develop new industrial crops in marginal areas, whilst also investing in research which focuses on improving the supply chains of existing resources [7]. In this regard, Information and Communication Technologies (ICT) are playing an increasing role in improving supply chain efficiency. These include technologies like radio frequency identification (RFID) or sensors for monitoring biomass quality and storage conditions, or location tracking to allow logistics providers to optimize their services [8]. Other ICT tools which can work on improving existing biomass supply chain efficiency include mapping and modelling platforms [8]. These platforms can map data on available and potential biomass resources and help users to make decisions on how best they can be utilised. OPTIMASS is one such example where a mathematical model was developed to optimise strategic and tactical decisions in bio-based supply chains [9]. Another approach from Smith et al. (2019) focuses on the development and application of a decision support tool for biomass co-firing in existing coal-fired power plants [10]. This study modelled multiple biomass sources as well as pretreatment options and process configurations. Leduc et al. (2010) developed a Mixed-Integer Linear Programming model to determine the optimal geographic locations and scale of wood gasification plants in Austria [11]. Sosa et al. (2015) introduced a tactical linear-based optimisation model developed to minimize total biomass supply chain costs, including harvesting, storage, chipping, and truck transportation [12]. Alam et al. (2012) used a Geographic Information Systems (GIS)-based optimisation model to optimise the supply chain of a forest biomass power plant with the goal of minimizing the total cost including felling, pruning, piling, loading, and transportation. The GIS model is used to estimate transport costs from each forest cell to the power plant [13]. Peterson et al. described the use of a biomass scenarios model to model the entire biomass-to-biofuels supply chain in the United States. In order to gain a clear view into the evolution of the supply chain for biofuels, the model focuses on the interplay between marketplace structures, various input scenarios, and government policy sets [14]. Funded research projects have also attempted to improve information on supply chain availability at a national level. The S2Biom project, for example, has carried out a national-level scoping of biomass for countries across Europe, covering the whole biomass delivery chain—from primary biomass to end use of nonfood products, and from logistics

and pretreatment to conversion technologies [15]. The AGROinLOG project, meanwhile, focused on demonstration and evaluation of integrated biomass logistics centres while also carrying out some mapping of biomass sources in participating countries [16].

Another approach to biomass supply modelling is Zero Waste Scotland's bioresource mapping model, which maps out the availability, fate, price, and freight costs of several biomass feedstocks around Scotland [10]. This paper describes how this Zero Waste Scotland mapping model was used to map and analyse biomass supply chains in Andalusia (Spain) and the Republic of Ireland, areas characterised by diverse primary production. Previous work has been conducted on availability and supply of biomass at a European level, and indeed for some EU countries [3,17–20]. The importance of the work in this paper stems from the, heretofore, limited level of biomass mapping in both jurisdictions. In Ireland and Spain to date, various reports have put forward estimates of total national biomass arising across a variety of sectors. Previous work through nationally funded initiatives such as BioÉire in Ireland and PROBIOGAS in Spain, along with the EU-funded AgroCycle project which covers both regions, have provided estimates of biomass on a national level only [21–25]. One additional paper does attempt to quantify biomass potential for the Andalusian region for bioenergy purposes but does not provide a provincial level breakdown of biomass and bioresources. [26]. Additional literature review finds that other studies similarly took a national-level approach to estimating biomass for the regions [27–29]. The work documented in this paper goes further than previous studies, in attempting to provide a regional breakdown which highlights the geographical distribution of selected biomasses and bioresources for both the Irish and Andalusian regions. Such information is necessary to begin identifying regional bioeconomy opportunities. Furthermore, the approach of the authors provides a first look at the existing fate, transport costs, and prices of different biomass sources in both regions. Another aspect that sets this current modelling work apart is its focus on bioresources, a factor that focuses on the main constituents of the biomass, for example, the protein, carbohydrates, fat, lignin, and nutrients component of each feedstock. Previous studies on biomass arisings in these jurisdictions have focused solely on the bioenergy potential of such arisings [29–31]. The fact that all EU countries must meet ambitious 2030 renewable energy targets in line with Renewable Energy Directive II may provide a basis for that. However, biomass also offers the opportunity for member states to develop sustainable alternative chemicals, materials, and fertilisers as well as food and feed supplies. Focusing this research on the bioresources provides regional stakeholders with a first look at the potential of various bioresource arisings, along with biomass arisings for both regions.

2. Materials and Methods

2.1. Bioresource Scoping

In order to generate meaningful estimates to allow assessment of the potential of supply chains for biorefining in Ireland and Andalusia, a phased methodology was adopted for data collection, material characterisation, modelling of data, and interpretation of outputs. This methodology was designed with the full expectation that data gaps would be encountered, and therefore that flexibility would be required to arrive at a usable model based on the best currently available data. All local data from the two regions were collated by the respective local partner: Institute of Technology, Tralee (ITT) for the Irish region and Consejería de Agricultura, Ganadería, Pesca y Desarrollo Sostenible de la Junta de Andalucía (CAGPDS) for the Andalusian region. The manipulation of the data into the Bioresource Mapping Model was conducted by Ricardo Energy and Environment with input from the Industrial Biotechnology Innovation Centre in Scotland. The data were limited to three value chains to allow the models to act as a proof of concept for each region with the opportunity to expand the models with further value chains in the future. The selected value chains for each region are highlighted in Table 1 below.

2.2. The Methodology Developed for Bioresource Scoping was a Three-Step Process

- **Material arising:** material arising from the selected three value chains within each region were quantified with geographical breakdown to county/provincial level
- **Characterisation (bioresource content):** composition of the bioresource was identified (dry matter, calorific value, protein, fat, carbohydrate, etc.)
- **Accessibility:** temporal availability (transport) and existing uses and economic constraints were assessed

The three value chains assessed within the two regions are as follows (see Table 1):

Table 1. Selected value chains for Ireland and Andalusia.

Ireland	Andalusia
Lignocellulose	Olive
Horticulture	Horticulture
Manure	Algae

For each selected value chain, the three levels of data, materials arising, bioresource content, and accessibility constraints, were collected. These data were then manipulated within the model, as shown in Figure 1, to provide an output of the bioresource availability.



Figure 1. Simple overview of model calculation.

2.3. Material Arising

In order to build the bioresource mapping model for each region, a large amount of data was collated from various sources. The specification of the type of information required was based on the Bioresource Mapping Model previously developed and implemented in Scotland [17]. The cumulative total included is over 30 million tonnes for the Irish region and 4.8 million tonnes for the Andalusian region of potential feedstocks for biorefining, which was mapped within the dynamic tool.

2.4. Bioresource Content

The model allows for key biochemical components to be reviewed. The team decided on 24 key components that would be collated to define each biomass arising. The main components were Protein, Fat, and Carbohydrate (C5 and C6 sugars). The source of these data was varied with data from existing literature sources including the United States Department of Agriculture, Energy Research Centre of the Netherlands, and Teagasc and data calculated by the Irish biomass analytical company Celignis in the case of Ireland, while for Andalusia, data were mainly provided by Agencia de Gestión Agraria y Pesquera de Andalucía, (Agency for Agrarian and Fisheries Management of Andalusia) from CAGPDS.

