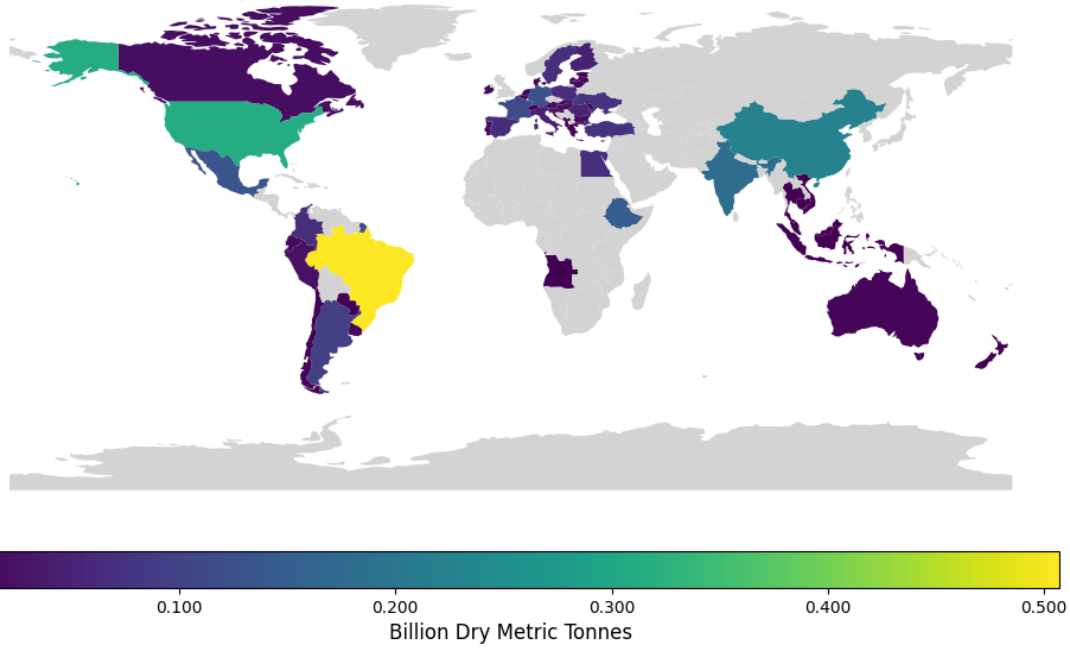
ORNL/TM-2024/3634

Mapping and Synthesis of International Biomass Supply Assessments



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January 2025

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Environmental Sciences Division

MAPPING AND SYNTHESIS OF INTERNATIONAL BIOMASS SUPPLY ASSESSMENTS

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EXECUTIVE SUMMARY

This report, *Mapping and Synthesis of International Biomass Supply Assessments* (or *Global Biomass Resource Assessment*) is the first step in a long-term process to assemble data from around the globe into a virtual repository that can be updated and provide user-friendly access to the data. The Clean Energy Ministerial (CEM) Biofuture Platform Initiative recommended that research be completed to "address the need for internationally accepted benchmarks quantifying sustainable biomass feedstock supplies." To act upon the CEM Biofuture recommendation, in 2024, the U.S. Department of Energy (DOE) commissioned Oak Ridge National Laboratory (ORNL) to prepare this report as the primary deliverable for a one-year assignment to assemble data into a citable form that could help resolve the persistent question presented related to bioenergy policy, "Is there enough sustainable biomass?"

In response to that query, this report includes information received by August 2024 from national CEM representatives, collaborators, and public sources on current and future sustainable biomass supplies in 62 nations,and subsequently documents (a) the approach used by ORNL to analyze and categorize the information received in a manner that enables aggregation and comparability; and (b) recommendations for next steps and guidelines to help others update and harmonize future assessments of global sustainable biomass supplies.

The initial tally of biomass supplies represents only a portion of potential global sourcing and thus remains incomplete. Additionally, the requirements applied to quantify sustainable supplies varied among national assessments and merit further analysis and harmonization. With those caveats, the estimates from this 62-nation subset of the world sum to over 2,800 million metric tons of sustainable biomass supplies, primarily from Brazil, the USA, China, Indonesia and India (Figure ES-1).

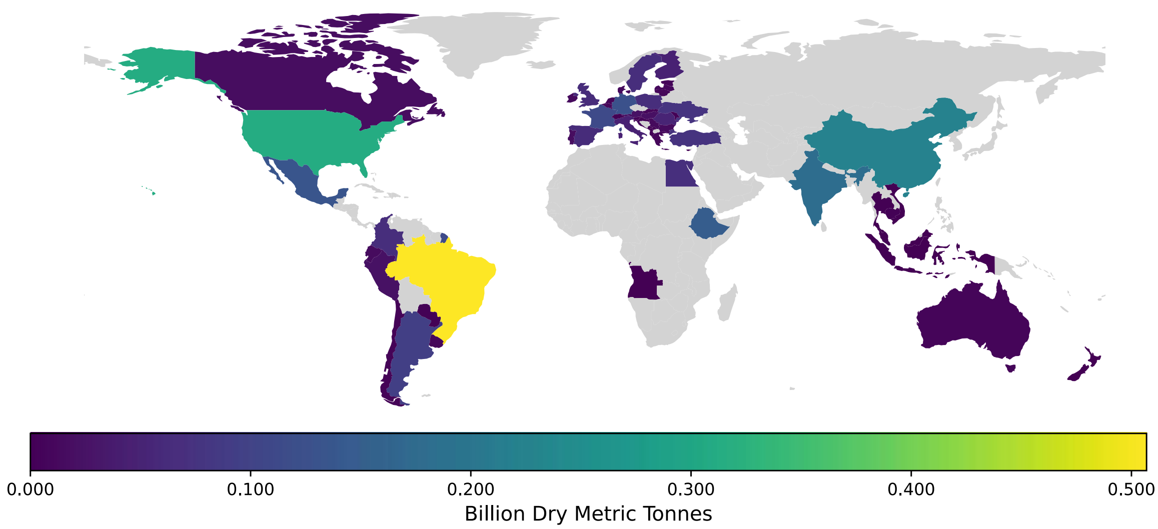

Figure ES-1. National estimates of biomass

This report is intended to provide a foundation and first step for a continuing process of improvement based on further collection and systematization. Recommendations are provided aiming to increase the consistency and utility of future sustainable biomass assessment reports and datasets. As funding permits, ORNL will continue to maintain a public data-sharing portal within the bioenergy knowledge discovery framework and will perform periodic updates and improvements to the dataset based on information submitted by stakeholders to: biomass.updates@ornl.gov.

1. INTRODUCTION

The Clean Energy Ministerial (CEM) Biofuture Platform Initiative, or *Biofuture Initiative*, was launched in 2020 at CEM11. The purpose of the *Biofuture Initiative* is to accelerate the development, scale-up, and deployment of sustainable bio-based alternatives to fossil-based fuels, chemicals, and materials. A strategic goal of the *Biofuture Initiative* is to foster consensus on biomass sustainability, availability, and governance. To contribute to this strategic goal, the *Biofuture Initiative* developed a 2024 Action Plan that included a new task to review sustainable biomass resource availability.

The lack of reliable and consistent data on sustainable biomass supplies has created barriers to investment, implementation, and public confidence in bio-based industries. In response, the *Biofuture Initiative* and U.S. DOE supported a global, bottom-up review of biomass resource availability. This report represents a first step to address the lack of an internationally recognized benchmark report quantifying sustainable biomass feedstocks. In preparing this report, many obstacles were identified that help explain the absence of a reliable data set on global sustainable biomass supplies. Barriers include high variability across studies in the terms, definitions, resource types, units, sustainability assumptions, and geographic coverage in national and regional reports.

This report supports the CEM *Biofuture Initiative* 2024 Action Plan and is prepared with the support and guidance of the U.S. DOE Technologies Office (BETO).[1] This report aims to (1) share the best available and citable data submitted by national representatives on current and future sustainable biomass supplies; (2) analyze and categorize the information received in a manner that enables aggregation and comparability; and (3) provide guidelines designed to help others update and harmonize future assessments of sustainable biomass supplies, both national and global.

This report, *Mapping and Synthesis of International Biomass Supply Assessments* (or *Global Biomass Resource Assessment*) is the first step in a longer-term process to assemble data on sustainable biomass supplies from around the globe into a virtual depository that can be updated and provide user-friendly access to the data. The report represents the launch of an ongoing process of identification, collection, and systematization that can increase the consistency and utility of future sustainable biomass assessment reports carried out by others.

Assembling, processing, and interpreting data from around the world on available national estimates of biomass resource quantities are challenges because of the following factors:

(a) The need to qualify any use of the term "sustainable supply" with a definition and sustainability criteria used by each assessment; yet the term and criteria are rarely defined and documented clearly and verifiably.
(b) The lack of consistency in units, terminology, and definitions.
(c) Lack of clarity or documentation regarding relevant biomass qualities (moisture content, heating value), conversion factors, and how technical or economic feasibility of a supply was determined.

Assigning classifications to the biomass potentials reported was complicated by the various types of supply potentials, and details of those potentials, that are presented in the data sources. These supply potentials range from resource to economic potentials (see Figure 1). These variances can have dramatic impacts on both the volume of the estimate and the associated implications for sustainability and

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[1] We appreciate and acknowledge the support and guidance form Jim Spaeth in BETO. ORNL is managed by UT-Battelle for DOE under contract number DE-AC05-00OR22725. The views expressed in this presentation are the authors' and do not necessarily represent the views of the United States Government, any sponsor, or agency.

eligibility for specific Green House Gas (GHG) reduction programs. Figure 1 illustrates a few of the factors that influence variability in types and amounts of reported biomass resource availability.

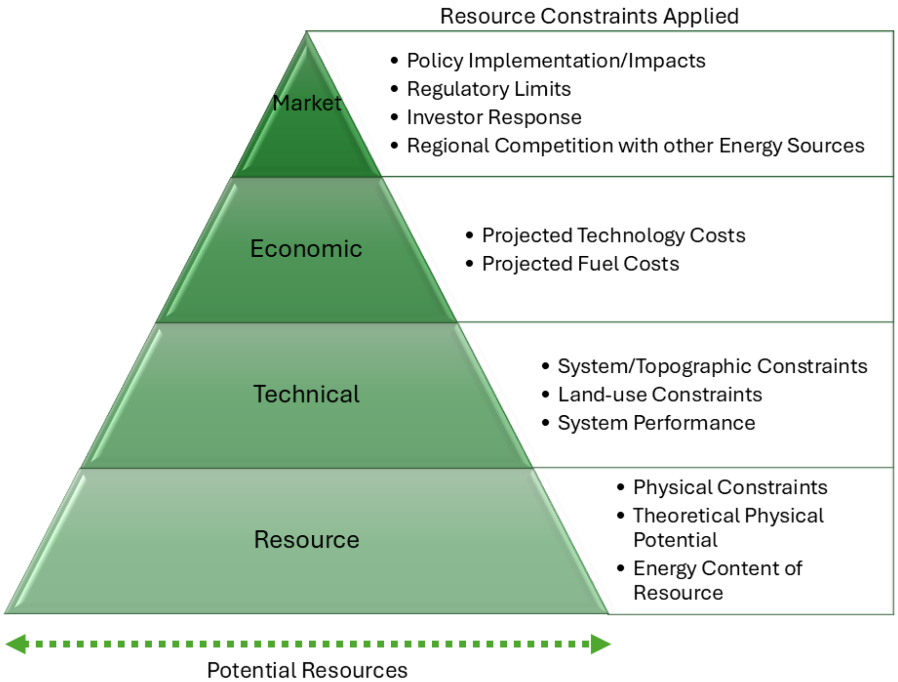

Figure 1. Types of biomass resource potential [66].

For example, the *2023 Billion-Ton Report* [1](U.S. DOE 2023) provides data on current uses and highlights the additional sustainable biomass resources available at specific time steps for bioenergy under specified market conditions, and excluding biomass projected to be used for conventional markets (food, feed, fiber, lumber, etc.). The U.S. DOE report also analyzes sustainable biomass supplies at different price points under explicit constraints to enable sustainable production and examines the sensitivity of results to such constraints. Most other reports lack such level of detail and some focus only on potential production from specific crops or sectors, or only feedstocks for selected biofuels (e.g., aviation fuels).

A significant effort was made to harmonize the information in the reports received for this task. However, this report merely documents the data received by August 2024. We hope that the data will continue to be updated and improve over time. To be included in the report, data must meet two conditions: (1) it must be non-proprietary and publicly sharable, and (2) it must provide supporting documentation so that the source can be cited and verified. Thus, this report reflects only the citable data as submitted by national representatives and does not yet reflect a comprehensive review of biomass resource production in all the listed countries.

This report summarizes the data collected to date, the types of entities producing biomass reports, and the geographic and sustainability constraints as documented in those reports. The first section of this report presents a summary of the biomass resource availability assessments based on a review of 65 national and multinational assessments submitted by Biofuture collaborators. The second section of the report presents the methodology followed in the processing of the information collected for this report.

Most of the biomass resources represented in this report are unique to a particular country or a set of countries; consequently, a significant harmonization effort was undertaken, as presented in Section 3. Another significant issue is the way countries have defined and/or implemented the concept of sustainable resources; this issue is addressed in Section 4. Finally, Section 5 provides some guidelines and suggestions to improve the quality and comparability of data in future biomass assessments. We hope that the report and recommendations contribute to an improved understanding of reported biomass supplies and help decision-makers in their efforts to accelerate the development of sustainable local and global supply chains.

The report reflects a one-year task, designed to be handed over to an international organization or governing body to continue collecting, harmonizing, and sharing estimates of biomass resource supplies. While many nations have shared some data, the current tabulation of resources is not comprehensive, and we are aware of national and regional assessments that are currently underway. Thus, further data collection, refinements, and contributions from interested governing bodies are desired and encouraged.

This report documents how the virtual data repository (available here: https://bioenergykdf.ornl.gov/document/international-feedstock-reporting) was designed and represents an initial step in what is hoped to be an ongoing process of periodic updates and expansion that includes additional countries and improved data. The U.S. DOE BETO funded the *BioEnergy Knowledge Discovery Framework*, or *BioenergyKDF.* This virtual portal will host, at least temporarily, the dataset and associated information, including the reports that are the foundation of the dataset. The *BioenergyKDF* is a centralized data hub designed to accelerate bioenergy innovation and sustainable bioeconomy practices. BETO and ORNL also support the *BioenergyKDF* and its premier report, the *Billion-Ton report* series that shares detailed geo-spatial estimates of current and future sustainable biomass resources in the United States.

2. FINDINGS

This study is based on a review of 65 reports with data for 62 countries. These countries are separated into two groups based on the time frame of reported biomass supplies. The first group consists of countries with current[2] biomass resource data availability; the second group consists of countries that have estimates for the year 2030. The first group, which includes all 62 countries, is referred to as having the *most current data availability* rather than availability at a particular year because the most current year may vary by country: for a given country the most current available data might be 2020, whereas for another it could be 2023. Additionally, the report may have been released in 2018 and contain projections for 2023; this is still considered within the most current data availability group. The second group is a subset of the 62 total countries and includes 41 countries for which estimates are available for the year 2030. However, some of the corresponding studies may have data beyond 2030, but 2030 was a year for which all 41 countries have estimates available.

Table 1 presents a summary of the estimates for each of the two groups. The most current estimates for all 62 countries indicate a volume of 2.83 billion dry metric tonnes of biomass resources. The 2024 estimate for the subset of countries with 2030 data indicates 1.32 billion dry metric tonnes of biomass production; meanwhile, the 2030 estimate for these countries reaches 2.13 billion metric tonnes of biomass production, which implies an increase in biomass production of roughly 60% or 0.81 billion tons in those countries. The comparison of biomass resource estimates within this subset is useful to highlight how the most up-to-date estimates compare to projected biomass resource production capacity in 2030.

[2] The most current estimates reflect the most recent data received from contributors. While most data are from analyses and reports completed within the past five years, the timestamps associated with the source data range from 2000–2024. In all cases, this report used the most recent values from a reporting nation produced on or before August 2024.

Table 1. Number of countries and volume reported for most current biomass resource production and 2030 biomass resource production estimates.

Countries in Processed Reports and Biomass Estimates			
Country Group	**Country Count**	**Most Current* (billion dry metric tonnes)**	**Production Capacity in 2030** (billion dry metric tonnes)**
Most Current	62	2.83	—
2030 Estimates	41	1.32	2.13

*** Production indicates produced biomass resource or production estimate**
**** Production Capacity 2030 indicates reported potential to produce that volume.**

As shown in Table 1, the data reported on 62 nations from all 65 reports with current estimates (2023 or earlier) sum to 2.83 billion dry metric tonnes of biomass. As shown in Table 2, most of the reported resources are in the Americas, where Brazil and the United States are the countries with the largest volume of feedstock production. The Americas are followed by countries in Europe, Asia, and Africa.