2.5. Material Accessibility

Two factors were used in order to quantify the potential of each bioresource material for use in biorefinery applications: the existing uses of the material and the distance of the material from a potential biorefinery site. These two factors were identified as accessibility constraints in Figure 1 above. Information was gathered on the existing fate of the bioresource material arising, both the quantity and cost associated with the current outcome. The availability and accuracy of data varied across both regions according to the material and their fates; however, estimates were formed using existing knowledge from the two regions.

In order to address the question of whether the material is too far away from the point of use, the following calculation was performed. Firstly, centroid locations were identified for each county/province using GIS. A straight-line distance between counties/provinces was then calculated, which was then augmented by a factor (1.3 for the Irish region and 1.2 for the Andalusian region) to account for the deviation of roads from straight-line distances. Finally, a unit price for freight was applied. These calculations were yielded in a table of prices (in €/tonne) to move material between any two local counties/provinces.

The information flow of the mapping model is highlighted in Figure 2 below. The model contains three calculation sheets where the user can manipulate the data from the background data sheets to get the output they require. Selection options within the model include the selection of a single bioresource to be modelled. The user may also not be interested in considering all possible materials, therefore the Arisings potential (PT) and Bioresources potential (PT) can be used to screen for certain categories, materials, and fates as desired. In order to update the model for the desired output, “Refresh All” buttons are used to update any changes. Another possible adjustment is the assumed location of a biorefinery. On the Arisings PT sheet, the model calculates the optimum location for a biorefinery that minimises the tonnes-kilometres of freight required to bring all arisings to a single location. Alternatively, the user can edit the freight sheet to switch between a “calculated centre” to a chosen location of the biorefinery.

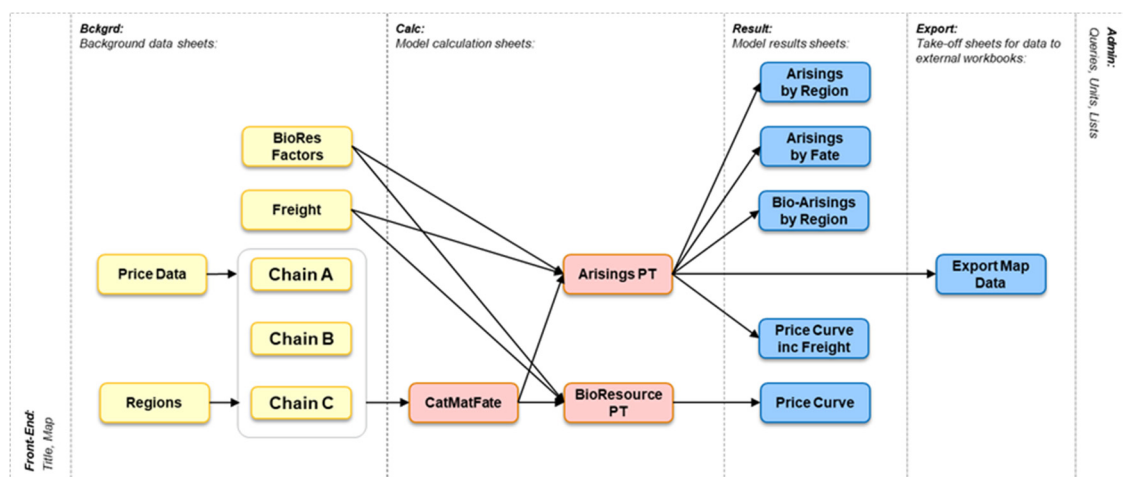


Figure 2. Bioresource Mapping Tool Model.

Once the user has manipulated the calculation data sheets, the results can be viewed in the results data sheets. The results data sheets primarily produce visual outputs in graphic form, as illustrated below.

3. Results

3.1. Bioresource Mapping in Ireland

The model for the Irish region compiles information for the whole of Ireland, broken down by each county, for the three value chains: lignocellulose, horticulture, and manure. The total of these

materials arisings is 30 million tonnes (wet weight) of potential feedstocks for biorefining, the summary of which is shown in Figure 3. This information can also be viewed as a geographical heat map that visualises the distribution of the materials (dry weight), as shown in Figure 4.

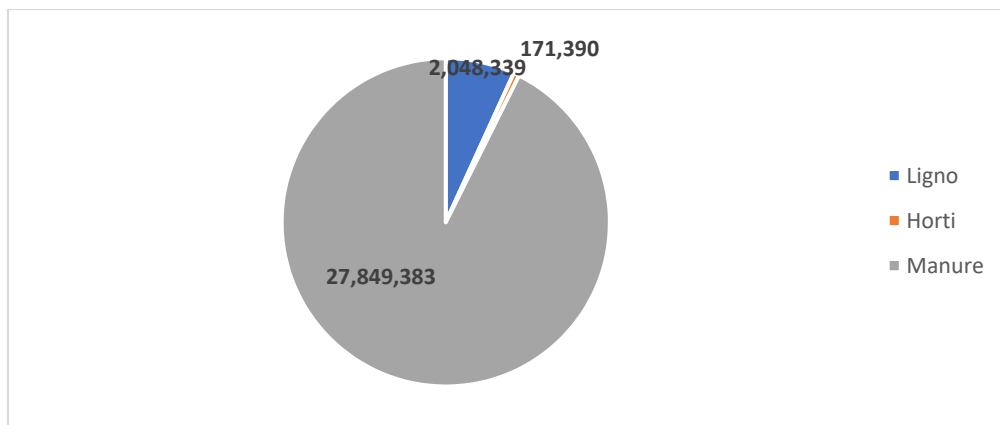


Figure 3. Total potential feedstocks for biorefining in the Irish region in tonnes.

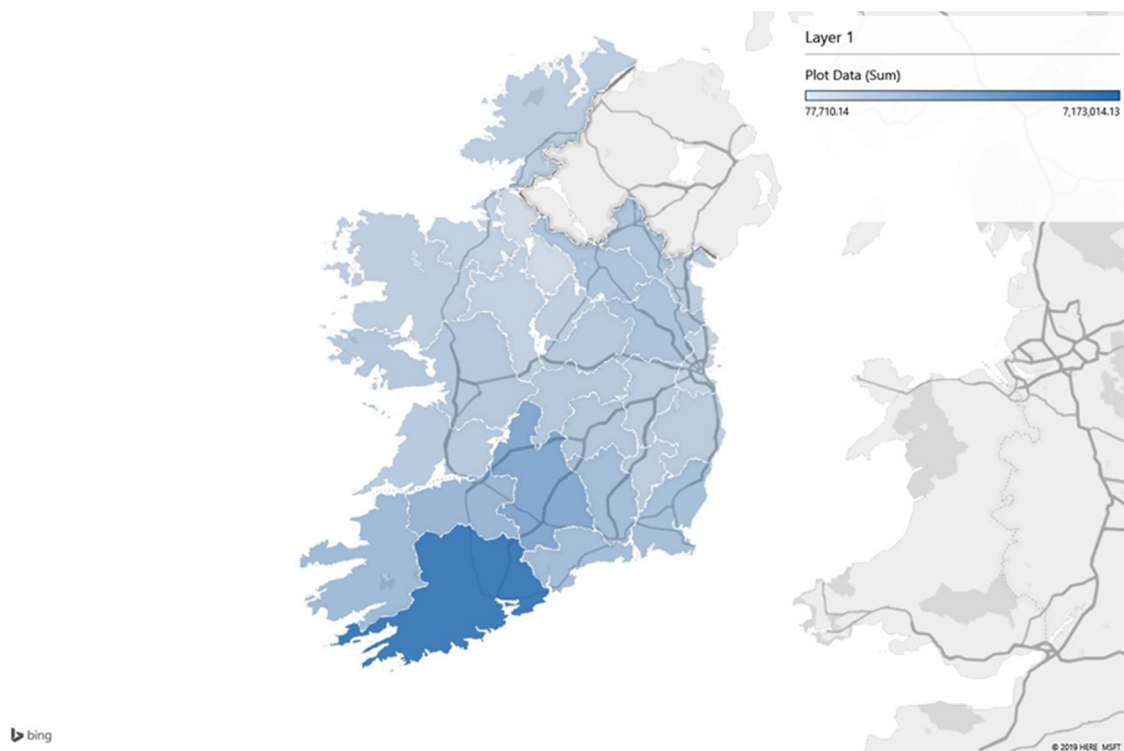


Figure 4. Geographical heat map of potential feedstock distribution.

The heat map distribution of the materials in Ireland reveals that Co. Cork in particular stands out as the main contributor, with over seven million tonnes of materials. Figure 5 below shows the six counties with the highest amount of materials from the three materials categories of lignocellulose, horticulture, and manure. The dominant source of biomass in each of these counties is found to be manure from either dairy or pig.

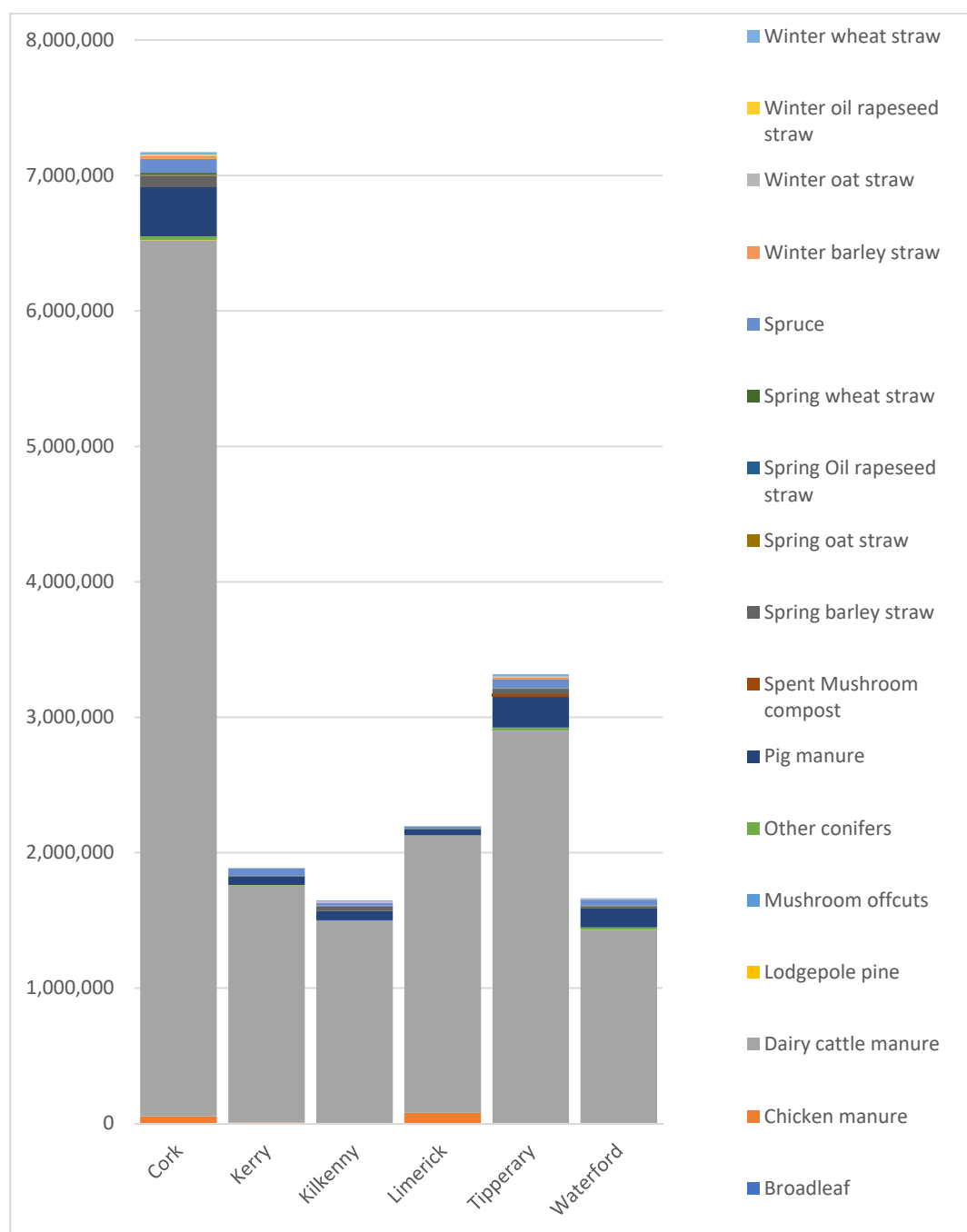


Figure 5. Six counties with highest quantity of biomass materials in tonnes.

The available bioresource from the different materials that have been mapped in the region can be calculated based on the compositional data for each material arising. The individual components called bioresources were calculated for each county and are presented in the graphs and the heat map below for the modelled area. Figure 6 below shows the dry weight tonnage of lignin per county and the accompanying “Material versus Bioresource” schematic shows how the selected material from a specific region contributes to the bioresource being analysed. The scale is relative so that the highest value will always be given the value of 100%. The plot data in the table are the input values for the heat map graph. Figure 7 below shows the availability of lignin from the Irish region arising from the different feedstock material categories that have been mapped (manure, lignocellulose, and horticulture). Total lignin is interesting for energy as well as new biomaterial applications, as new

innovative concepts are being commercialised where lignin is used as resins, building blocks for bioplastics, or in the production of nanofibers [32].