Table 2. Biomass production by continent in the most current set of national estimates (billions dry metric tonnes).

Summary of Most Current Biomass Resource Production by Continent (62 countries)	
	Production (billion dry metric tonnes)
Africa	0.22
Americas	1.18
Asia	0.52
Europe	0.91
Oceania	—
Global	2.83

Geographic and political coverage of the continents is not uniform or comprehensive. The countries for which data are available in the database are presented in Figure 2. The Americas and Europe are the continents with the most countries for which reports and data are currently available, while Africa has less representation. This lack of representation is also evident in Figure 1, which shows that Egypt and Ethiopia are the only African nations for which data were received as of August 2024. This figure also indicates that the Americas and Europe are the continents for which data reflect the most complete spatial coverage, in part thanks to two studies, the Biofuels and Rural Economic Development study from the Food and Agriculture Organization (FAO) [26] and the S2Biom project from the European Commission [27], which provide multi-country information for several countries in each of the two continents.

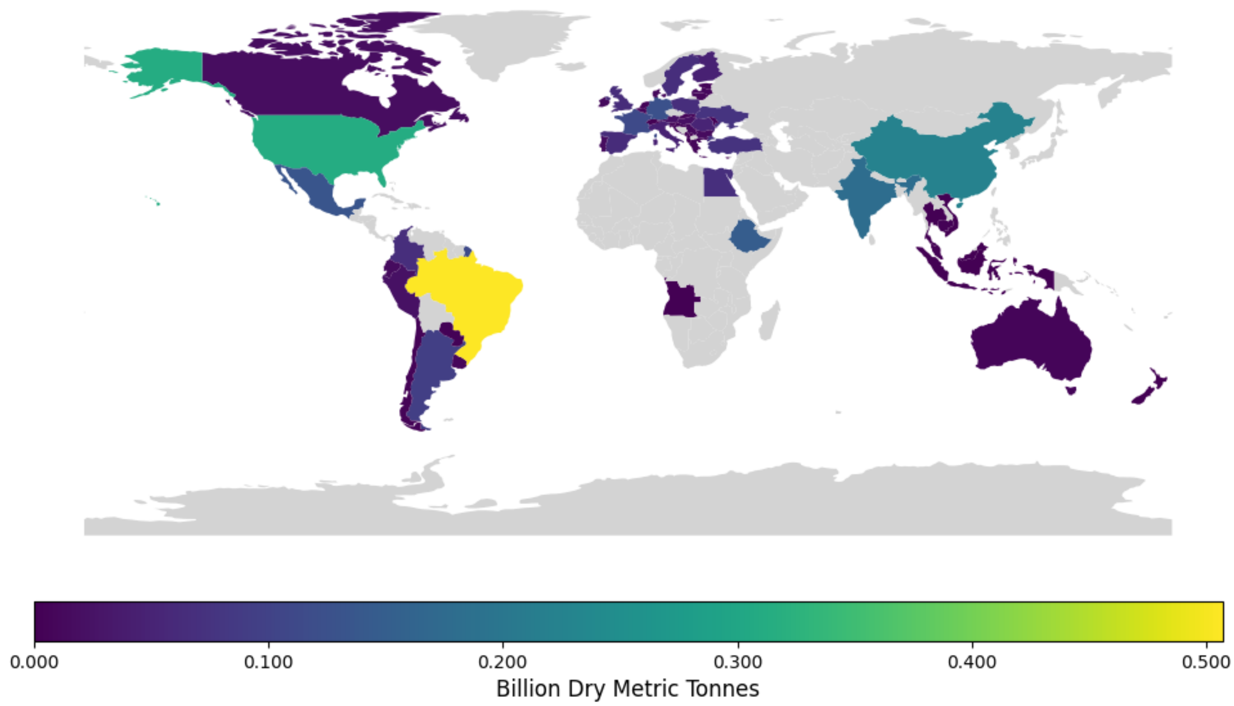

Figure 2. Map of most current biomass resource production estimates by country. Sixty-two countries are included and reported supplies sum to 2.83 billion tonnes (billion dry metric tonnes).

Figure 2 illustrates reported current production of biomass resources by country. Brazil and the U.S. are the largest biomass producers. Brazil's largest resource type is sugarcane, whereas corn/starch and soybean oil are the largest current reported biomass resources in the U.S. In both countries, crop resources are primarily used to produce ethanol and biodiesel, while bagasse and wood resources are used to generate power. In the European Union, the largest reported current feedstock source is lipids (fats and greases derived from crops) which are used to produce biodiesel. In most other cases, forest residues are the single most important biomass feedstock, and heat and cooking represent the predominant uses.

All information discussed in this report, along with links to the source reports, can be obtained in the virtual repository in the *BioenergyKDF* (https://bioenergykdf.ornl.gov/). Additional information on biomass resource production and usage around the world can be found in data products from the IEA and FAO. On June 17, 2024 the FAO released a new domain for bioenergy on its FAO Statistics (FAOSTAT) data repository which contains reported data on biomass energy production and consumption (https://www.fao.org/faostat/en/#data/BE)[4]. The International Energy Agency (IEA) offers some feedstock data in its Renewables 2024 Dataset (https://www.iea.org/data-and-statistics/data-product/renewables-2024-dataset)[5] which focuses on renewable fuel production and consumption, including biofuels for transport and corresponding feedstock demands. The biomass resource data summarized in this report derive from a variety of sources reporting sustainable biomass supplies and are incomplete. Thus, at this point in time, they are not intended to match the data presented in the FAO or IEA datasets, which are derived from more structured national reporting systems. Biomass consumption data were reported in a small subset of countries in the analyses used for this report but capturing such data is not the primary goal of this project.

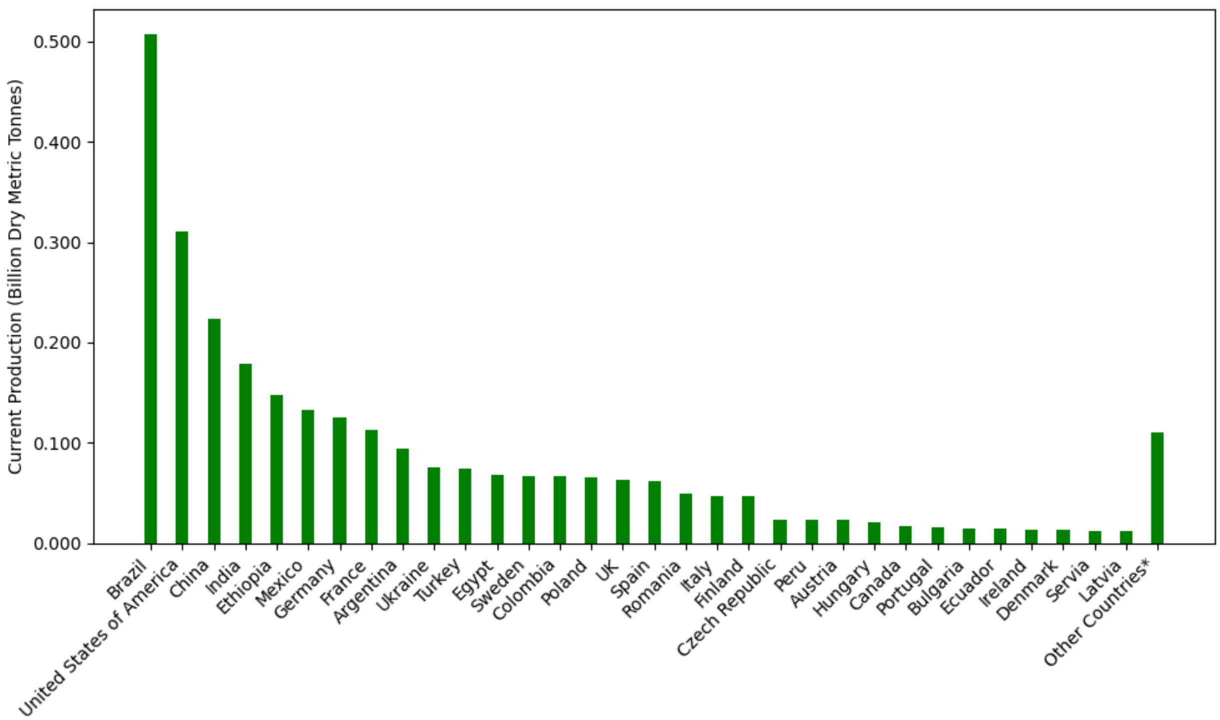

Figure 3. Most current biomass resource production by country for all 62 countries included in the collected data (billion dry metric tonnes).

The second subset of data associated with 41 countries reporting biomass resource estimates in 2030 is displayed in Tables 1 and 3. These 41 countries reported 1.32 billion dry metric tonnes of biomass resources in the most current data and projected that 2.13 billion dry metric tonnes of biomass resources could become available in 2030 for the bioeconomy. This represents roughly 60% expansion in biomass resource availability by 2030.

Section 5 of this report discusses the sustainability constraints and factors that were applied or assumed in these estimates. Estimates for future biomass resources availability primarily come from the European Union (EU), additional European countries, the U.S., and countries in Southeast Asia. Only 8 countries, representing 0.43 billion dry metric tonnes of total current biomass supply, provided biomass consumption estimates with the current data; this leaves roughly 2.40 billion dry metric tonnes of reported biomass resources whose use is undetermined. The estimates of production capacity to supply biomass resources will increase in the future as additional data are collected, processed, and standardized.

Table 3. Most current biomass resource production and projected biomass production by continent for 41 countries with data for 2030 (billions dry metric tonnes).

Summary by Continent of Reported Most Current and Future (2030) Production (41 countries, billion dry metric tonnes)		
	Most Current	Projected for 2030
Africa	—	—
Americas	0.47	0.67
Asia	0.07	0.57
Europe	0.80	0.90
Oceania	—	—
Global	1.32	2.13

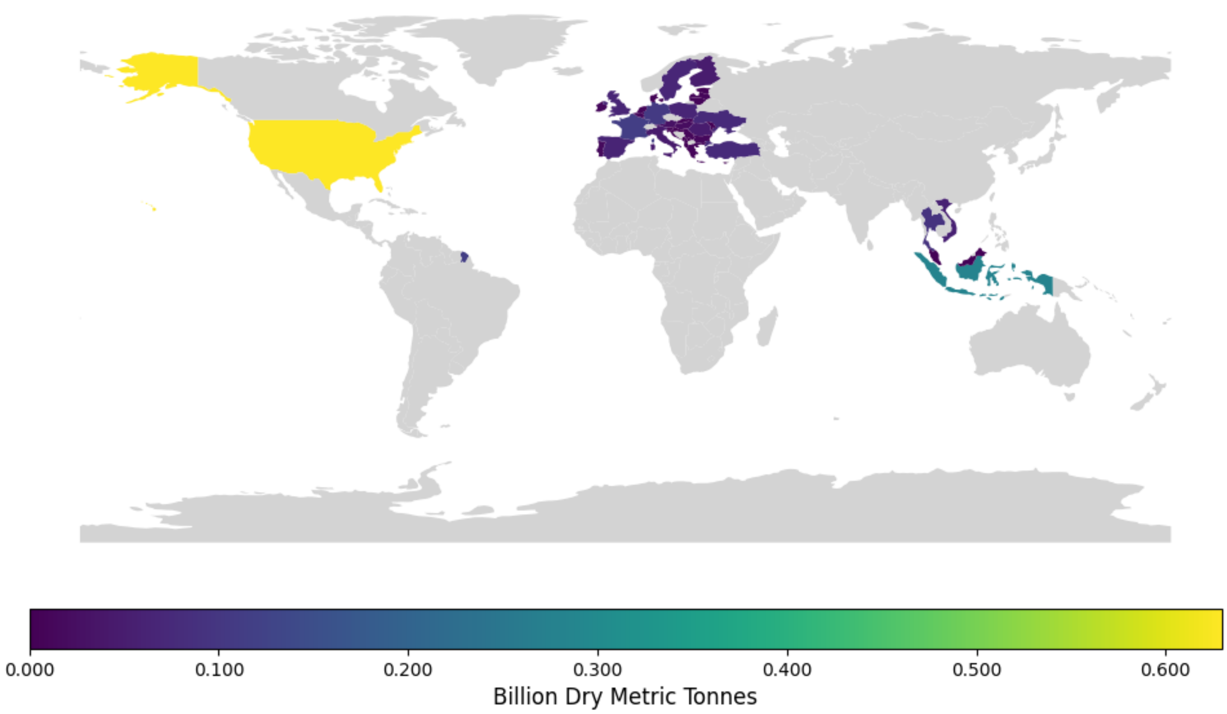

Figure 4. Map illustrating projected future biomass resource production in 2030 for 41 reporting countries (billion dry metric tonnes).

Figure 5 illustrates the volume of biomass per the reports received by August 2024, for future biomass production by country. The U.S. and Indonesia have the highest biomass resource production potential in 2030, with the U.S. growth in biomass resources coming from agricultural crop residues and dedicated energy crops and the Indonesia growth in biomass resources coming from palm oil, rice hulls, and coconut harvest residues.

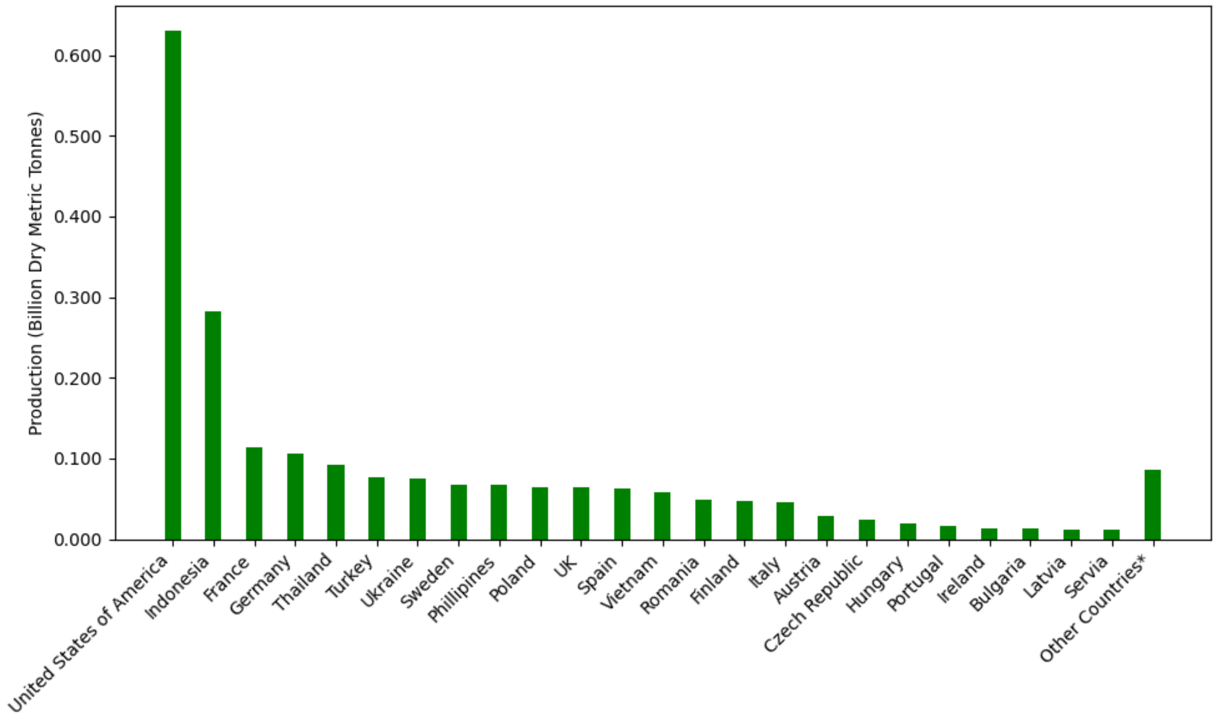

Figure 5. Biomass resource estimates for 2030 by country for 41 countries with data for 2030 (billions dry metric tonnes).

It is important to put the biomass supply estimates provided in this report within the context of the total area represented by the reporting nations. The cumulative land area represented by the countries included in this report are presented in Table 4, in terms of their share of global land area by major land cover type based on FAO global land cover statistics (https://www.fao.org/faostat/en/#data/LC) [67]. The 62 nations with current data account for about 38% of global land area as shown in the first column. The second column reflects the areas for countries reporting biomass in 2030 (41 countries). The latter omits some of the largest potential biomass producing countries such as Canada, Brazil, China, and India. Table 4 is not meant to imply that any of these land cover groupings are, or would be, dedicated to the bioeconomy, but simply puts into context the total land area represented by the countries included in this report.

The countries contained in the most current data have significant agricultural activity and account for almost of half the agricultural and forest/wood landcovers. A deeper examination of the land use in these countries could provide important insights to the pressures that expansive biomass resource production and/or collection may have on cropland and forests. The potential impacts on cropland from expanding future biomass production to supply a growing bioeconomy is a concern of policymakers and civil society. While this report was not designed to analyze the data received with respect to such concerns, source reports aimed to provide estimates of sustainable supplies as defined in each national context or assessment. Sustainability issues including land use are discussed in Section 5 and Appendix C below.

Table 4. Share of global land cover in countries reporting most current and future (2030) data or estimates [66].

Percentage of World Land Cover (2022)		
Land Cover	**Current (62 countries)**	**Future (41 countries)**
Herbaceous	47%	20%
Grassland	38%	15%
Tree and Woody	45%	15%
Other Cover	29%	6%
Total Land Cover	38%	12%

3. METHODOLOGY

The *Global Biomass Resource Assessment* has employed a bottom-up approach, seeking subnational or national level data and information provided by stakeholders where possible. Consequently, the first step was to identify the stakeholders who could provide data on biomass resource availability and to complement those data with stakeholder participation from engaged interests or key players in the development of bioeconomy supply chains.

The stakeholders identified for this effort range from international governing bodies to research institutions and academia, and numerous use cases exist. The identified and contacted stakeholders have stated a pressing need for an authoritative source for global biomass estimates and how regulatory schemes and their corresponding sustainability requirements or criteria impact the quantity available. The stakeholders for the *Global Biomass Resource Assessment* and the use cases have been categorized into three groups:

- **Governing Bodies (Local, National, International):** These stakeholders need authoritative, citable biomass resource numbers to help justify policies and target regulations and policies for the greatest effect. They can also use these numbers to identify and encourage cooperation opportunities.
- **Industry/Private Interests:** These stakeholders can use such data to identify locations for further studies on the feasibility of capital investment.
- **Research:** These stakeholders can use these data for further research, with some of the financial and time burden for assembling the data being removed by this effort.

Given the one-year time frame and limited resources available to prepare this report, a decision was made to start with the stakeholders that are members and industry partners of the *Biofutures Initiative*, including members of the Global Bioenergy Partnership. Once the stakeholders were identified, the following methodological steps were implemented.

> **First**, an inventory and review of current sources of data and biomass resource assessments were conducted. This step included a search for recent (since 2012) publications with national, regional, and (to a lesser extent) global assessments generated by public agencies and international organizations (e.g., IEA, FAO, United Nations Framework Convention on Climate Change (UNFCCC), International Renewable Energy Agency (IRENA)), supplemented by academic studies where data from the first two sources are limited or incomplete. The necessary

condition for a source to be included in this inventory is the data must be publicly available and shareable. Biofuture member countries were asked to provide information on national production and use of biomass resources for energy and/or industrial uses, and for current and future sustainable biomass resource availability. In response, reports from 18 countries were received. These reports were then supplemented with information from intergovernmental studies and datasets. Thus, a total of 49 reports were reviewed and incorporated in the analysis for this report.

Second, the reports and datasets were reviewed considering the source of the report, the public availability of the dataset, how current the data are, and the need for representation across geographic areas. Current production and availability of biomass resources were the most common reports, while a smaller number provided future availability, and less were able to incorporate an integrated technical, economical, and environmental approach.

Third, biomass resource terminology and assessment assumptions were documented for each report. This led to a significant effort to harmonize between all the collected reports. A centralized database was developed to catalogue the various biomass resource classification, definitions, and characteristics and create a clear and replicable harmonization process to translate resource names into categories with comparable characteristics, and permit aggregation of reported resource volumes. This database facilitates reporting and future additions and updates regarding biomass resource and sustainability characteristics.

The next step was to assess which studies addressed sustainability of biomass resources. This assessment required review of the text of each report and is a topic of interest for proposed follow-on discussions with selected national report authors. In most cases, reports of *current* availability did not specify sustainability constraints. However, *future* assessments of biomass supply addressed sustainability either as a goal or through the utilization of some specific land use criteria to qualify resources as sustainable. As discussed in Section 5, there is a great diversity across reports in terms of both level of detail and methods.

Finally, based on the review of the reports and efforts to understand the data, recommendations are provided to enable practical and comparable future assessments and biomass reporting. These include steps that would facilitate future updates and maintenance of the database, focusing on suggestions to improve the interoperability of future reports.

There were 65 reports or studies reviewed in this analysis. Table 5 summarizes the origin of these reports and specifies whether they were included in the global database of biomass resource availability. The reporting origin or source is classified into one of three categories: **International Organization** – organizations composed of multiple countries; **National** – organizations associated with national governments such as agencies and administrations; or **Other** – journal articles, academic or university reports, non-government organizations (NGOs), and other entities that do not fit in the first two categories. Not all the reports provided quantified volumes for biomass availability—and even if provided, some may have been excluded from the database because a more recent source was identified or because the alternative source provides more consistent data. A total of 65 reports were collected; the origin was evenly distributed among three types of sources. The biomass resource availability database includes data from 29 reports, and data for 62 countries.

Table 5. Number of reports collected by type of producing organization.

Report Generating Entity Type			
Organization Type	Count	Included in Global Database	
		Yes	No
International Organization	19	6	13
National	22	11	11
Other	24	12	12
Total	**65**	**29**	**36**

Within the 65 collected reports, there is a large diversity of reporting. Currently, collected data are heavily concentrated in highly developed areas with national interests in reducing emissions and promoting sustainable biofuel production, with European countries expressing particular interest. Collected data are notably sparse in Africa and the Middle East. The methods used to collect and report biomass resource data are illuminating with respect to the interests and goals of the reporting agencies. Reports totaled in crop yield per unit of production often express interest in using biofuels as a diversification opportunity for agricultural producers or an opportunity for economic growth through processing: Brazil's use of soybeans as biodiesel is a good example of this interest. European countries are more likely to report energy and heat measurements and express their interest in using bioenergy to completely replace their nations' energy needs.

There are 62 countries with estimates or projections considered as part of the most current dataset: Albania, Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Cambodia, Canada, Chile, China, Colombia, Croatia, Cyprus, Czech Republic, Denmark, Dominican Republic, Ecuador, Egypt, Estonia, Ethiopia, Finland, France, Germany, Greece, Hungary, India, Indonesia, Ireland, Italy, Lao PDR, Latvia, Lithuania, Luxembourg, Macedonia, Malaysia, Malta, Mexico, Moldova, Montenegro, Netherlands, New Zealand, Paraguay, Peru, Philippines, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Thailand, Turkey, Ukraine, United Kingdom, United States, Uruguay, Vietnam.

Additionally, there are 41 countries with 2030 projections for at least one resource: Albania, Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Indonesia, Ireland, Italy, Latvia, Lithuania, Luxembourg, Macedonia, Malaysia, Malta, Moldova, Montenegro, Netherlands, Philippines, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Thailand, Turkey, UK, Ukraine, United States, Vietnam.

4. HARMONIZATION

With respect to the data that have been collected to date, an expansive list of biomass types, reporting units (mass, volume, yield, or energy content), and biomass resource characteristics must be accounted for to reach a single standardized reporting unit. Currently, there are over 632 unique resource names captured in the collected data. While some of these reflect simple spelling or regional nomenclature differences (e.g., corn versus maize), many are unique resources or reflect specific conditions for a reported volume of a resource which may depend on local customs or methods for proper interpretation (e.g., bone dry, versus field dry, versus green – tonnage of different types of biomass).

The data collected for this *Global Biomass Resource Assessment* have been organized and classified in a manner consistent with ORNL and U.S. DOE BETO hosted *Bioenergy KDF* schemas to facilitate data sharing based on a common public portal infrastructure. The *Bioenergy KDF* is a centralized repository for data on sustainable biomass production strategies in the U.S., which supports the data-driven bioeconomy in the U.S. and across the globe and supports access to these data in an interoperable and reusable manner, abiding by the FAIR (Findability, Accessibility, Interoperability, Reuse) doctrine.

The Bioenergy KDF is available at: https://bioenergykdf.ornl.gov/

The *Global Biomass Resource Assessment* database continues to expand on the efforts of the *2023 Billion-Ton Report*, which describes the current and future biomass production capacity of the U.S. to support and expand an economic and ecologically sustainable biomass resource production base to support bioenergy and biofuels production. This database utilizes a centralized repository of the collected reports and biomass data, with additional databases developed to house information on the countries for which information is contained in the reports and the characteristics of the biomass resources included in the database. This structure reduces the effort and time required to include new data and resources in the databases and to update the characteristics of biomass resources.

The country information database uses the World Bank list of countries and includes countries that are not captured in the current biomass resource reports; this choice was made to facilitate the future expansion of the *Global Biomass Resource Assessment* without requiring changes to existing data. The database includes a three-digit country code assigned alphabetically to the countries contained in the database, the name of the country, the most recent (2020) population count [68] and the surface area of the country (km^2) [67], and whether the country is a member of the CEM Biofuture Platform Initiative or the Global Bioenergy Partnership (GBEP).

The biomass resource characteristics are housed in a separate but linked database and include the reported name of the resource, the standardized name of the resource, the subclass of the resource, the class of the resource, the estimated energy content of the dry biomass, material form (solid, slurry, gas), the ash content, and the reported or assumed moisture content of the green material. The primary source class of a material relates to the economic sector that generates the biomass resource, with three options for current biomass supplies: Agriculture, Forestry, and Waste. Algae is an additional class for future supplies. Agricultural biomass resources include products and residues from traditional agriculture operations, energy crop operations, short rotation woody crops (willows, poplars, etc.), orchards, vineyards, and other sources of a similar nature. Forestry biomass resources include all woody residues and biomass from traditional forestry operations and processing. Wastes include the organic components of municipal solid waste, construction and demolition materials (organic portion), yard waste, and more. The subclass of a resource relates to the step in a production process that generates the biomass resource, such as agricultural harvest residues, agricultural processing residues, logging residues, or forest processing waste. Biomass form describes whether the biomass generally presents as a solid, gas or liquid slurry. Composition describes the resource in terms of lignocellulosic biomass, sugar/carbohydrate-based biomass, or oils and greases. When possible, only the organic portions of waste resources are reported.

An algorithm was developed to process and convert the data included in the *Global Biomass Resource Assessment* database. This approach preserves the original reported biomass resource names, units, and amounts; it uses the resource characteristic database to convert reported biomass resources to the standardized biomass resource names, ontology, and characteristics; and it calculates the reporting units and amounts for the standardized output. In these reports, 349 reported resources have been reclassified into 105 standardized resources, as found in the compendium database (Appendix B). Figure 6 contains a diagram that illustrates the ontology of the resources.

The resources are sorted into three classes—Agriculture, Forestland, and Wastes/other—and eighteen subclasses: Agriculture processing waste, Agriculture residues, Energy crops (herbaceous), Energy crops (woody), Fats, oils and greases (FOGs), Forest processing waste, Gaseous resources, Intermediate oilseeds, Logging residues, Macroalgae, Microalgae, Oil crops, Other forest waste, Other solid waste, Other wet waste, Paper, Plastic, and Small-diameter trees. A table of these resources is presented in Appendix B: Biomass Resource Classification.

5. ADDRESSING SUSTAINABILITY

This section reviews how sustainability is defined, and/or how it is operationalized in the reviewed country or multicounty reports. The utilization of sustainable biomass resources for the bioeconomy is a requirement for the continued deployment of the bioeconomy. Establishing a universal definition of sustainability has been elusive, because sustainability depends on the circumstances, opportunities and constraints in a given time and place (context). Thus, sustainability is characterized in the reports according to criteria and objectives specific to each study.

A clearly articulated, concise definition of sustainability is absent from the reports as sustainability assessment involves the considerations of trade-offs and complex interactions among many different variables and social, environmental and economic systems. Establishing specific criteria with measurable indicators is helpful to compare the sustainability constraints in different reports. This process was initiated via a standard matrix to compare the sustainability constraints identified. As this method is expanded to additional reports, the approach can be adapted by adding or combining criteria and improving the methodology used to classify sustainability criteria into groupings. Establishing consistent, replicable methods is critical to successfully comparing biomass estimates globally.

Table 6 presents a high-level characterization of the sustainability concepts contained in the reports reviewed for this study. Of the 27 reports contributing to the dataset of biomass resource availability, 14 include information to address sustainability, seven do so through constraints, exclusions of resources or specific land uses from the bioeconomy, and another 7 indirectly mention sustainability without providing details on how the term was operationalized. In the 7 reports that introduced constraints, most constraints focus on environmental aspects of sustainability. One report includes supply curves that permit consideration of economic aspects of sustainability and discussed potential effects on food prices, and two of the seven studies limited competition with food crops by design. Select reports— one for the USA [29], one for countries in the European Union and selected east European countries [27], and one that presents estimates for Southeast Asia [36]—provide the definition for sustainability and the specific criteria applied in the elaboration of the supply estimates. The report by FAO Inter-America Development Bank (IDB) for Latin America and the Caribbean directly analyzes the impacts on food prices and food security without imposing any constraints [26].

Table 6. Inclusion of sustainability in reports reviewed.

Inclusion of Sustainability in Reports Reviewed		
	Number of Reports	**Reports**
Total Reports Providing Data	27	
Reference to Sustainability	12	
Directly Address Sustainability	6	26, 27, 29, 30, 34, 36, 37
Indirectly Address Sustainability	7	1, 6, 8, 23, 24, 25, 38
Do Not Address Sustainability	13	3, 4, 5, 7, 9, 18, 19, 21, 22, 28, 32, 42, 48

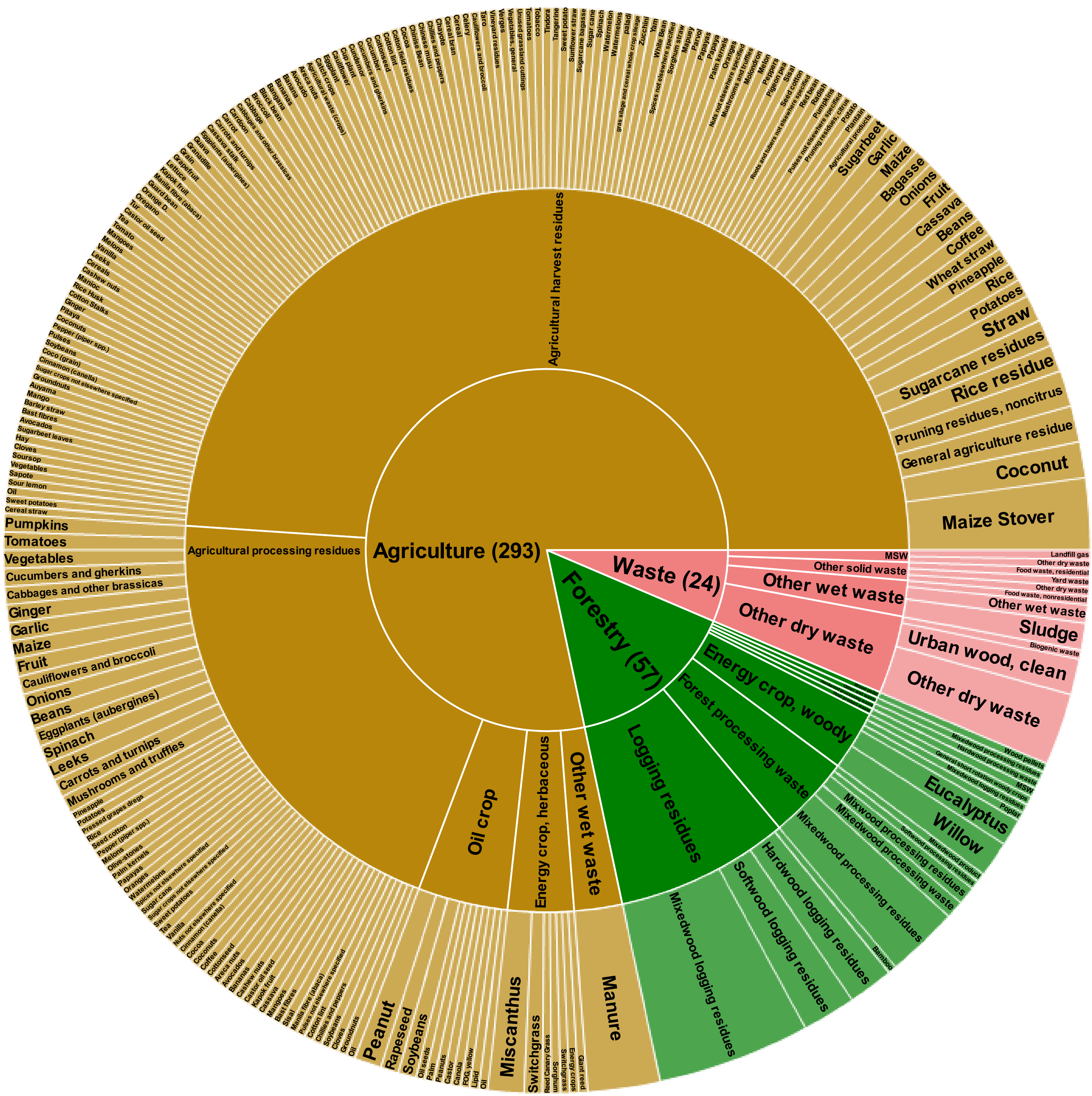

Figure 6. This sunburst diagram shows the classification nomenclature for different agricultural, forestry, and waste biomass resources using the 349 specific terms found in the collected reports.