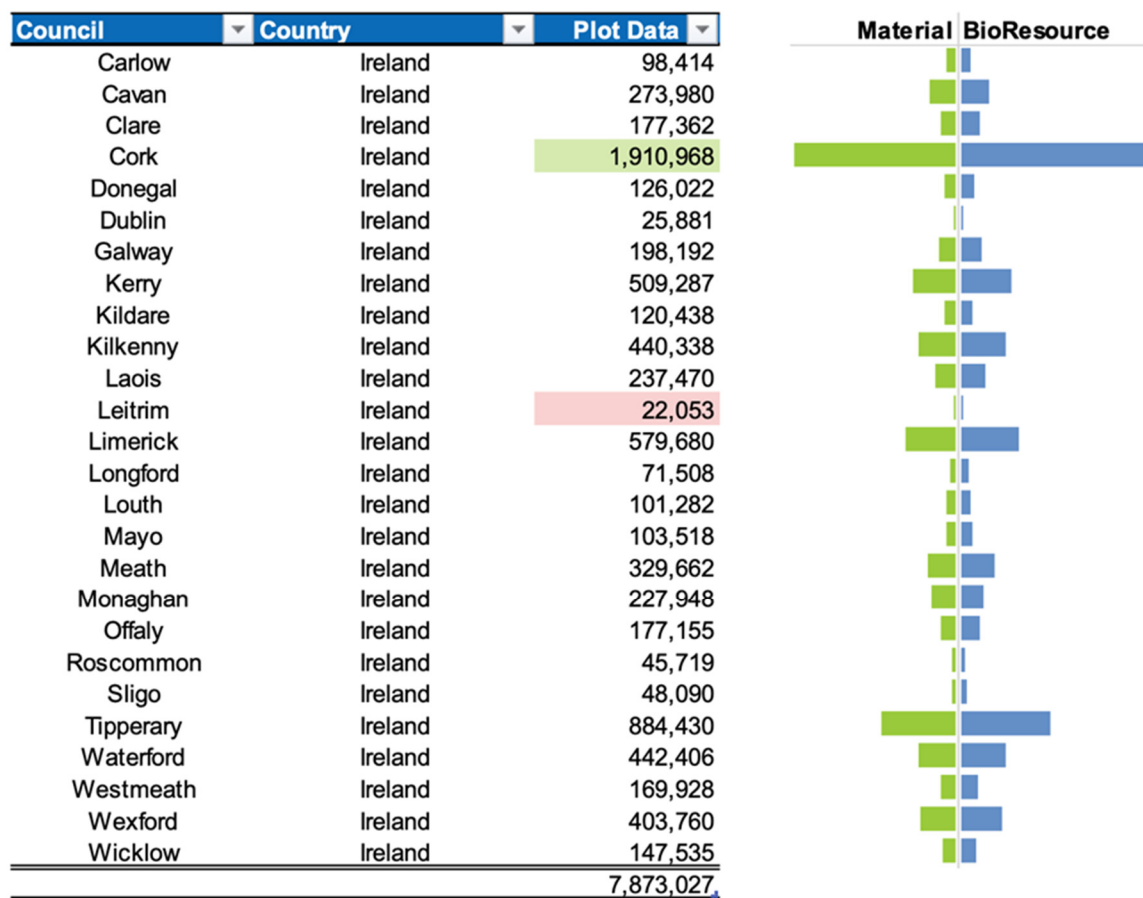


Figure 6. Material versus Bioresource for Total Lignin per county.

Other bioresources that can be analysed through the mapping model include, but are not limited to, protein, fat, and carbohydrates (broken down into C5 and C6 sugars), along with nutrient composition such as nitrogen, potassium and phosphorous. Some of the applications that are relevant for these bioresources are, for example, protein into food and feed products, fat into biodiesel or surfactants, or other specialty chemicals. Carbohydrates are an important source for fermentable sugars that can be further converted into chemicals, materials, food, feed, and fuels. The further breakdown of carbohydrates to C5 sugars (pentoses) and C6 sugars (hexoses) is an important distinction for the different suitable conversion routes available. Glucose and mannose are, for example, easily fermented into products, whereas xylose and arabinose are potentially easier to convert through chemical catalysis routes.

The dominant biomass found is manures from cattle and pigs, which is a suitable feedstock for the production of biogas and biomethane through anaerobic digestion. Through a combination of forestry residues and straw from cereals, there is also a sizeable quantity, approximately 2 million tonnes, of lignocellulosic biomass. This feedstock can have interesting applications in the production of fuels and chemicals as well as bioplastics [33,34]. Mushroom residues, while found in comparatively small quantities and only in specific regions of Ireland, can be a good a source of value-added products such as chitin and chitosan, or for the conversion into bio-based products such as biochemicals or biopesticides.

Figures 8 and 9 below are shown to exemplify the model functionality to generate a price curve of a given bioresource (in this case Total Lignin) calculated from the price associated with its current use (fate) and also including the cost of transport (freight). This information provides insight into the cost

side of the business case and how much of a bioresource can be accessed depending on how much a business is willing to pay.

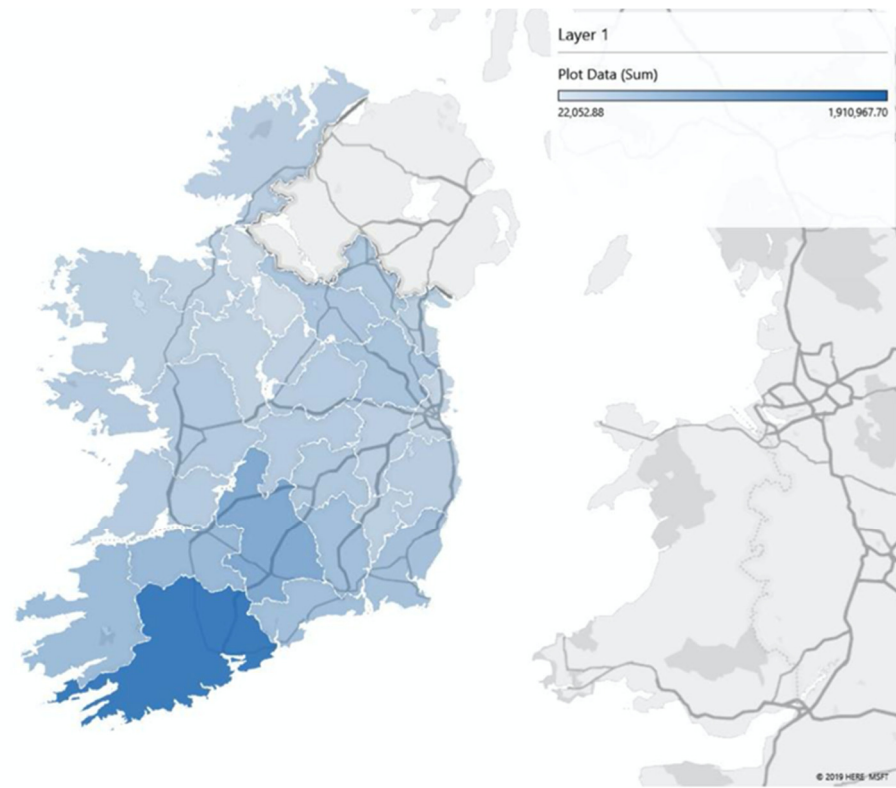


Figure 7. Heat Map Distribution of Total Lignin in Ireland.