Several trends in reporting sustainability constraints have been observed in our review of data. Many reports mention local or regional laws and regulations that promote sustainability but stop short of providing details on how they are applied to the biomass estimate provided in the report. The missing information can be found by locating additional documents in many cases. Local practices are referenced in some reports without additional details for the reader to understand how the inclusion or exclusion of such practices would impact the reported biomass supplies. A smaller number of reports detail constraints in-depth and, in some cases, may contribute to understanding what restrictions apply to less detailed reports in the same region.

Understanding how sustainability constraints are applied is important in determining how different national estimates compare. And clarity on criteria is critical to develop an estimate of the total "sustainable biomass" available globally. Currently, a seven-factor matrix is used to assess the sustainability constraints in the collected reports. These factors are as follows:

1. **Biomass Resource** – Limits to the estimated supply of biomass or acreage based on biomass resource requirements.
2. **Soil and Water Quality** – Limits to biomass or acreage based on requirements to environmental protections for erosion, soil health, or water quality.
3. **Water Use –** Limits to biomass or acreage based on water use requirements to grow or process the resource.
4. **Land Use** – Limits to biomass or acreage based on reserving lands for other uses, and land-use change limitations (i.e., no conversion of forest to biomass production).
5. **Biodiversity** – Limits to biomass or acreage based on requirements to protect habitat or encourage biodiversity conservation.
6. **GHG Emissions** – Limits to biomass or acreage based on estimated life-cycle emissions and requirements to provide feedstocks that meet GHG emission reduction thresholds.
7. **Growth and Yield** – Limits to biomass or acreage based on future growth and yield equations (which may incorporate impacts of climate change).

These factor groupings are broad and not always exclusive. Even when a report includes constraints in a category, there can be significant differences in the level of constraint and the level of detail provided about the constraint. This could mean that reports that appear comparable based on common considerations per this matrix are distinct. Thus, it is important to verify specific constraints applied in the source reports or analyses. One proposed solution is for future biomass assessments and reporting to include a standard set of sustainability criteria and indicators under each of the 7 factor categories listed in the matrix.

Using these categories, Table 7 has been assembled. In the sustainability category columns, examples of constraints found in particular reports are shared. But these are not inclusive of all constraints found in every report. Three reports focus primarily on environmental criteria, and one focuses on the impact in food prices and food security. The environmental criteria implemented deal with the resources that can be used as biomass for energy, and constraints on soils and water quality, water use, specific land uses, biodiversity and GHG emissions, and all environmental issues. The DOE report uses an approach that solves to meet projected future demands for food, feed, forage, fiber and other biobased materials (e.g., lumber) simultaneously with the corresponding biomass potential, under a set of defined economic growth scenarios. The DOE report also considers potential impacts on food prices. The EU/Renewable Energy Directive (RED) report [27] directly removes land in food and feed crops from the potential biomass production areas to avoid competition with food production. The IRENA study for Southwest Asia focuses on utilization of food waste as a mechanism to reduce competition with food [36]. In the FAO-IDB report for Latin America and the Caribbean, the major concern is the potential impact on food prices; the report does not identify and apply sustainability criteria explicitly but discusses food prices and food security as key indicators of the impacts of current and future biomass resource availability.

Table 7. Evaluations of sustainability constraints from a subset of collected reports.

Sustainability Categories							
Report Title	**Biomass Resources**	**Soil & Water Quality**	**Water Use**	**Land Use**	**Biodiversity**	**GHG Emissions**	**Food**
US DOE Billion-Ton 2023 [29]	Sixty-seven biomass resources, including wastes, forestry, agricultural, and algae resources	Crop residue removal constrained based on county-level modeled wind and water erosion and soil carbon loss limitations p [69-71] Logging residue retention constraints for forest soil conservation [29,72]	No dedicated energy crops in irrigated cropland	Energy crops' modeled spatial solution based on comparative agronomic advantage [29, 73] No transition of nonagricultural lands, including forest and native grassland	No transition of nonagricultural lands, including forest and native grassland, to energy crops, cropland, or grazing	Energy crops on all pastureland assume management-intensive grazing costs	Fulfillment of projected demands for food, feed, forage, fiber, and exports. Impacts on row crop production and prices reported within historic variability [73]
S2Biom EU/RED [27]	Agriculture, Forestry	Producers must keep their land in good agricultural and environmental condition and ensure that there is no significant decrease in or reallocation of permanent grassland. Measures to maintain soil quality and soil carbon content	Water resources must be properly protected and managed to ensure adequate human, livestock, and crops supply	Land already used for agriculture before January 1, 2008, Biofuels, bioliquids, and biomass fuels cannot be produced from land with high-carbon. No land conversion after January 1, 2008, without fulfilling sustainable biomass requirements	Biofuels, bioliquids, and biomass fuels cannot be produced from high biodiversity-value land	Sustainable biomass production requires that economic operators uphold principles of social responsibility	Food crops and land to grow food are reserved to avoid competition with potential biomass resources
IRENA-SE Asia [36]	Agriculture, Forestry	Only 25% of harvest residues are collected	The yield gap is half closed	Only half of the forest potential is collected	N/A	N/A	All regions reduce waste and losses in the food chain to the shares in each food group that obtain in the region with best practice
FAO-IDB Latin America and Caribbean [26]	Agricultural grasses, fast growing trees and MSW						Estimate effects in food prices and food security

We note that categorization of sustainability constraints and reported volumes of sustainable biomass can have a subjective element at various levels. Verifying compliance with sustainability criteria remains an area of active research and scientific debate. Addressing potential sources of misinterpretation regarding sustainability is challenging. A practical catalog with clearly defined terms and methods of measurement and verification could provide more assurance to stakeholders but requires additional effort to complete.

An alternative to these seven categories is using the 17 United Nations Sustainable Development Goals (SDGs) to categorize and discuss the constraints in the reports. The SDGs have broad applicability, but many constraints may only fall into a select few SDGs, and details on comparable sustainability constraints will be lost as more data are grouped into fewer categories.

An additional alternative is to expand the number of categories used to assess reports to provide more granularity in what is applied in each report. Further granularity and a scoring system can give the user a clear picture of how reports' estimates can be compared. However, expanding categories may clutter the results and reduce the system's utility to the standard user. As further reports are processed, missing categories may be identified and added to the assessment matrix.

6. GUIDELINES FOR FUTURE COUNTRY ASSESSMNETS

The review of the country reports and data and the discussion with stakeholders has supported the drafting of recommendations for future country resources assessments. Implementation of these suggestions could enable more efficient and reliable reporting on biomass supplies, enhancing the information needed to support sound decision making for policies and investments. These recommendations focus on two basic challenges and one major gap in the reported information. The challenges are (a) consistent classification of the biomass resources and (b) the operationalization of sustainability criteria. The gap relates to answering the question "at what prices are the biomass resources available?" The following are five suggestions for future sustainable biomass availability country assessments.

1. The review of reports generated 632 specific names for biomass resources across 62 countries. Many of them refer to the state of resource—for example, whether it is a crop, a harvesting residue from the crop, a meal or oil resulting from the processing of the crop, etc. Another source of complexity arises due to differences in composition or conditions of resources that share a common name in many countries—for example, sweet potato or sugar. But there is wide variability in the qualities and composition associated with the crop across geographic locations. Therefore, country resource assessments should include clear characterization of each resource, including scientific name, mass, moisture content, and energy content using standard methods of measurement. This comprehensive characterization will facilitate inter-resource and intercountry comparisons and be helpful to guide the question of which conversion and end use is the most likely pathway for each resource.

2. Related to the first suggestion, it would be extremely useful if country assessments applied a common method for resource classification, a standard *ontology of resources*. The use of a common set of names and definitions for subclasses and classes to organize the individual resources will contribute to a more robust global assessment of resources, and a more transparent comparison of resources across countries. The current classification methodology follows the structure used in the U.S. DOE *2023 Billion-Ton Report* as a starting point with the expectation that adjustments will be made in response to the feedstock types and definitions in other nations, as additional data are collected and processed in the future.

3. Many of the reports reviewed in this project estimate the potential availability of biomass resource on the basis of technical feasibility, that is, the quantity of residues that could be available from harvesting or processing a crop over a specified area of land, often based on estimated production potential from energy crops planted on lands considered idle, marginal, or other spaces assumed to avoid competition with food production. However, these estimates do not

assess the economic feasibility of making the biomass resources available to the bioeconomy. To provide public and private decision-makers with actionable information, it is important to include a techno-economic analysis in assessments. A techno-economic analysis provides information on the cost of producing or provisioning biomass resources and, ideally, volumes of resources available under specific market conditions and prices. In practice, this allows the least cost opportunities or "low-hanging fruit" to be identified while also providing estimates of the profitability of the whole value chain.

4. Sustainability criteria must be met for biomass-based products to be encouraged under many regulatory frameworks. Substantial long-term investments are required to develop sustainable biomass feedstock supply chains. Such investments are unlikely without assurance that the biobased products will have long-term market acceptance. However, operationalizing sustainability in resource assessments is challenging, given many different and evolving requirements and definitions. While efforts continue to define specific requirements such as net GHG emission reductions or carbon intensity, there is not international agreement on how to measure and verify compliance with such requirements. It will be helpful is each biomass assessment clearly documents how sustainability is determined, and whether there are systems in place to enable and measure a continuous process of improvement, which is a fundamental concept for sustainability in dynamic biological production systems. Transparency is essential to understand the context in which the "sustainable biomass supply" is calculated. While information with indicators addressing the seven sustainability factors identified in this report would be helpful, we must recognize that sustainability ultimately must be defined locally, and respect the differences in opportunities, constraints and capabilities in each location.

5. Related to the definition of sustainability, while most reports consider some environmental dimensions, it is important to expand to consider social and economic dimensions and tradeoffs among different indicators. Social and economic dimensions directly and indirectly impact human well-being, particularly at the local level. Thus, sustainable biomass assessments should consider all three dimensions of sustainability—economic, social, and environmental. This sets a stage to consider tradeoffs and make informed decisions that contextualize the performance of biomass with respect to other options for achieving sustainable development goals which include reduction of poverty and hunger. By integrating the three dimensions into the analysis it is possible to harness the synergies that biomass resources may offer to deter respond to the reality in a country or in a locality.

The introduction of these suggestions into future sustainable biomass assessments should be a step forward to increase the usefulness of the information produced and shared with private and public stakeholders. They would also help to put into perspective any interventions and investments that aim to promote the sustainable expansion of the bioeconomy.

7. REFERENCES

1. Technology Information, Forecasting and Information Council (TIFAC). 2018. Estimation of Surplus Crop Residue in India for Biofuel Production. Technical Report. New Delhi, India: Technology Information, Forecasting and Information Council (TIFAC). CS-IARI-Publication. https://tifac.org.in/images/pdf/pub/TIFACReports/newreports/biomass_w(1).pdf.
2. Gesto-Energia, S.A. 2016. Angola Energia 2025: Angola Power Sector Long Term Vision. National Energy Report 373118/14. Republic of Angola Ministry of Energy and Water. https://angolaenergia2025.gestoenergy.com/sites/default/files/editor/livro_angola_energia_2025_baixa.pdf.
3. Degreenia, J., Wynne, G. 2023. Biofuels Annual- Brazil. USDA-FAS Brazil. https://fas.usda.gov/data/brazil-biofuels-annual-10#:~:text=Total%20Brazilian%20ethanol%20production%20for,increase%20in%20corn%20ethanol%20production.
4. Joseph, K. 2023. Biofuels Annual- Argentina. USDA-FAS Argentina. fas.usda.gov/data/argentina-biofuels-annual-8
5. Danielson, E., 2023. Biofuels Annual- Canada. USDA-FAS Canada. https://www.fas.usda.gov/data/canada-biofuels-annual-9
6. Enea and Deloitte for ARENA. 2021. Australia's Bioenergy Roadmap. Canberra, Australia: ENEA Australia, Deloitte Financial Advisory Pty Ltd, ARENA. https://arena.gov.au/assets/2021/11/australia-bioenergy-roadmap-report.pdf.
7. Ministerio de Industria, Energía y Minería, 2023. National Energy Balance 2023: Historical Series 1965-2023 (National Energy Report), Energy Balance. Ministerio de Industria, Energía y Minería, Uruguay.
8. Benti, Natei Ermias, Gamachis Sakata Gurmesa, Tegenu Argaw, Abreham Berta Aneseyee, Solomon Gunta, Gashaw Beyene Kassahun, Genene Shiferaw Aga, and Ashenafi Abebe Asfaw. 2021. The Current Status, Challenges and Prospects of Using Biomass Energy in Ethiopia. Biotechnology for Biofuels 14 (1): 1?24. https://doi.org/10.1186/s13068-021-02060-3.
9. Ministerio de Ganaderia, Agricultura y Pesca. 2023. Agricultural Statistical Yearbook 2023. Annual. Annual Statistics Yearbook. Montevideo, Uruguay: Ministerio de Ganaderia, Agricultura y Pesca. https://descargas.mgap.gub.uy/DIEA/Anuarios/Anuario2023/ANUARIO2023WEB.pdf.
10. Mansuy, Nicolas, Julie Barrette, Jerome Laganiere, Warren Mabee, David Pare, Shuva Gautam, Evelyne Thiffault, and Saeed Ghafghazi. 2018. Salvage Harvesting for Bioenergy in Canada: From Sustainable and Integrated Supply Chain to Climate Change Mitigation. WIREs Energy and Environment 7 (5): e298. https://doi.org/10.1002/wene.298.
11. Mansuy, Nicolas, David Pare, Evelyne Thiffault, Pierre Y. Bernier, Guillaume Cyr, Francis Manka, Benoit Lafleur, and Luc Guindon. 2017. Estimating the Spatial Distribution and Locating Hotspots of Forest Biomass from Harvest Residues and Fire-Damaged Stands in Canada's Managed Forests. Biomass and Bioenergy 97 (February): 90?99. https://doi.org/10.1016/j.biombioe.2016.12.014.
12. Smyth, C. E., B. Hudson, J. Metsaranta, C. Howard, M. Fellows, and W. A. Kurz. 2023. Fire-Killed Forest Biomass for Mills and Communities and Bioenergy GHG Impacts. Biomass and Bioenergy 175 (August): 106877. https://doi.org/10.1016/j.biombioe.2023.106877.
13. Dymond, C. C., B. D. Titus, G. Stinson, and W. A. Kurz. 2010. Future Quantities and Spatial Distribution of Harvesting Residue and Dead Wood from Natural Disturbances in Canada. Forest Ecology and Management 260 (2): 181?92. https://doi.org/10.1016/j.foreco.2010.04.015.

14. Mupondwa, Edmund, Xue Li, and Lope Tabil. 2018. Integrated Bioethanol Production from Triticale Grain and Lignocellulosic Straw in Western Canada. Industrial Crops and Products 117 (July): 75?87. https://doi.org/10.1016/j.indcrop.2018.02.070.
15. Barrette, Julie, David Pare, Francis Manka, Luc Guindon, Pierre Bernier, and Brian Titus. 2018. Forecasting the Spatial Distribution of Logging Residues across the Canadian Managed Forest. Canadian Journal of Forest Research 48 (12): 1470?81. https://doi.org/10.1139/cjfr-2018-0080.
16. Canuel, Claudie-Maude, Evelyne Thiffault, and Nelson Thiffault. 2022. An Empirical Financial Analysis of Integrating Biomass Procurement in Sawtimber and Pulpwood Harvesting in Eastern Canada. Canadian Journal of Forest Research 52 (6): 920-939. https://doi.org/10.1139/cjfr-2021-0327.
17. Popper, Rafael, Nina Rilla, Klaus Niemela, Juha Oksanen, Matthias Deschryvere, Matti Virkkunen, and Torsti Loikkanen. 2020. The Future of Forest-Based Bioeconomy Areas: Strategic Openings in Uruguay and the World by 2050. VTT Technology No. 379. VTT Technical Research Centre of Finland. https://doi.org/10.32040/2242-122X.2020.T379.
18. The Danish Energy Agency. 2022. Danish Basic Bioenergy Data 2022. Dataset. Basic Energy Data Timeseries. Copenhagen, Denmark: The Danish Energy Agency. https://ens.dk/sites/ens.dk/files/Statistik/grunddata2022_-_basicdata2022.xlsx.
19. Akgun, Orkide, Mika Korkeakoski, Suvisanna Mustonen, and Jyrki Luukkanen. 2011. Theoretical Bioenergy Potential in Cambodia and Laos. In World Renewable Energy Congress, 335-342. https://doi.org/10.3384/ecp11057335.
20. Li, Xue, Edmund Mupondwa, Satya Panigrahi, Lope Tabil, Shahab Sokhansanj, and Mark Stumborg. 2012. A Review of Agricultural Crop Residue Supply in Canada for Cellulosic Ethanol Production. Renewable and Sustainable Energy Reviews 16 (5): 2954?65. https://ideas.repec.org//a/eee/rensus/v16y2012i5p2954-2965.html.
21. Said, N., S.A. El-Shatoury, L.F. Diaz, and M. Zamorano. 2013. Quantitative Appraisal of Biomass Resources and Their Energy Potential in Egypt. Renewable and Sustainable Energy Reviews 24 (August): 84?91. https://doi.org/10.1016/j.rser.2013.03.014.
22. Szarka, Nora, Henryk Haufe, Nora Lange, Franziska Schier, Holger Weimar, Martin Banse, Viktoriya Sturm, Lara Dammer, Stephan Piotrowski, and Daniela Thran. 2021. Biomass Flow in Bioeconomy: Overview for Germany. Renewable and Sustainable Energy Reviews 150 (October): 111449. https://doi.org/10.1016/j.rser.2021.111449.
23. D. Matschegg and D. Bacovsky, “Bioenergy in Austria,” Federal Ministry of Transport, Innovation and Technology, Wien, Austria, National Assessment 52/2019, Nov. 2019. Accessed: Feb. 12, 2024. [Online]. Available: https://nachhaltigwirtschaften.at/resources/nw_pdf/schriftenreihe/schriftenreihe-2019-52-bioenergy-in-austria.pdf
24. Aghaei, Siavash, Masih Karimi Alavijeh, Marzieh Shafiei, and Keikhosro Karimi. 2022. A Comprehensive Review on Bioethanol Production from Corn Stover: Worldwide Potential, Environmental Importance, and Perspectives. Biomass and Bioenergy 161 (June): 106447. https://doi.org/10.1016/j.biombioe.2022.106447.
25. Zhang,C., Nie, J., Yan, X. 2023. "Estimation of biomass utilization potential in China and the impact on carbon peaking". https://doi.org/10.1007/s11356-023-28891-1.
26. Falck-Zepeda, J., Mangi, S., Sulser, T., Zambrano, P., & Falconi, C. (2010). Biofuels and Rural Economic Development in Latin America and the Caribbean [Assessment](2010/015 FAO-IDB-LAC)
27. Datta, P., M. Dees, B. Elbersen, and I. Staritsky. 2017. The Data Base of Biomass Cost Supply Data for EU 2, Western Balkan Countries, Moldavia, Turkey and Ukraine. Project Report.

S2BIOM- a Project Funded under the European Union 7th Framework Programme for Research. Freiburg, Germany: Chair of Remote Sensing and Landscape Information Systems, Institute of Forest Sciences. https://s2biom.wenr.wur.nl/doc/S2Biom_D1_5_v1_2_FINAL_19_04_2017_CP.pdf.

28. Australian Government Department of Climate Change, Energy, the Environment and Water. 2023. Australian Energy Update 2023. Canberra, Australia: Australian Government Department of Climate Change, Energy, the Environment and Water. https://www.energy.gov.au/sites/default/files/Australian%20Energy%20Update%202023_0.pdf.
29. U.S. Department of Energy. 2024. 2023 Billion-Ton Report: An Assessment of U.S. Renewable Carbon Resources. M. H. Langholtz (Lead). Oak Ridge, TN: Oak Ridge National Laboratory. ORNL/SPR-2024/3103. doi: 10.23720/BT2023/2316165.
30. Thees, Oliver, Vanessa Burg, Matthias Erni, Gillianne Bowman, and Renato Lemm. 2017. Potentials of Domestic Biomass Resources for the Energy Transition in Switzerland. XLSX. Swiss Federal Institute for Forest, Snow and Landscape Research WSL / Swiss Competence Center for Energy Research - Biomass for Swiss Energy Transition SCCER-BIOSWEET. https://doi.org/10.16904/18.
31. Drigo, Rudi, Alicia Anschau, Stella Carballo, Noelia Flores Marco, and Miguel Trossero. 2009. Analisis del Balance de Energia derivada de Biomasa en Argentina: Analisis espacial de la produccion y consumo de biocombustibles aplicando la metodologia de Mapeo de Oferta y Demanda Integrada de Dendrocombustibles. (Woodfuel Integrated Supply / Demand Overview Mapping). TCP/ARG/3103. WISDOM Argentina. Rome, Italy: FAO. https://www.fao.org/3/i0900s/i0900s00.pdf.
32. Boscana, M, L Boragno, and R Echeverria. 2023. ESTADISTICAS FORESTALES 2023. Annual. Forest Statistics. Montevideo, Uruguay: Ministerio de Ganaderia, Agricultura y Pesca. https://www.gub.uy/ministerio-ganaderia-agricultura-pesca/sites/ministerio-ganaderia-agricultura-pesca/files/2023-07/DGF%20Boletin%20Estadistico_2023.pdf.
33. Lucid Insights Ltd, and Biotechnology and Biological Sciences Research Council. n.d. UK Grown: How Biotechnology Can Unlock High Value Products from UK Crops. Oxford, England, UK: High Value Biorenewables. Accessed March 8, 2024. https://www.highvaluebiorenewables.net/seecmsfile/?id=419.
34. Brown, Adam, Lars Waldheim, Ingvar Landalv, Jack Saddler, Mahmood Ebadian, James D. McMillan, Antonio Bonomi, and Bruno Klein. 2020. Advanced Biofuels- Potential for Cost Reduction. Task 41. Paris, France: International Energy Agency Bioenegy. https://www.ieabioenergy.com/wp-content/uploads/2020/02/T41_CostReductionBiofuels-11_02_19-final.pdf.
35. Hall, Peter, and Scion. 2023. Comparison of Possible Supply Chains for Forestry Derived Biomass for Bioenergy in New Zealand. Technical Report 58052648. IEA Bioenergy: Task 43. https://www.ieabioenergy.com/wp-content/uploads/2023/10/IEA-Bioenergy_Report_Biomass-Supply-Chains_V2-3.pdf.
36. J. Skeer, S. Nakada, and Y. Inoue, Biofuel potential in Southeast Asia: Raising food yields, reducing food waste and utilising residues, International Renewable Energy Agency, Abu Dhabi, United Arab Emirates, 978-92-9260-028?0, 2017. Accessed: Jul. 07, 2024. [Online]. Available: https://www.irena.org/Publications/2017/Jun/Biofuel-potential-in-Southeast-Asia-Raising-food-yields-reducing-food-waste-and-utilising-residues
37. Guzman-Bello, Hugo, Iosvani Lopez-Diaz, Miguel Aybar-Mejia, Maximo Dominguez-Garabitos, and Jose Atilio De Frias. 2023. Biomass Energy Potential of Agricultural Residues in the Dominican Republic. Sustainability 15 (22): 15847. https://doi.org/10.3390/su152215847.

38. Wang, R., Cai, W., Yu, L., et al. 2023. "A high spatial resolution dataset of China's biomass resource potential." Scientific Data 10: 384. https://doi.org/10.1038/s41597-023-02227-7
39. Navius Research Inc. 2021. Biofuels in Canada 2021: Tracking Biofuel Consumption, Feedstocks and Avoided Greenhouse Gas Emissions. Vancouver, BC, Canada: Navius Research Inc. https://www.naviusresearch.com/wp-content/uploads/2021/11/Biofuels-in-Canada-Final-2021-11-09.pdf.
40. Strengers, Bart, and Hans Elzenga. 2020. Availability and Applications of Sustainable Biomass. Report on a Search for Shared Facts and Views. Policy Brief 4205. The Hague, Netherlands: PBL Netherlands Environmental Assessment Agency. https://doi.org/10.13140/RG.2.2.12630.06729.
41. Errera, M. R., T. A. da C. Dias, D. M. Y. Maya, and E. E. S. Lora. 2023. Global Bioenergy Potentials Projections for 2050. Biomass and Bioenergy 170 (March): 106721. https://doi.org/10.1016/j.biombioe.2023.106721.
42. Tolessa, Amsalu. 2023. Bioenergy Potential from Crop Residue Biomass Resources in Ethiopia. Heliyon 9 (2): e13572. https://doi.org/10.1016/j.heliyon.2023.e13572.
43. Welfle, Andrew, Robert A. Holland, Iain Donnison, and Patricia Thornly. 2020. UK Biomass Availability Modelling Scoping Report. 02/2020. Birmingham, England, UK: Supergen Bioenergy Hub. https://www.supergen-bioenergy.net/wp-content/uploads/2020/10/Supergen-Bioenergy-HubUK-Biomass-Availability-Modelling-Scoping-Report-Published-Final.pdf.
44. Ramon Fernando Colmenares-Quintero, Natalia Rojas, Sandy Kerr & Diana M. Caicedo-Concha. (2020) Industry and academia partnership for aquatic renewable energy development in Colombia: A knowledge-education transfer model from the United Kingdom to Colombia. Cogent Engineering 7:1.
45. Committee on Climate Change. 2020. Land Use: Policies for a Net Zero UK. Policy Suggestion. Land Use. London, UK: Committee on Climate Change. https://www.theccc.org.uk/wp-content/uploads/2020/01/Land-use-Policies-for-a-Net-Zero-UK.pdf.
46. Department of Energy Security and Net Zero. 2023. Biomass Strategy 2023. Policy Document. Biomass Strategy. London, UK: Department for Energy Security and Net Zero. www.gov.uk/official-documents.
47. Fritsche, Uwe R., Goran Berndes, Annette Cowie, Francis X. Johnson, Virginia Dale, Hans Langeveld, Navin Sharma, Helen Watson, and Jeremy Woods. 2017. Energy and Land Use - Global Land Outlook: Working Paper. Working Paper 10.13140/RG.2.2.24905.44648. Global Land Outlook. Abu Dhabi, United Arab Emirates: IRENA. http://rgdoi.net/10.13140/RG.2.2.24905.44648.
48. Food and Agriculture Organization of the United Nations, "FAOSTAT Bioenergy," 2024. [Online]. Available: https://www.fao.org/faostat/en/#data/BE. [Accessed: Nov. 14, 2024].
49. D. Chiaramonti and A. Salimbeni, "BIKE Final Project Publication," Renewable Energy - Consortium for Research and Demonstration (RE-CORD), Firenze, Italy, Final Report D7.6, Aug. 2023. Accessed: Dec. 19, 2023. [Online]. Available: https://www.bike-biofuels.eu/wp-content/uploads/2023/09/BIKE_Final-Publication-7.pdf
50. H. Wenzel, "Biomass availability and sector competition." May 17, 2022.
51. S. Ladanai and J. Vinterbäck, "Biomass for Energy versus Food and Feed, Land Use Analyses and Water Supply," Swedish University of Agricultural Sciences, Department of Energy and Technology, Uppsala, Sweden, Land Use Assessment 022, 2010.
52. J. O'Malley, N. Pavlenkok, and S. Y. Searle, "Estimating sustainable aviation fuel feedstock availability to meet growing European Union demand Working Paper," International Council on Clean Transportation, Working Paper 2021–13, Mar. 2021.

53. World Bioenergy Association, “Global Bioenergy Statistics 2022,” World Bioenergy Association, Stockholm, Sweden, 2023. Accessed: Dec. 19, 2023. [Online]. Available: https://www.worldbioenergy.org/uploads/221223%20WBA%20GBS%202022.pdf
54. International Energy Agency Bioenergy, “Implementation of bioenergy in Brazil – 2021 update,” International Energy Agency Bioenegy, Paris, France, Update, Oct. 2021. Accessed: Dec. 20, 2023. [Online]. Available: https://www.ieabioenergy.com/wp-content/uploads/2021/11/CountryReport2021_Brazil_final.pdf
55. L. Cozzi and T. Gül, “Net Zero by 2050 - A Roadmap for the Global Energy Sector (4th edition),” International Energy Agency, Directorate of Sustainability, Technology and Outlooks, Paris, France, Strategic Plan, Oct. 2021. Accessed: Dec. 19, 2023. [Online]. Available: https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf
56. J. Liebetrau et al., “Potential and utilization of manure to generate biogas in seven countries,” IEA Bioenergy: Task 37, 2021. [Online]. Available: https://www.ieabioenergy.com/wp-content/uploads/2021/07/Potential-utilization_WEB_END_NEW.pdf
57. International Energy Agency, “Renewable Energy Market Update: Outlook for 2023 and 2024,” International Energy Agency, Paris, France, Market Update, Jun. 2023. [Online]. Available: https://iea.blob.core.windows.net/assets/63c14514-6833-4cd8-ac53-f9918c2e4cd9/RenewableEnergyMarketUpdate_June2023.pdf
58. IRENA, “Renewable Energy Statistics 2023,” International Renewable Energy Agency, Abu Dhabi, United Arab Emirates, Statistics, 2023. [Online]. Available: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2023/Jul/IRENA_Renewable_energy_statistics_2023.pdf
59. P. Cazzola, F. Gerard, M. Gorner, M. Gibbs, and K. Young, “Research for TRAN Committee: Assessment of the potential of sustainable fuels in bike”.
60. P. C. Faaij, “Securing sustainable resource availability of biomass for energy applications in Europe; review of recent literature.” University of Groningen, Netherlands, Nov. 2018. Accessed: Dec. 19, 2023. [Online]. Available: https://energy.nl/wp-content/uploads/bioenergy-europe-eu-biomass-resources-andre-faaij-final-3.pdf
61. European Commission. Directorate General for Energy., “Sustainable and optimal use of biomass for energy in the EU beyond 2020,” PricewaterhouseCoopers EU Services EESV’s consortium, Belgium, Final Report, May 2017. [Online]. Available: https://energy.ec.europa.eu/publications/sustainable-and-optimal-use-biomass-energy-eu-beyond-2020_en
62. C. Mort, “Unlocking the UK’s biomass resources as a feedstock for Chemical Manufacturing,” Innovate UK KTN, London, UK.
63. Air Transport Action Group, “Waypoint 2050: An Air Transport Action Group Project - Second Edition,” Air Transport Action Group, Geneva, Switzerland, Strategic Plan, Sep. 2021. Accessed: Dec. 19, 2023. [Online]. Available: https://aviationbenefits.org/media/167417/w2050_v2021_27sept_full.pdf
64. IRENA, “World Energy Transitions Outlook 2023: 1.5°C Pathway Volume 1,” International Renewable Energy Agency, Abu Dhabi, United Arab Emirates, Global Assessment, 2023. [Online]. Available: https://mc-cd8320d4-36a1-40ac-83cc-3389-cdn-endpoint.azureedge.net/-/media/Files/IRENA/Agency/Publication/2023/Jun/IRENA_World_energy_transitions_outlook_v1_2023.pdf?rev=cc4522ff897a4e26a47906447c74bca6

65. Food and Agriculture Organization of the United Nations, "FAOSTAT Land, Inputs and Sustainability," 2024. [Online]. Available: https://www.fao.org/faostat/en/#data/RL. [Accessed: Aug. 27, 2024].
66. Lopez, B. Roberts, D. Heimiller, N. Blair, and G. Porro, "U.S. Renewable Energy Technical Potentials: A GIS-Based Analysis," Renewable Energy, 2012.
67. The World Bank, "Surface area (sq. km)," 2024. [Online]. Available: https://data.worldbank.org/indicator/AG.SRF.TOTL.K2. [Accessed: Nov. 14, 2024].
68. The World Bank, "Population, total," 2024. [Online]. Available: https://data.worldbank.org/indicator/SP.POP.TOTL. [Accessed: Nov. 14, 2024].
69. United States Department of Agriculture. Revised Universal Soil Loss Equation, Version 2. Official NRCS RUSLE2 Program https://fargo.nserl.purdue.edu/rusle2_dataweb/RUSLE2_Index.htm (2016).
70. Muth, D. J., Bryden, K. M. & Nelson, R. G. Sustainable agricultural residue removal for bioenergy: A spatially comprehensive US national assessment. Applied Energy 102, 403–417 (2013).
71. USDA-ARS. *The Wind Erosion Prediction System (WEPS): Technical Documentation*. 533 https://www.nrcs.usda.gov/sites/default/files/2022-12/WEPS-Technical-Documentation-p272.pdf (2020).
72. U.S. Department of Energy. 2016 Billion-Ton Report: Advancing Domestic Resources for a Thriving Bioeconomy, Volume 1: Economic Availability of Feedstocks. 448 http://energy.gov/eere/bioenergy/2016-billion-ton-report. (2016).
73. Hellwinckel, C., Ugarte, D., Field, J. & Langholtz, M. Chapter 5: Biomass from Agriculture. in 2023 Billion-Ton Report: An Assessment of U.S. Renewable Carbon Resources (Oak Ridge National Laboratory (ORNL), Oak Ridge, TN (United States), 2024). doi:10.23720/BT2023/2316171.