Figure 8. Price curve for Total Lignin in Ireland.

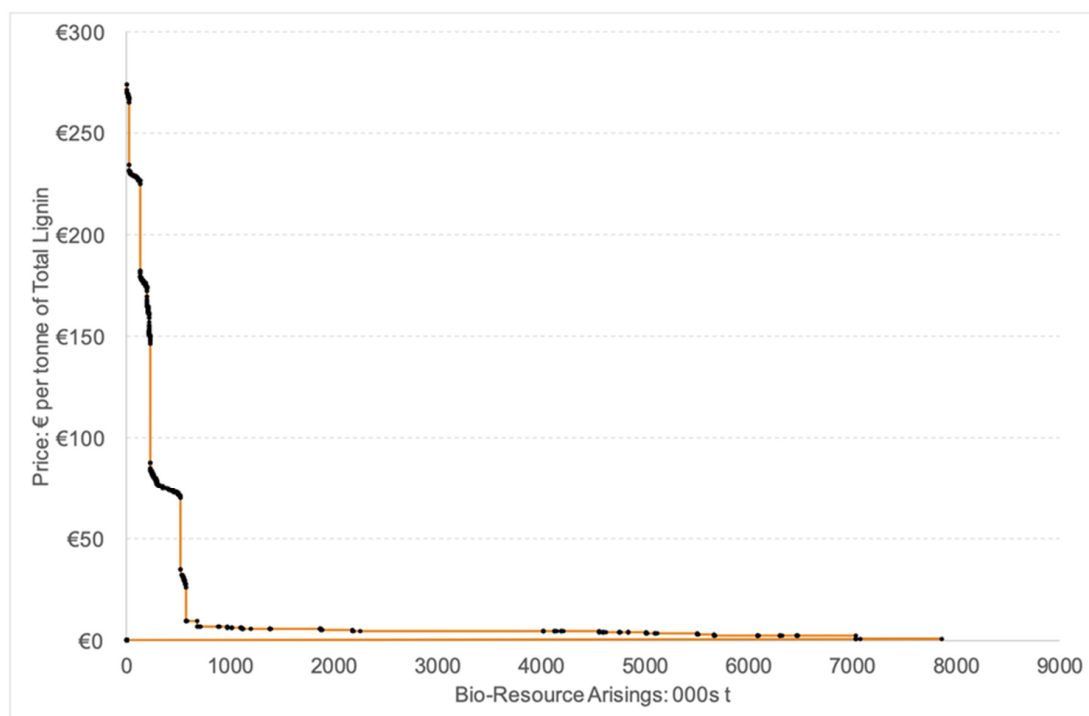


Figure 9. Price curve (including freight cost) for Total Lignin in Ireland.

3.2. Bioresource Scoping in Andalusia, Spain

The model for the Andalusian region compiles information broken down on a provincial level for the whole of Andalusia for the three value chains: olive, horticulture, and algae. The total of these materials arisings is 4.8 million tonnes (wet weight) of potential feedstocks for biorefining, the summary of which is shown in Figure 10. This information can also be viewed as a geographical heat map that visualises the distribution of the materials (dry weight), as shown in Figure 11. As the total algae arisings are comparatively small compared with olive and horticultural residues, this is not clearly visible in Figure 10 below.

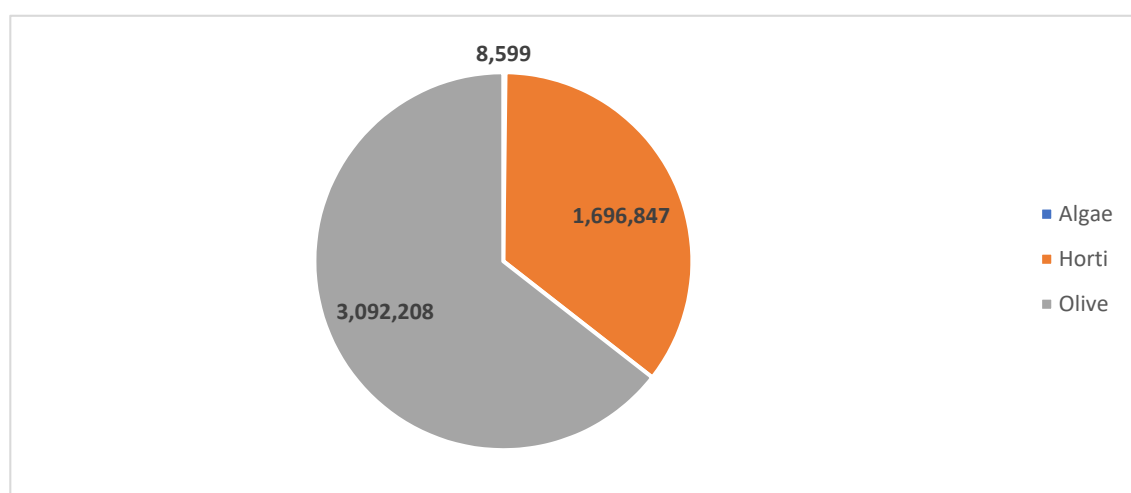


Figure 10. Total materials arising in Andalusia, Spain, in tonnes.

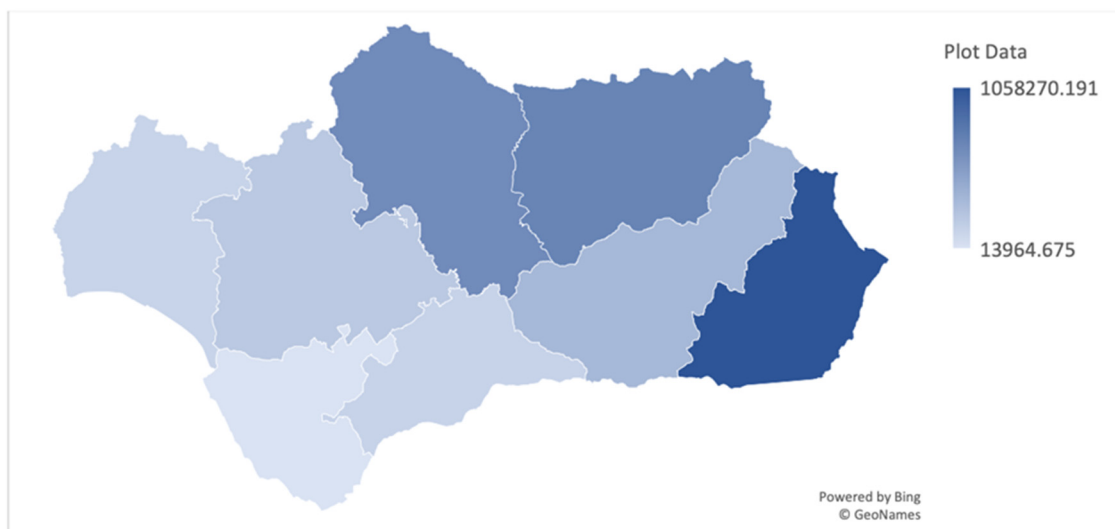


Figure 11. Heat map distribution of dry matter from total materials arising in Andalusia, Spain.