APPENDIX A. Included Country List

APPENDIX A. INCLUDED COUNTRY LIST

Included Country List		
Albania	Finland	Peru
Angola	France	Philippines
Argentina	Germany	Poland
Australia	Greece	Portugal
Austria	Hungary	Romania
Belgium	India	Russia
Brazil	Indonesia	Serbia
Bulgaria	Ireland	Slovakia
Cambodia	Italy	Slovenia
Canada	Lao PDR	South Africa
Chile	Latvia	Spain
China	Lithuania	Sweden
Colombia	Luxembourg	Switzerland
Croatia	Macedonia	Thailand
Cyprus	Malaysia	Turkey
Czechia	Malta	UK
Denmark	Mexico	Ukraine
Dominican Republic	Moldova	United Kingdom
Ecuador	Montenegro	United States of America
Egypt	Netherlands	Uruguay
Estonia	New Zealand	Vietnam
Ethiopia	Paraguay	

APPENDIX B. Resource Classification

APPENDIX B. RESOURCE CLASSIFICATION

Biomass Classification			
Resource from Report	**Resource**	**Subclass**	**Class**
Watermelon	Watermelon	Agricultural harvest residues	Agriculture
Wheat	Wheat straw	Agricultural harvest residues	Agriculture
Cotton	Cotton field residues	Agricultural harvest residues	Agriculture
Sorghum Stalks	Sorghum straw	Agricultural harvest residues	Agriculture
Municipal Solid Waste (MSW)	Other dry waste	Other dry waste	Waste
Sour Lemon	Sour lemon	Agricultural harvest residues	Agriculture
Municipal Wastes	Other dry waste	Other dry waste	Waste
Cauliflower	Cauliflower	Agricultural harvest residues	Agriculture
Trees outside the forest	Mixedwood logging residues	Logging residues	Forestry
Switchgrass- Abandoned Land	Switchgrass	Energy crop, herbaceous	Agriculture
Pineapple	Pineapple	Agricultural harvest residues	Agriculture
Oregano	Oregano	Agricultural harvest residues	Agriculture
Granadille	Granadille	Agricultural harvest residues	Agriculture
Sunflower straw	Sunflower straw	Agricultural harvest residues	Agriculture
Hazardous post consumer wood	Urban wood, clean	Other dry waste	Waste
Sludge	Other wet waste	Other wet waste	Waste
Charcoal	Bioenergy	Bioenergy	Biofuel
Wood Waste	Mixedwood processing waste	Forest processing waste	Forestry
Sugar	Sugarcane residues	Agricultural harvest residues	Agriculture
Final fellings from nonconifer trees	Hardwood logging residues	Logging residues	Forestry
Residues from further wood processing	Mixedwood processing waste	Forest processing waste	Forestry

Avocado	Avocado	Agricultural harvest residues	Agriculture
Cocoa (Grain)	Coco (grain)	Agricultural harvest residues	Agriculture
Pitaya	Pitaya	Agricultural harvest residues	Agriculture
Cereals	Cereals	Agricultural harvest residues	Agriculture
Pulses	Pulses	Agricultural harvest residues	Agriculture
Cotton Stalks	Cotton Stalks	Agricultural harvest residues	Agriculture
Pressed grapes dregs	Pressed grapes dregs	Agricultural processing residues	Agriculture
Coffee	Coffee	Agricultural harvest residues	Agriculture
sugar for bioethanol from cereal	Cereal	Agricultural harvest residues	Agriculture
MSW	Other dry waste	Other dry waste	Waste
Stumps from final fellings from conifer trees	Softwood logging residues	Logging residues	Forestry
Potato	Potato	Agricultural harvest residues	Agriculture
Agricultural Products	General agriculture residue	Agricultural harvest residues	Agriculture
Forest Logging Timber	Mixedwood logging residues	Logging residues	Forestry
Maize stover	Corn stover	Agricultural harvest residues	Agriculture
Tomato	Tomato	Agricultural harvest residues	Agriculture
Logging residues from final fellings from conifer trees	Softwood logging residues	Logging residues	Forestry
Miscanthus- Abandoned Land	Miscanthus	Energy crop, herbaceous	Agriculture
Red Bean	Red bean	Agricultural harvest residues	Agriculture
Wheat Straw	Wheat straw	Agricultural harvest residues	Agriculture
Soursop	Soursop	Agricultural harvest residues	Agriculture
Black liquor	Mixedwood processing residues	Forest processing waste	Forestry
Parvol	Parvol	Agricultural harvest residues	Agriculture
Taro	Taro	Agricultural harvest residues	Agriculture
Sapote	Sapote	Agricultural harvest residues	Agriculture
Biowaste separately collected	Other dry waste	Other dry waste	Waste
Eucalyptus- Abandoned Land	Eucalyptus	Energy crop, woody	Forestry
Rice straw	Rice residue	Agricultural harvest residues	Agriculture

Corn Cobs	Corn stover	Agricultural harvest residues	Agriculture
Willow- Abandoned Land	Willow	Energy crop, woody	Forestry
Cundemor	Cundemor	Agricultural harvest residues	Agriculture
straw residues	Straw	Agricultural harvest residues	Agriculture
Forest Logging Economic	Mixedwood logging residues	Logging residues	Forestry
Rapeseed and Mustard	Rapeseed	Oil crop	Agriculture
Biogenic Waste	Biogenic waste	Other dry waste	Waste
Wood Pellets	Wood pellets	Wood pellet	Forestry
Logging Residues	Mixedwood logging residues	Logging residues	Forestry
Root Crops	General agriculture residue	Agricultural harvest residues	Agriculture
Rice Husk	Rice Husk	Agricultural harvest residues	Agriculture
Peanuts	Peanuts	Oil crop	Agriculture
Logging residues from final fellings from nonconifer trees	Hardwood logging residues	Logging residues	Forestry
Tindora	Tindora	Agricultural harvest residues	Agriculture
Miscanthus	Miscanthus	Energy crop, herbaceous	Agriculture
Switchgrass- Marginal Land	Switchgrass	Energy crop, herbaceous	Agriculture
Forest Logging Shrub	Mixedwood logging residues	Logging residues	Forestry
Celery	Celery	Agricultural harvest residues	Agriculture
Cereal bran	Cereal bran	Agricultural harvest residues	Agriculture
Forestry Products	Mixedwood processing residues	Forest processing waste	Forestry
Unused grassland cuttings	Unused grassland cuttings	Agricultural harvest residues	Agriculture
sugar for bioethanol from sugarbeat	Sugarbeet	Agricultural harvest residues	Agriculture
Tur	Tur	Agricultural harvest residues	Agriculture
Residues from vineyards	Vineyard residues	Agricultural harvest residues	Agriculture
Buffalo Manure	Manure	Other wet waste	Agriculture
Ground Nut	Peanut	Oil crop	Agriculture
Oil seed rape straw	General agriculture residue	Agricultural harvest residues	Agriculture
Corn	Corn stover	Agricultural harvest residues	Agriculture

Sugarcane Residue	Sugarcane residues	Agricultural harvest residues	Agriculture
Logging residues from thinnings from nonconifer trees	Hardwood logging residues	Logging residues	Forestry
Sawdust (conifers)	Softwood processing residues	Forest processing waste	Forestry
Recovered Wood	Mixedwood logging residues	Logging residues	Forestry
Maize Residue	Corn stover	Agricultural harvest residues	Agriculture
Rice	Rice	Agricultural harvest residues	Agriculture
wood and other	Mixedwood logging residues	Logging residues	Forestry
Guava	Guava	Agricultural harvest residues	Agriculture
Coconut	Coconut	Agricultural harvest residues	Agriculture
Eucalyptus	Eucalyptus	Energy crop, woody	Forestry
Giant reed	Giant reed	Energy crop, herbaceous	Agriculture
Sawmill by-products	Mixwood processing residues	Forest processing waste	Forestry
Cow Manure	Manure	Other wet waste	Agriculture
sludge biogas and biofuels	Sludge	Other wet waste	Waste
Other residues (conifers)	Softwood logging residues	Logging residues	Forestry
Coconut Frond	Coconut	Agricultural harvest residues	Agriculture
Manure	Manure	Other wet waste	Agriculture
Agricultural Products	Agricultural products	Agricultural harvest residues	Agriculture
Sugarcane Bagasse	Sugarcane bagasse	Agricultural harvest residues	Agriculture
Final fellings from conifer trees	Softwood logging residues	Logging residues	Forestry
Commercial & industrial organic waste	Other dry waste	Other dry waste	Waste
Broccoli	Broccoli	Agricultural harvest residues	Agriculture
Soybeans	Soybeans	Oil crop	Agriculture
bagasse	Bagasse	Agricultural harvest residues	Agriculture
palm oil for biodiesel- import	Palm	Oil crop	Agriculture
Wastes, Renewable	Other dry waste	Other dry waste	Waste
soya oil for biodiesel - import	Soybeans	Oil crop	Agriculture
Canola	Canola	Oil crop	Agriculture

Wood Industry Residues	Mixedwood processing residues	Forest processing waste	Forestry
Forest Logging Sparse	Mixedwood logging residues	Logging residues	Forestry
MSW	Other dry waste	Other solid waste	Waste
Sheep/Goat Manure	Manure	Other wet waste	Agriculture
Sawdust (nonconifers)	Hardwood processing waste	Hardwood processing waste	Forestry
Switchgrass	Switchgrass	Energy crop, herbaceous	Agriculture
Forest wood	Mixedwood logging residues	Logging residues	Forestry
Molondron	Molondron	Agricultural harvest residues	Agriculture
Banana	Banana	Agricultural harvest residues	Agriculture
landfill biogas	Landfill gas	MSW	Waste
Thinnings from nonconifer trees	Hardwood logging residues	Logging residues	Forestry
Wood Industry Bamboo	Bamboo	Logging residues	Forestry
paladi	paladi	Agricultural harvest residues	Agriculture
Forest Residues	Mixedwood logging residues	Logging residues	Forestry
SRC	General short rotation woody crops	Energy crop, woody	Forestry
Papaya	Papaya	Agricultural harvest residues	Agriculture
White Bean	White Bean	Agricultural harvest residues	Agriculture
Fruit Crops	Pruning residues, noncitrus	Agricultural harvest residues	Agriculture
Forest Logging Fuel	Mixedwood logging residues	Logging residues	Forestry
Chicken/Duck/Turkey Manure	Manure	Other wet waste	Agriculture
Wood Chips	Mixedwood processing residues	Forest processing waste	Forestry
Eggplant	Eggplant	Agricultural harvest residues	Agriculture
Barley Straw	Barley straw	Agricultural harvest residues	Agriculture
Non hazardous post consumer wood	Urban wood, clean	Other dry waste	Waste
Road side verges (grassy)	Verges	Agricultural harvest residues	Agriculture
landscaping hay	Hay	Agricultural harvest residues	Agriculture
Logging residues from thinnings from conifer trees	Softwood logging residues	Logging residues	Forestry
MSW	Other dry waste	Other dry waste	Waste

Potatoes	Potatoes	Agricultural harvest residues	Agriculture
manure	Manure	Other wet waste	Agriculture
Oils	Other wet waste	Other wet waste	Waste
sugarbeat	Sugarbeet	Agricultural harvest residues	Agriculture
Zucchini	Zucchini	Agricultural harvest residues	Agriculture
Wastes, Non-renewable	Other dry waste	MSW	Waste
Municipal sewage sludge	Sludge	Other wet waste	Waste
Waste Wood	Urban wood, clean	Other dry waste	Waste
Cabbage	Cabbage	Agricultural harvest residues	Agriculture
Cardoon	Cardoon	Agricultural harvest residues	Agriculture
Wood Industry Log Residue	Mixedwood logging residues	Logging residues	Forestry
Short Rotation Forestry Forest Residues	Mixedwood logging residues	Energy crop, woody	Forestry
Black Liquor	Mixedwood processing residues	Other wet waste	Forestry
Sugarcane Trash	Sugarcane residues	Agricultural harvest residues	Agriculture
Straw	Straw	Agricultural harvest residues	Agriculture
Wood and Wood Waste	Mixedwood processing residues	Forest processing waste	Forestry
Mango	Mango	Agricultural harvest residues	Agriculture
Rice Straw	Rice residue	Agricultural harvest residues	Agriculture
Coconut Husk	Coconut	Agricultural harvest residues	Agriculture
Thinnings from conifer trees	Softwood logging residues	Logging residues	Forestry
Corn Stover	Corn stover	Agricultural harvest residues	Agriculture
Garlic	Garlic	Agricultural harvest residues	Agriculture
gras silage and cereal whole crop sileage	gras silage and cereal whole crop sileage	Agricultural harvest residues	Agriculture
corn cobs	Corn stover	Agricultural harvest residues	Agriculture
Chinise Bean	Chinise Bean	Agricultural harvest residues	Agriculture
Sugarbeet leaves	Sugarbeet leaves	Agricultural harvest residues	Agriculture
Residues from citrus tree plantations	Pruning residues, citrus	Agricultural harvest residues	Agriculture
maize silage	Corn stover	Agricultural harvest residues	Agriculture

Sorghum	Sorghum	Energy crop, herbaceous	Agriculture
Residues from industries producing semi finished wood based panels	Mixedwood processing residues	Forest processing waste	Forestry
pure plant oil	Oil	Oil crop	Agriculture
straw	Straw	Agricultural harvest residues	Agriculture
Peanut	Peanut	Oil crop	Agriculture
Agricultural Wastes (Crops)	Agricultural waste (crops)	Agricultural harvest residues	Agriculture
Coconut Shell	Coconut	Agricultural harvest residues	Agriculture
Other residues (nonconifers)	Mixedwood logging residues	Logging residues	Forestry
Groundnut	Peanut	Oil crop	Agriculture
rapeseed oil for biodiesel	Rapeseed	Oil crop	Agriculture
Agricultural Wastes (Livestock)	Manure	Other wet waste	Agriculture
Miscanthus- Marginal Land	Miscanthus	Energy crop, herbaceous	Agriculture
Other Grain	Grain	Agricultural harvest residues	Agriculture
Horse/Ass/Mule/Camel Manure	Manure	Other wet waste	Agriculture
Cassava Stalk	Cassava stalk	Agricultural harvest residues	Agriculture
Forest Logging Special Purpose	Mixedwood logging residues	Logging residues	Forestry
Willow- Marginal Land	Willow	Energy crop, woody	Forestry
Onion	Onions	Agricultural harvest residues	Agriculture
SRC Willow	Willow	Energy crop, woody	Forestry
Sweet Potato	Sweet potato	Agricultural harvest residues	Agriculture
Melon	Melon	Agricultural harvest residues	Agriculture
Pigeon Pea	Pigeon pea	Agricultural harvest residues	Agriculture
Maize	Corn stover	Agricultural harvest residues	Agriculture
Oil Seeds	Oil seeds	Oil crop	Agriculture
Black Bean	Black bean	Agricultural harvest residues	Agriculture
Sugarcane	Sugarcane		Agriculture
Castor	Castor	Oil crop	Agriculture
Peppers	Peppers	Agricultural harvest residues	Agriculture