The heat map distribution in Figures 11 and 12 below reveals that Almería stands out as the main contributor of biomass, with over 1 million tonnes of dry weight materials. Figures 13–16 below display a breakdown of all materials over all of the 8 provinces in the three value chains of olive, horticulture, and algae. The figures reveal that Almería, Jaén, and Córdoba stand out as large contributors of feedstock for biorefining. The dominant biomass in these provinces are found to be from olive production in Córdoba and Jaén and from vegetable production in Almería. Olive residues have shown to be an interesting feedstock, both in terms of energy production and for the extraction of high-value compounds such as antioxidants, while horticultural residues such as tomato waste can be used as input in bio-based processing, for example, extraction of bioactive compounds from the pomace or the production of biomaterials such as particleboard using the stalk fibres [35–38]. Micro and macroalgae can be used as a suitable feedstock for the extraction of lipids (for use in biodiesel and food applications) and bioactive compounds (for use in pharmaceutical and nutraceutical applications), respectively.

Province	District	Community	Country	Plot Data	Material	BioResource
Almería	Almeria	Andalucia	Spain	1.058.270	1.243.498	1.058.270
Cádiz	Cadiz	Andalucia	Spain	13.965	-36.245	13.965
Córdoba	Cordoba	Andalucia	Spain	658.302	-993.832	658.302
Granada	Granada	Andalucia	Spain	323.742	-502.744	323.742
Huelva	Huelva	Andalucia	Spain	123.902	-179.720	123.902
Jaén	Jaen	Andalucia	Spain	707.988	1.184.055	707.988
Málaga	Malaga	Andalucia	Spain	130.927	-215.142	130.927
Sevilla	Sevilla	Andalucia	Spain	205.025	-442.419	205.025
				3.222.121		

Figure 12. Total materials arising in Andalusia (dry matter).

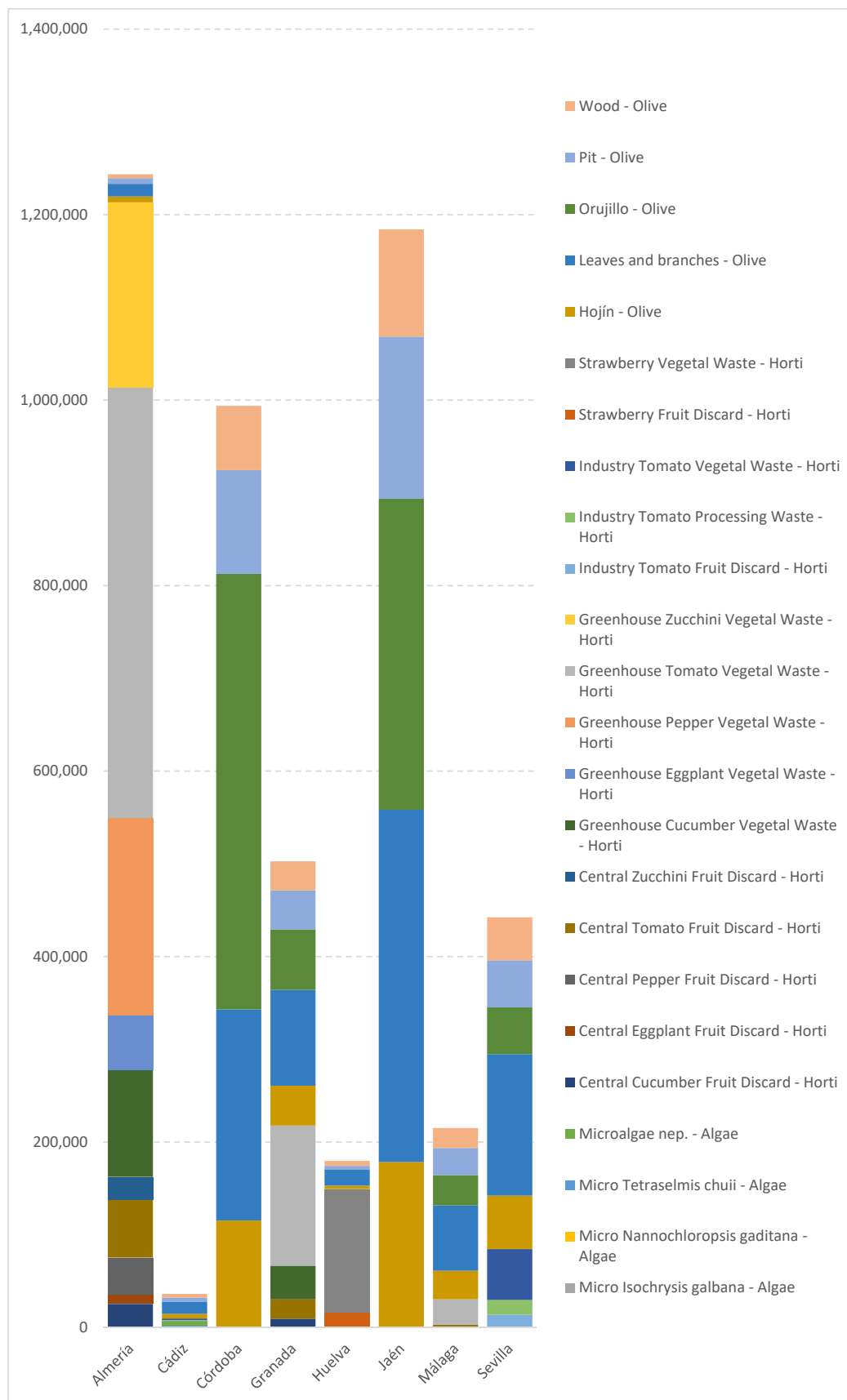


Figure 13. Biomaterials in Andalusia on a regional basis.

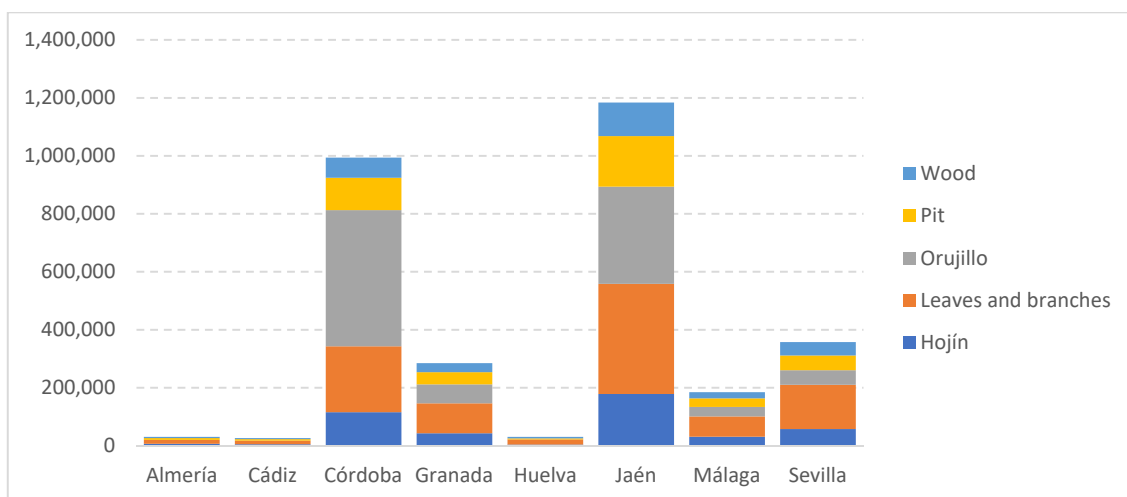


Figure 14. Olive residues in Andalusia on a regional basis.