Firewood	Mixedwood product	Forest processing waste	Forestry
Cassava	Cassava	Agricultural harvest residues	Agriculture
Cherry	Pruning residues, noncitrus	Agricultural harvest residues	Agriculture
municipal and industrial waste	Other dry waste	Other dry waste	Waste
Yam	Yam	Agricultural harvest residues	Agriculture
catch crops	Catch crops	Agricultural harvest residues	Agriculture
Bangana	Bangana	Agricultural harvest residues	Agriculture
Stumps from final fellings from nonconifer trees	Hardwood logging residues	Logging residues	Forestry
Reed Canary Grass	Reed Canary Grass	Energy crop, herbaceous	Agriculture
Radish	Radish	Agricultural harvest residues	Agriculture
Olive-stones	Olive-stones	Agricultural processing residues	Agriculture
Gram	Lipid	Oil crop	Agriculture
Residues from olives tree plantations	Pruning residues, noncitrus	Agricultural harvest residues	Agriculture
Green waste from households and landscape	Yard waste	Other solid waste	Waste
Sewage sludge	Sludge	Other wet waste	Waste
Other SRC	Willow	Energy crop, woody	Forestry
Mill Residues	Mixedwood processing residues	Forest processing waste	Forestry
Cucumber	Cucumber	Agricultural harvest residues	Agriculture
Energy Crops	Energy crops	Energy crop, herbaceous	Agriculture
Guard Bean	Guard bean	Agricultural harvest residues	Agriculture
Auyama	Auyama	Agricultural harvest residues	Agriculture
Wood Industry Firewood Residue	Mixedwood logging residues	Logging residues	Forestry
Wood residues	Mixedwood logging residues	Logging residues	Forestry
Chinese Musu	Chinese musu	Agricultural harvest residues	Agriculture
Residues from fruit tree plantations	Pruning residues, noncitrus	Agricultural harvest residues	Agriculture
SRC Poplar	Poplar	Energy crop, woody	Forestry
Orange D.	Orange D.	Agricultural harvest residues	Agriculture
Eucalyptus- Marginal Land	Eucalyptus	Energy crop, woody	Forestry

Organic part of household garbage	Food waste, residential	Other solid waste	Waste
Vegetables	Vegetables, general	Agricultural harvest residues	Agriculture
Tangerine	Tangerine	Agricultural harvest residues	Agriculture
cup plant	Cup plant	Agricultural harvest residues	Agriculture
Tobacco	Tobacco	Agricultural harvest residues	Agriculture
Urban Waste	Urban wood, clean	Other dry waste	Waste
Plantain	Plantain	Agricultural harvest residues	Agriculture
Grapefruit	Grapefruit	Agricultural harvest residues	Agriculture
Manioc	Manioc	Agricultural harvest residues	Agriculture
Soybeans, Assorted Oils and Fats	FOG, yellow	Oil crop	Agriculture
Mapuey	Mapuey	Agricultural harvest residues	Agriculture
Bark	Mixedwood processing residues	Forest processing waste	Forestry
Carrot	Carrot	Agricultural harvest residues	Agriculture
Bagasse	Bagasse	Agricultural harvest residues	Agriculture
Chayote	Chayote	Agricultural harvest residues	Agriculture
pulp and paper waste	Mixwood processing residues	Forest processing waste	Forestry
Agricultural crop by-products	General agriculture residue	Agricultural harvest residues	Agriculture
Rice husk	Rice residue	Agricultural harvest residues	Agriculture
Forest Logging Protect Residues	Mixedwood logging residues	Logging residues	Forestry
Lettuce	Lettuce	Agricultural harvest residues	Agriculture
miscanthus	Miscanthus	Energy crop, herbaceous	Agriculture
Plywood Residues	MSW	Final product waste	Forestry
Cereals straw	Cereal straw	Agricultural harvest residues	Agriculture
Biowaste unseparately collected	Food waste, nonresidential	Other wet waste	Waste
Cassava, harvesting residues	Cassava	Agricultural harvest residues	Agriculture
Cotton lint, harvesting residues	Cotton lint	Agricultural harvest residues	Agriculture
Cottonseed, harvesting residues	Cottonseed	Agricultural harvest residues	Agriculture
Seed cotton, harvesting residues	Seed cotton	Agricultural harvest residues	Agriculture

Avocados, harvesting residues	Avocados	Agricultural harvest residues	Agriculture
Bananas, harvesting residues	Bananas	Agricultural harvest residues	Agriculture
Fruit, fresh not elsewhere specified, harvesting residues	Fruit	Agricultural harvest residues	Agriculture
Fruit, tropical fresh not elsewhere specified, harvesting residues	Fruit	Agricultural harvest residues	Agriculture
Mangoes, mangosteens, guavas, harvesting residues	Mangoes	Agricultural harvest residues	Agriculture
Melons, other (including cantaloupes), harvesting residues	Melons	Agricultural harvest residues	Agriculture
Oranges, harvesting residues	Oranges	Agricultural harvest residues	Agriculture
Papayas, harvesting residues	Papayas	Agricultural harvest residues	Agriculture
Pineapples, harvesting residues	Pineapple	Agricultural harvest residues	Agriculture
Watermelons, harvesting residues	Watermelons	Agricultural harvest residues	Agriculture
Groundnuts, with shell, harvesting residues	Groundnuts	Agricultural harvest residues	Agriculture
Bast fibres, other, harvesting residues	Bast fibres	Agricultural harvest residues	Agriculture
Manila fibre (abaca), harvesting residues	Manila fibre (abaca)	Agricultural harvest residues	Agriculture
Sisal, harvesting residues	Sisal	Agricultural harvest residues	Agriculture
Maize, harvesting residues	Maize	Agricultural harvest residues	Agriculture
Maize, green, harvesting residues	Maize	Agricultural harvest residues	Agriculture
Coconuts, harvesting residues	Coconuts	Agricultural harvest residues	Agriculture
Oil, palm fruit, harvesting residues	Oil	Agricultural harvest residues	Agriculture
Palm kernels, harvesting residues	Palm kernels	Agricultural harvest residues	Agriculture
Potatoes, harvesting residues	Potatoes	Agricultural harvest residues	Agriculture
Beans, dry, harvesting residues	Beans	Agricultural harvest residues	Agriculture
Beans, green, harvesting residues	Beans	Agricultural harvest residues	Agriculture
Pulses not elsewhere specified, harvesting residues	Pulses not elsewhere specified	Agricultural harvest residues	Agriculture
Rice, paddy, harvesting residues	Rice	Agricultural harvest residues	Agriculture
Soybeans, harvesting residues	Soybeans	Agricultural harvest residues	Agriculture
Chillies and peppers, green, harvesting residues	Chillies and peppers	Agricultural harvest residues	Agriculture
Cinnamon (canella), harvesting residues	Cinnamon (canella)	Agricultural harvest residues	Agriculture
Cloves, harvesting residues	Cloves	Agricultural harvest residues	Agriculture

Pepper (piper spp.), harvesting residues	Pepper (piper spp.)	Agricultural harvest residues	Agriculture
Spices not elsewhere specified, harvesting residues	Spices not elsewhere specified	Agricultural harvest residues	Agriculture
Vanilla, harvesting residues	Vanilla	Agricultural harvest residues	Agriculture
Cocoa, beans, harvesting residues	Cocoa	Agricultural harvest residues	Agriculture
Coffee, green, harvesting residues	Coffee	Agricultural harvest residues	Agriculture
Tea, harvesting residues	Tea	Agricultural harvest residues	Agriculture
Sugar cane, harvesting residues	Sugar cane	Agricultural harvest residues	Agriculture
Sugar crops not elsewhere specified, harvesting residues	Sugar crops not elsewhere specified	Agricultural harvest residues	Agriculture
Sweet potatoes, harvesting residues	Sweet potatoes	Agricultural harvest residues	Agriculture
Areca nuts, harvesting residues	Areca nuts	Agricultural harvest residues	Agriculture
Cashew nuts, with shell, harvesting residues	Cashew nuts	Agricultural harvest residues	Agriculture
Castor oil seed, harvesting residues	Castor oil seed	Agricultural harvest residues	Agriculture
Kapok fruit, harvesting residues	Kapok fruit	Agricultural harvest residues	Agriculture
Nuts not elsewhere specified, harvesting residues	Nuts not elsewhere specified	Agricultural harvest residues	Agriculture
Cabbages and other brassicas, harvesting residues	Cabbages and other brassicas	Agricultural harvest residues	Agriculture
Carrots and turnips, harvesting residues	Carrots and turnips	Agricultural harvest residues	Agriculture
Cauliflowers and broccoli, harvesting residues	Cauliflowers and broccoli	Agricultural harvest residues	Agriculture
Cucumbers and gherkins, harvesting residues	Cucumbers and gherkins	Agricultural harvest residues	Agriculture
Eggplants (aubergines), harvesting residues	Eggplants (aubergines)	Agricultural harvest residues	Agriculture
Garlic, harvesting residues	Garlic	Agricultural harvest residues	Agriculture
Ginger, harvesting residues	Ginger	Agricultural harvest residues	Agriculture
Leeks, other alliaceous vegetables, harvesting residues	Leeks	Agricultural harvest residues	Agriculture
Mushrooms and truffles, harvesting residues	Mushrooms and truffles	Agricultural harvest residues	Agriculture
Onions, dry, harvesting residues	Onions	Agricultural harvest residues	Agriculture
Pumpkins, squash and gourds, harvesting residues	Pumpkins	Agricultural harvest residues	Agriculture
Spinach, harvesting residues	Spinach	Agricultural harvest residues	Agriculture
Tomatoes, harvesting residues	Tomatoes	Agricultural harvest residues	Agriculture
Vegetables, fresh not elsewhere specified, harvesting residues	Vegetables	Agricultural harvest residues	Agriculture

Roots and tubers not elsewhere specified, harvesting residues	Roots and tubers not elsewhere specified	Agricultural harvest residues	Agriculture
Cassava, processing residues	Cassava	Agricultural processing residues	Agriculture
Cotton lint, processing residues	Cotton lint	Agricultural processing residues	Agriculture
Cottonseed, processing residues	Cottonseed	Agricultural processing residues	Agriculture
Seed cotton, processing residues	Seed cotton	Agricultural processing residues	Agriculture
Avocados, processing residues	Avocados	Agricultural processing residues	Agriculture
Bananas, processing residues	Bananas	Agricultural processing residues	Agriculture
Fruit, fresh not elsewhere specified, processing residues	Fruit	Agricultural processing residues	Agriculture
Fruit, tropical fresh not elsewhere specified, processing residues	Fruit	Agricultural processing residues	Agriculture
Mangoes, mangosteens, guavas, processing residues	Mangoes	Agricultural processing residues	Agriculture
Melons, other (including cantaloupes), processing residues	Melons	Agricultural processing residues	Agriculture
Oranges, processing residues	Oranges	Agricultural processing residues	Agriculture
Papayas, processing residues	Papayas	Agricultural processing residues	Agriculture
Pineapples, processing residues	Pineapple	Agricultural processing residues	Agriculture
Watermelons, processing residues	Watermelons	Agricultural processing residues	Agriculture
Groundnuts, with shell, processing residues	Groundnuts	Agricultural processing residues	Agriculture
Bast fibres, other, processing residues	Bast fibres	Agricultural processing residues	Agriculture
Manila fibre (abaca), processing residues	Manila fibre (abaca)	Agricultural processing residues	Agriculture
Sisal, processing residues	Sisal	Agricultural processing residues	Agriculture
Maize, processing residues	Maize	Agricultural processing residues	Agriculture
Maize, green, processing residues	Maize	Agricultural processing residues	Agriculture
Coconuts, processing residues	Coconuts	Agricultural processing residues	Agriculture
Oil, palm fruit, processing residues	Oil	Agricultural processing residues	Agriculture
Palm kernels, processing residues	Palm kernels	Agricultural processing residues	Agriculture
Potatoes, processing residues	Potatoes	Agricultural processing residues	Agriculture
Beans, dry, processing residues	Beans	Agricultural processing residues	Agriculture
Beans, green, processing residues	Beans	Agricultural processing residues	Agriculture
Pulses not elsewhere specified, processing residues	Pulses not elsewhere specified	Agricultural processing residues	Agriculture

Rice, paddy, processing residues	Rice	Agricultural processing residues	Agriculture
Soybeans, processing residues	Soybeans	Agricultural processing residues	Agriculture
Chillies and peppers, green, processing residues	Chillies and peppers	Agricultural processing residues	Agriculture
Cinnamon (canella), processing residues	Cinnamon (canella)	Agricultural processing residues	Agriculture
Cloves, processing residues	Cloves	Agricultural processing residues	Agriculture
Pepper (piper spp.), processing residues	Pepper (piper spp.)	Agricultural processing residues	Agriculture
Spices not elsewhere specified, processing residues	Spices not elsewhere specified	Agricultural processing residues	Agriculture
Vanilla, processing residues	Vanilla	Agricultural processing residues	Agriculture
Cocoa, beans, processing residues	Cocoa	Agricultural processing residues	Agriculture
Coffee, green, processing residues	Coffee	Agricultural processing residues	Agriculture
Tea, processing residues	Tea	Agricultural processing residues	Agriculture
Sugar cane, processing residues	Sugar cane	Agricultural processing residues	Agriculture
Sugar crops not elsewhere specified, processing residues	Sugar crops not elsewhere specified	Agricultural processing residues	Agriculture
Sweet potatoes, processing residues	Sweet potatoes	Agricultural processing residues	Agriculture
Areca nuts, processing residues	Areca nuts	Agricultural processing residues	Agriculture
Cashew nuts, with shell, processing residues	Cashew nuts	Agricultural processing residues	Agriculture
Castor oil seed, processing residues	Castor oil seed	Agricultural processing residues	Agriculture
Kapok fruit, processing residues	Kapok fruit	Agricultural processing residues	Agriculture
Nuts not elsewhere specified, processing residues	Nuts not elsewhere specified	Agricultural processing residues	Agriculture
Cabbages and other brassicas, processing residues	Cabbages and other brassicas	Agricultural processing residues	Agriculture
Carrots and turnips, processing residues	Carrots and turnips	Agricultural processing residues	Agriculture
Cauliflowers and broccoli, processing residues	Cauliflowers and broccoli	Agricultural processing residues	Agriculture
Cucumbers and gherkins, processing residues	Cucumbers and gherkins	Agricultural processing residues	Agriculture
Eggplants (aubergines), processing residues	Eggplants (aubergines)	Agricultural processing residues	Agriculture
Garlic, processing residues	Garlic	Agricultural processing residues	Agriculture
Ginger, processing residues	Ginger	Agricultural processing residues	Agriculture
Leeks, other alliaceous vegetables, processing residues	Leeks	Agricultural processing residues	Agriculture
Mushrooms and truffles, processing residues	Mushrooms and truffles	Agricultural processing residues	Agriculture

Onions, dry, processing residues	Onions	Agricultural processing residues	Agriculture
Pumpkins, squash and gourds, processing residues	Pumpkins	Agricultural processing residues	Agriculture
Spinach, processing residues	Spinach	Agricultural processing residues	Agriculture
Tomatoes, processing residues	Tomatoes	Agricultural processing residues	Agriculture
Vegetables, fresh not elsewhere specified, processing residues	Vegetables	Agricultural processing residues	Agriculture
Cabbages and other brassicas, processing residues	Cabbages and other brassicas	Agricultural processing residues	Agriculture
Carrots and turnips, processing residues	Carrots and turnips	Agricultural processing residues	Agriculture
Cauliflowers and broccoli, processing residues	Cauliflowers and broccoli	Agricultural processing residues	Agriculture
Cucumbers and gherkins, processing residues	Cucumbers and gherkins	Agricultural processing residues	Agriculture
Eggplants (aubergines), processing residues	Eggplants (aubergines)	Agricultural processing residues	Agriculture
Garlic, processing residues	Garlic	Agricultural processing residues	Agriculture
Ginger, processing residues	Ginger	Agricultural processing residues	Agriculture
Leeks, other alliaceous vegetables, processing residues	Leeks	Agricultural processing residues	Agriculture
Mushrooms and truffles, processing residues	Mushrooms and truffles	Agricultural processing residues	Agriculture
Onions, dry, processing residues	Onions	Agricultural processing residues	Agriculture
Pumpkins, squash and gourds, processing residues	Pumpkins	Agricultural processing residues	Agriculture
Spinach, processing residues	Spinach	Agricultural processing residues	Agriculture
Tomatoes, processing residues	Tomatoes	Agricultural processing residues	Agriculture
Vegetables, fresh not elsewhere specified, processing residues	Vegetables	Agricultural processing residues	Agriculture

APPENDIX C. Sustainability Reporting

APPENDIX C. SUSTAINABILITY REPORTING

Report No.	*Citation*	*National Organizations*	*Internat'l Organizations*	*Other Organizations*	*Sustainability Definition*	*Sustainability Applied.*	*Sustainability Def. Incl.*	*Sustainability Mentioned*	*Social/Political/Economic Constraints*	*Social/Political/Economic Constraints Incl.*
1	Technology Information, Forecasting and Information Council (TIFAC). 2018. Estimation of Surplus Crop Residue in India for Biofuel Production. Technical Report. New Delhi, India: Technology Information, Forecasting and Information Council (TIFAC). CS-IARI-Publication. https://tifac.org.in/images/pdf/pub/TIFACReports/newreports/biomass_w(1).pdf.	1	0	0	Mentions of using biofuel to decrease pollution	discussed	0	1	0	
2	Gesto-Energia, S.A. 2016. Angola Energia 2025: Angola Power Sector Long Term Vision. National Energy Report 373118/14. Republic of Angola Ministry of Energy and Water. https://angolaenergia2025.gestoenergy.com/sites/default/files/editor/livro_angola_energia_2025_baixa.pdf.	1	0	0	No sustainability	N/A	0	0	0	
3	Degreenia, J., Wynne, G. 2023. Biofuels Annual- Brazil. USDA-FAS Brazil. https://fas.usda.gov/data/brazil-biofuels-annual-10#:~:text=Total%20Brazilian%20ethanol%20production%20for,increase%20in%20corn%20ethanol%20production.	0	0	1	No sustainability	N/A	0	0	0	
4	Joseph, K. 2023. Biofuels Annual- Argentina. USDA-FAS Argentina. fas.usda.gov/data/argentina-biofuels-annual-8	0	0	1	No sustainability	N/A	0	0	0	