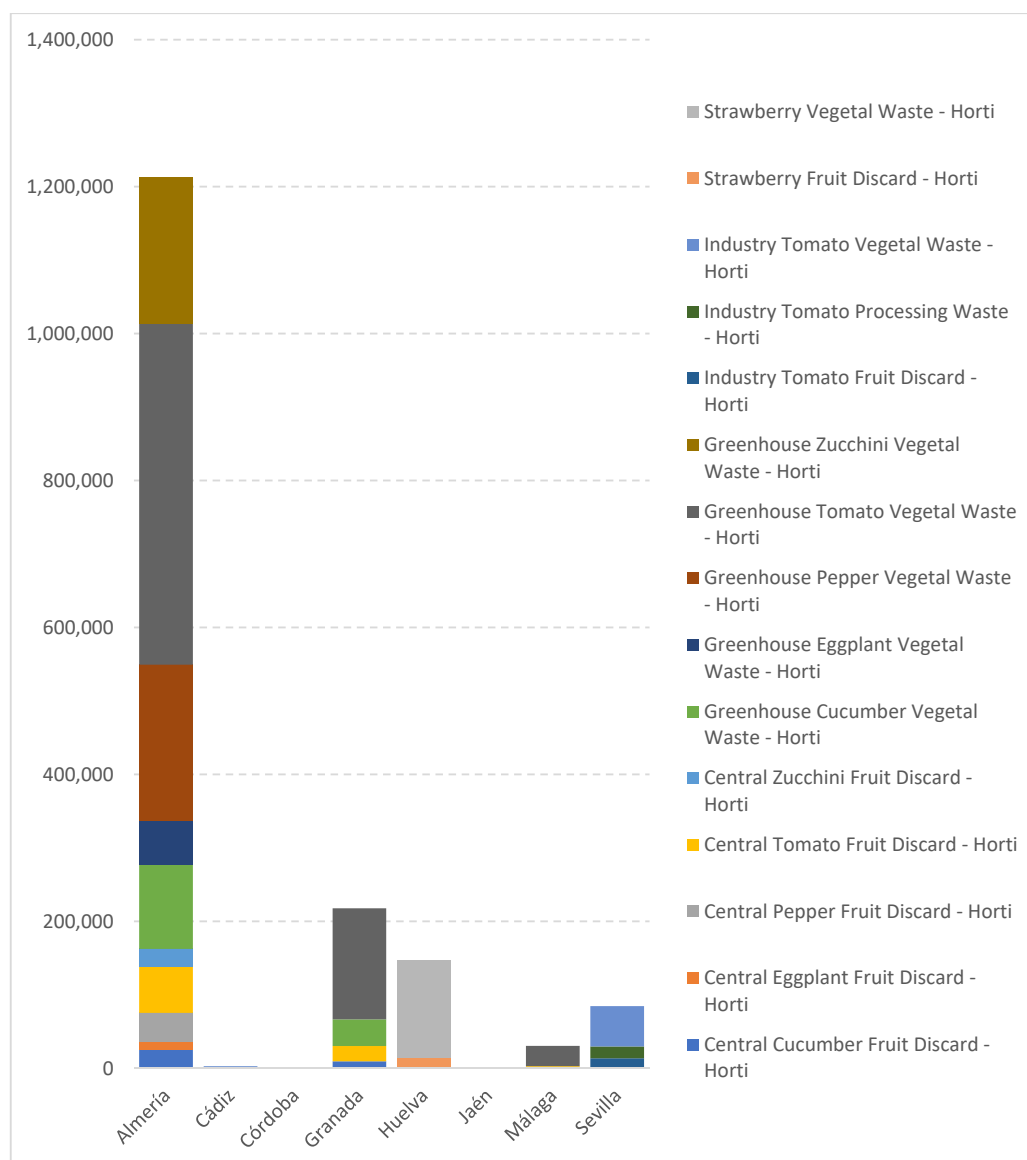


Figure 15. Horticulture residues in Andalusia on a regional basis.

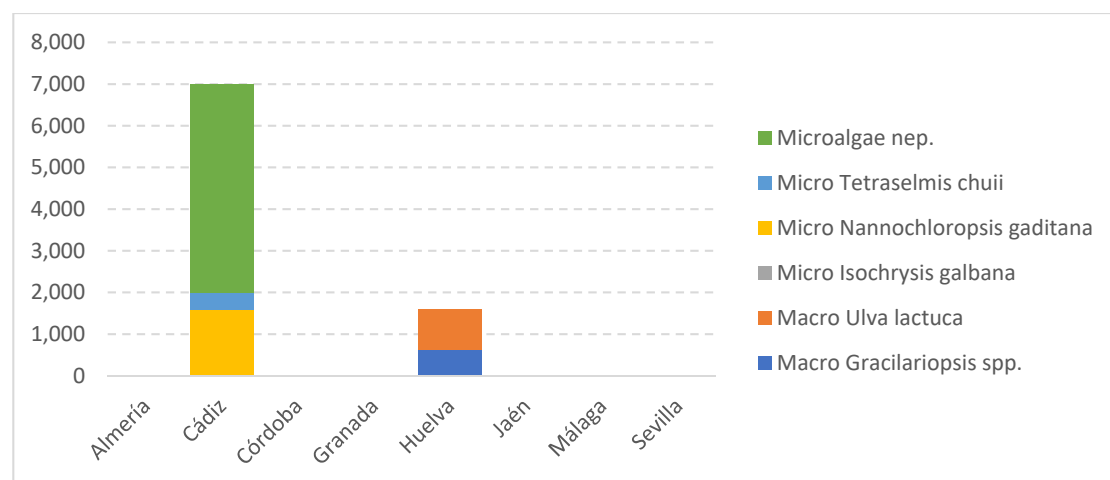


Figure 16. Algae residues in Andalusia on a regional basis.

As was shown above for the Irish region, similar tables and heat maps for the total output of a particular bioresource can also be modelled for the region of Andalusia. As an example, Figure 17 shows the total output of carbohydrates available from olive, horticulture, and algae. Figure 18 shows the dry weight tonnage of carbohydrates per province, and how the selected materials from a specific region contribute to the bioresource being analysed. The scale is again relative so that the highest value will always be given a value of 100%. The plot data in the table are the input values for the heat map graph.

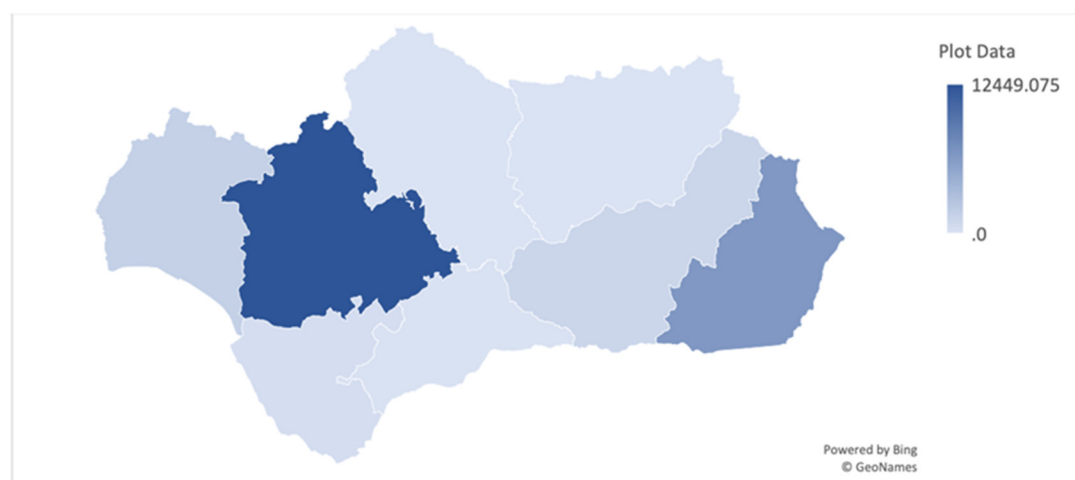


Figure 17. Heat map distribution for the total carbohydrate arising in Andalusia, Spain.

Province	District	Community	Country	Plot Data	Material	BioResource
Almería	Almeria	Andalucia	Spain	6.568	1.243.498	6.568
Cádiz	Cadiz	Andalucia	Spain	423	-36.245	423
Córdoba	Cordoba	Andalucia	Spain	0	-993.832	0
Granada	Granada	Andalucia	Spain	1.157	-502.744	1.157
Huelva	Huelva	Andalucia	Spain	1.629	-179.720	1.629
Jaén	Jaen	Andalucia	Spain	0	1.184.055	0
Málaga	Malaga	Andalucia	Spain	115	-215.142	115
Sevilla	Sevilla	Andalucia	Spain	12.449	-442.419	12.449
				22.342		

Figure 18. Total carbohydrate arising in Andalusia, Spain.

4. Discussion

By comparing the total amount of materials arising from the two regions, it is apparent that there is a large difference, with more than 30 million tonnes (wet weight) from Ireland (84,000 km²) and only around 4.8 million tonnes from the Andalusian region (87,000 km²). On a dry weight basis, the comparison is 23 million versus 3.2 million tonnes, indicating that the difference between the regions is independent from the water content of the selected materials. The distribution of material in the Irish region is very much dominated by the county of Cork, which holds almost a quarter of the total material with a large quantity of total bioresources, including protein, fat, carbohydrate, C5 sugars, C6 sugars, and total lignin located there. The source of material in Ireland is also heavily dominated by cattle and pig manures. The Andalusian region shows a more diverse distribution of materials, with the three provinces of Almería, Jaén, and Córdoba contributing strongly to the total amount of material. Compared to Ireland, which is strongly influenced by the category of manure, both olive and horticulture contribute significantly to the total amount in the Andalusian region, with 3 and 1.7 million tonnes, respectively. Less than 1% comes from Algae. The region of Almería holds the largest amount of protein, and the region of Sevilla holds the largest amount of fat and carbohydrates. In Ireland, the counties of Cork, Tipperary, Limerick, Kerry, Waterford, and Kilkenny rank at the top for all major bioresources (protein, fat, carbohydrate, C5 sugars, C6 sugars, and total lignin) except for protein, where Monaghan replaces Kilkenny in the top 6. In Andalusia, the concentration of the different categories of materials are very distinct and offer opportunities for biorefining from olives in mainly Jaén and Córdoba and from horticulture in Almería. The algae resources, which come with their own distinct opportunities of high-value products, are very focused in Cádiz and Huelva. In Ireland, Monaghan stands out as a potential location for biorefining operations based on spent mushroom compost and mushroom offcuts. With regards to manure and lignocellulose, these are more distributed than mushroom but with an increased concentration around Cork, Tipperary, and Limerick, with a few other counties following closely behind.

In collecting data for the mapping model, it was ensured that the sources were reputable, and where available, using government statistics including information from the agricultural census. The statistical information used was the most up-to-date information available in each region at the time of publication. Where such data were not available, data were obtained firsthand from industry experts, producers, co-op representatives, and industry organisations.

The work done within this study is a first assessment of the regional bioresource availability of two diverse regions, Ireland and Andalusia. Previously, much of the mapping of wastes was restricted to conventional wastes such as household and municipal wastes. The previously conducted mapping of biomass wastes has been restricted to a national level, rather than any real attempt to understand the regional distribution of these feedstocks. There are numerous benefits to mapping out bioresources and their current fate on a regional level. Understanding the quantities and locations of these resources can act as a first step towards new bio-based value chain development. This can help identify where organisations should be placing their efforts, which will serve as an opportunity to maximise the efficiency and output of their business. The identification of these resources could more importantly serve as an opportunity for new business ideas to base their income on applications of these resources or the logistics of accessing and transporting unused materials. For preexisting businesses, the biomass mapping model can help evaluate the possibility of shifting their feedstocks from fossil fuels to regional biomass sources if the current bioresource availability in the vicinity of their production plant, the current price, and the freight costs are all known. This could support regional companies, organisations, and municipalities in the transition to a low-carbon economy.

Apart from businesses, other stakeholders to benefit from the bioresource mapping are academics, who can focus their research on the strongest, and therefore most relevant, opportunities in the bioeconomy. Policy makers also benefit by obtaining a better understanding of the current biowaste ecosystem nationally, and can use these data as a basis for new legislation. This can thus help the countries and regions to meet their own targets, as well as the targets set in European and International agreements.

5. Conclusions

Using the same methodology, it has been possible to map and analyse the regional biomass and bioresource arisings in two diverse regions of primary production in Andalusia and Ireland. The methodology allows for a regional analysis of biomass feedstock supply chains, while also allowing inter-regional comparison of specific arisings. Both regions have clearly identifiable geographical areas where material streams and bioresources are clustered and thus provide potential suitable locations for future biorefining operations. The county of Cork stands out as a specifically strong area, holding almost one third of the total materials arising in Ireland, which is predominantly from manure. In Andalusia, Almería, Jaén, and Córdoba stand out as particularly strong provinces. Almería is dominated by horticulture resources and Jaén and Córdoba hold the majority of olive-derived material streams. Algae-based materials are only located in Cádiz and Huelva. This initial analysis of biomass and bioresource arisings can provide a platform for regional stakeholders to test the feasibility of new regional bio-based value chains.

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