5	Danielson, E., 2023. Biofuels Annual- Canada. USDA-FAS Canada. https://www.fas.usda.gov/data/canada-biofuels-annual-9	0	0	1	No sustainability	N/A	0	0	0	
6	Enea and Deloitte for ARENA. 2021. Australia's Bioenergy Roadmap. Canberra, Australia: ENEA Australia, Deloitte Financial Advisory Pty Ltd, ARENA. https://arena.gov.au/assets/2021/11/australia-bioenergy-roadmap-report.pdf.	0	1	0	Plans for future development of regulatory framework, no hard definitions.	discussed	0	1	1	Stakeholders identified social acceptance as a barrier.
7	Ministerio de Industria, Energía y Minería, 2023. National Energy Balance 2023: Historical Series 1965-2023 (National Energy Report), Energy Balance. Ministerio de Industria, Energía y Minería, Uruguay.	0	0	1	No sustainability	N/A	0	0	0	
8	Benti, Natei Ermias, Gamachis Sakata Gurmesa, Tegenu Argaw, Abreham Berta Aneseyee, Solomon Gunta, Gashaw Beyene Kassahun, Genene Shiferaw Aga, and Ashenafi Abebe Asfaw. 2021. The Current Status, Challenges and Prospects of Using Biomass Energy in Ethiopia. Biotechnology for Biofuels 14 (1): 1?24. https://doi.org/10.1186/s13068-021-02060-3.	0	0	1	No definitions, talk of need for policy	discussed	0	1	0	
9	Ministerio de Ganaderia, Agricultura y Pesca. 2023. Agricultural Statistical Yearbook 2023. Annual. Annual Statistics Yearbook. Montevideo, Uruguay: Ministerio de Ganaderia, Agricultura y Pesca. https://descargas.mgap.gub.uy/DIEA/Anuarios/Anuario2023/ANUARIO2023WEB.pdf.	1	0	0	No sustainability	N/A	0	0	0	
10	Mansuy, Nicolas, Julie Barrette, Jerome Laganiere, Warren Mabee, David Pare, Shuva Gautam, Evelyne Thiffault, and Saeed Ghafghazi. 2018. Salvage Harvesting for Bioenergy in Canada: From Sustainable and Integrated Supply Chain to Climate Change Mitigation. WIREs Energy and Environment 7 (5): e298. https://doi.org/10.1002/wene.298.	1	0	0	No sustainability	N/A	0	0	0	

11	Mansuy, Nicolas, David Pare, Evelyne Thiffault, Pierre Y. Bernier, Guillaume Cyr, Francis Manka, Benoit Lafleur, and Luc Guindon. 2017. Estimating the Spatial Distribution and Locating Hotspots of Forest Biomass from Harvest Residues and Fire-Damaged Stands in Canada's Managed Forests. Biomass and Bioenergy 97 (February): 90?99. https://doi.org/10.1016/j.biombioe.2016.12.014.	0	0	1	No sustainability	N/A	0	0	0	
12	Smyth, C. E., B. Hudson, J. Metsaranta, C. Howard, M. Fellows, and W. A. Kurz. 2023. Fire-Killed Forest Biomass for Mills and Communities and Bioenergy GHG Impacts. Biomass and Bioenergy 175 (August): 106877. https://doi.org/10.1016/j.biombioe.2023.106877.	0	0	1	No sustainability	N/A	0	0	0	
13	Dymond, C. C., B. D. Titus, G. Stinson, and W. A. Kurz. 2010. Future Quantities and Spatial Distribution of Harvesting Residue and Dead Wood from Natural Disturbances in Canada. Forest Ecology and Management 260 (2): 181?92. https://doi.org/10.1016/j.foreco.2010.04.015.	0	0	1	No sustainability	N/A	0	0	0	
14	Mupondwa, Edmund, Xue Li, and Lope Tabil. 2018. Integrated Bioethanol Production from Triticale Grain and Lignocellulosic Straw in Western Canada. Industrial Crops and Products 117 (July): 75?87. https://doi.org/10.1016/j.indcrop.2018.02.070.	0	0	1	No sustainability	N/A	0	0	0	
15	Barrette, Julie, David Pare, Francis Manka, Luc Guindon, Pierre Bernier, and Brian Titus. 2018. Forecasting the Spatial Distribution of Logging Residues across the Canadian Managed Forest. Canadian Journal of Forest Research 48 (12): 1470?81. https://doi.org/10.1139/cjfr-2018-0080.	0	0	1	No sustainability	N/A	0	0	0	
16	Canuel, Claudie-Maude, Evelyne Thiffault, and Nelson Thiffault. 2022. An Empirical Financial Analysis of Integrating Biomass Procurement in Sawtimber and Pulpwood Harvesting in Eastern Canada. Canadian Journal of Forest Research 52 (6): 920-939. https://doi.org/10.1139/cjfr-2021-0327.	0	0	1	No sustainability	N/A	0	0	0	

17	Popper, Rafael, Nina Rilla, Klaus Niemela, Juha Oksanen, Matthias Deschryvere, Matti Virkkunen, and Torsti Loikkanen. 2020. The Future of Forest-Based Bioeconomy Areas: Strategic Openings in Uruguay and the World by 2050. VTT Technology No. 379. VTT Technical Research Centre of Finland. https://doi.org/10.32040/2242-122X.2020.T379.	0	0	1	No sustainability	N/A	0	0	0	
18	The Danish Energy Agency. 2022. Danish Basic Bioenergy Data 2022. Dataset. Basic Energy Data Timeseries. Copenhagen, Denmark: The Danish Energy Agency. https://ens.dk/sites/ens.dk/files/Statistik/grunddata2022_-_basicdata2022.xlsx.	1	0	0	No sustainability	N/A	0	0	0	
19	Akgun, Orkide, Mika Korkeakoski, Suvisanna Mustonen, and Jyrki Luukkanen. 2011. Theoretical Bioenergy Potential in Cambodia and Laos. In World Renewable Energy Congress, 335-342. https://doi.org/10.3384/ecp11057335.	0	0	1	No sustainability	N/A	0	0	0	
20	Li, Xue, Edmund Mupondwa, Satya Panigrahi, Lope Tabil, Shahab Sokhansanj, and Mark Stumborg. 2012. A Review of Agricultural Crop Residue Supply in Canada for Cellulosic Ethanol Production. Renewable and Sustainable Energy Reviews 16 (5): 2954?65. https://ideas.repec.org//a/eee/rensus/v16y2012i5p2954-2965.html.	0	0	1	No sustainability	N/A	0	0	0	
21	Said, N., S.A. El-Shatoury, L.F. Diaz, and M. Zamorano. 2013. Quantitative Appraisal of Biomass Resources and Their Energy Potential in Egypt. Renewable and Sustainable Energy Reviews 24 (August): 84?91. https://doi.org/10.1016/j.rser.2013.03.014.	0	0	1	No sustainability	N/A	0	0	0	
22	Szarka, Nora, Henryk Haufe, Nora Lange, Franziska Schier, Holger Weimar, Martin Banse, Viktoriya Sturm, Lara Dammer, Stephan Piotrowski, and Daniela Thran. 2021. Biomass Flow in Bioeconomy: Overview for Germany. Renewable and Sustainable Energy Reviews 150 (October): 111449. https://doi.org/10.1016/j.rser.2021.111449.	1	0	0	No sustainability	N/A	0	0	0	

23	D. Matschegg and D. Bacovsky, "Bioenergy in Austria," Federal Ministry of Transport, Innovation and Technology, Wien, Austria, National Assessment 52/2019, Nov. 2019. Accessed: Feb. 12, 2024. [Online]. Available: https://nachhaltigwirtschaften.at/resources/nw_pdf/schriftenreihe/schriftenreihe-2019-52-bioenergy-in-austria.pdf	1	0	0	Renewable Energy Directive II	N/A	0	0	0	
23	Matschegg, Doris, and Dina Bacovsky. 2019. Bioenergy in Austria. National Assessment 52/2019. Reports of Energy and Environmental Research. Wien, Austria: Federal Ministry of Transport, Innovation and Technology. https://nachhaltigwirtschaften.at/resources/nw_pdf/schriftenreihe/schriftenreihe-2019-52-bioenergy-in-austria.pdf.	1	0	0	Nachhaltigkeitsverordnung BGBI II NR 157/2014	discussed	1	0	0	
24	Aghaei, Siavash, Masih Karimi Alavijeh, Marzieh Shafiei, and Keikhosro Karimi. 2022. A Comprehensive Review on Bioethanol Production from Corn Stover: Worldwide Potential, Environmental Importance, and Perspectives. Biomass and Bioenergy 161 (June): 106447. https://doi.org/10.1016/j.biombioe.2022.106447.	0	0	1	No sustainability applied to the estimates/study reports GHG reduction potential of using corn stover	discussed	1	0	0	
25	Zhang,C., Nie, J., Yan, X. 2023. "Estimation of biomass utilization potential in China and the impact on carbon peaking". https://doi.org/10.1007/s11356-023-28891-1	0	0	1	Focused on decreasing carbon impacts as a whole	discussed	0	1	0	
26	Falck-Zepeda, J., Mangi, S., Sulser, T., Zambrano, P., & Falconi, C. (2010). Biofuels and Rural Economic Development in Latin America and the Caribbean [Assessment](2010/015 FAO-IDB-LAC)	0	1	0	sustainability as food prices	applied	1	1	1	food prices
27	Datta, P., M. Dees, B. Elbersen, and I. Staritsky. 2017. The Data Base of Biomass Cost Supply Data for EU 2, Western Balkan Countries, Moldavia, Turkey and Ukraine. Project Report. S2BIOM- a Project Funded under the European Union 7th Framework Programme for Research. Freiburg, Germany: Chair of Remote Sensing and Landscape Information Systems, Institute of Forest Sciences. https://s2biom.wenr.wur.nl/doc/S2Biom_D1_5_v1_2_FINAL_19_04_2017_CP.pdf.	0	1	0	Noted in database developed for each country	applied	1	1	0	

28	Australian Government Department of Climate Change, Energy, the Environment and Water. 2023. Australian Energy Update 2023. Canberra, Australia: Australian Government Department of Climate Change, Energy, the Environment and Water. https://www.energy.gov.au/sites/default/files/Australian%20Energy%20Update%202023_0.pdf.	1	0	0	No sustainability	N/A	0	0	0	
29	U.S. Department of Energy. 2024. 2023 Billion Ton Report: An Assessment of U.S. Renewable Carbon Resources. M. H. Langholtz (Lead). Oak Ridge, TN: Oak Ridge National Laboratory. ORNL/SPR-2024/3103. doi: 10.23720/BT2023/2316165.	1	0	0	Defined	applied	1	1	0	
30	Thees, Oliver, Vanessa Burg, Matthias Erni, Gillianne Bowman, and Renato Lemm. 2017. Potentials of Domestic Biomass Resources for the Energy Transition in Switzerland. XLSX. Swiss Federal Institute for Forest, Snow and Landscape Research WSL / Swiss Competence Center for Energy Research - Biomass for Swiss Energy Transition SCCER-BIOSWEET. https://doi.org/10.16904/18.	1	0	0	Yes sustainability	applied	1	1	1	ecological, economic, legal and political constraints
31	Drigo, Rudi, Alicia Anschau, Stella Carballo, Noelia Flores Marco, and Miguel Trossero. 2009. Analisis del Balance de Energia derivada de Biomasa en Argentina: Analisis espacial de la produccion y consumo de biocombustibles aplicando la metodologia de Mapeo de Oferta y Demanda Integrada de Dendrocombustibles. (Woodfuel Integrated Supply / Demand Overview Mapping). TCP/ARG/3103. WISDOM Argentina. Rome, Italy: FAO. https://www.fao.org/3/i0900s/i0900s00.pdf.	1	0	0	No sustainability	N/A	0	0	0	
32	Boscana, M, L Boragno, and R Echeverria. 2023. ESTADISTICAS FORESTALES 2023. Annual. Forest Statistics. Montevideo, Uruguay: Ministerio de Ganaderia, Agricultura y Pesca. https://www.gub.uy/ministerio-ganaderia-agricultura-pesca/sites/ministerio-ganaderia-agricultura-pesca/files/2023-07/DGF%20Boletin%20Estadistico_2023.pdf.	1	0	0	No sustainability	N/A	0		0	
33	Lucid Insights Ltd, and Biotechnology and Biological Sciences Research Council. n.d. UK Grown: How Biotechnology Can Unlock High Value Products from UK Crops. Oxford, England, UK: High Value Biorenewables. Accessed March 8, 2024. https://www.highvaluebiorenewables.net/seecmsfile/?id=419.	1	0	0	No sustainability	N/A	0	0	0	

34	Brown, Adam, Lars Waldheim, Ingvar Landalv, Jack Saddler, Mahmood Ebadian, James D. McMillan, Antonio Bonomi, and Bruno Klein. 2020. Advanced Biofuels- Potential for Cost Reduction. Task 41. Paris, France: International Energy Agency Bioenegy. https://www.ieabioenergy.com/wp-content/uploads/2020/02/T41_CostReductionBiofuels-11_02_19-final.pdf.	0	1	0	Yes sustainability	applied	1	1	1	water
35	Hall, Peter, and Scion. 2023. Comparison of Possible Supply Chains for Forestry Derived Biomass for Bioenergy in New Zealand. Technical Report 58052648. IEA Bioenergy: Task 43. https://www.ieabioenergy.com/wp-content/uploads/2023/10/IEA-Bioenergy_Report_Biomass-Supply-Chains_V2-3.pdf.	1	0	0	No sustainability	N/A	0	0	0	
36	J. Skeer, S. Nakada, and Y. Inoue, Biofuel potential in Southeast Asia: Raising food yields, reducing food waste and utilising residues, International Renewable Energy Agency, Abu Dhabi, United Arab Emirates, 978-92-9260-028?0, 2017. Accessed: Jul. 07, 2024. [Online]. Available: https://www.irena.org/Publications/2017/Jun/Biofuel-potential-in-Southeast-Asia-Raising-food-yields-reducing-food-waste-and-utilising-residues	0	1	0	yes	applied	1	1	1	land use
37	Guzman-Bello, Hugo, Iosvani Lopez-Diaz, Miguel Aybar-Mejia, Maximo Dominguez-Garabitos, and Jose Atilio De Frias. 2023. Biomass Energy Potential of Agricultural Residues in the Dominican Republic. Sustainability 15 (22): 15847. https://doi.org/10.3390/su152215847.	0	0	1	yes	applied	1	1	1	residues as sustainable resources
38	Wang, R., Cai, W., Yu, L., et al. 2023. "A high spatial resolution dataset of China's biomass resource potential." Scientific Data 10: 384. https://doi.org/10.1038/s41597-023-02227-7	0	0	1	Notes marginal and abandoned cropland use	discussed	0	1	0	
39	Navius Research Inc. 2021. Biofuels in Canada 2021: Tracking Biofuel Consumption, Feedstocks and Avoided Greenhouse Gas Emissions. Vancouver, BC, Canada: Navius Research Inc. https://www.naviusresearch.com/wp-content/uploads/2021/11/Biofuels-in-Canada-Final-2021-11-09.pdf.	1	0	0	No sustainability	N/A	0	0	0	

40	Strengers, Bart, and Hans Elzenga. 2020. Availability and Applications of Sustainable Biomass. Report on a Search for Shared Facts and Views. Policy Brief 4205. The Hague, Netherlands: PBL Netherlands Environmental Assessment Agency. https://doi.org/10.13140/RG.2.2.12630.06729.	1	0	0	No sustainability	N/A	0	0	0	
41	Errera, M. R., T. A. da C. Dias, D. M. Y. Maya, and E. E. S. Lora. 2023. Global Bioenergy Potentials Projections for 2050. Biomass and Bioenergy 170 (March): 106721. https://doi.org/10.1016/j.biombioe.2023.106721.	0	0	1	No sustainability	N/A	0	0	0	
42	Tolessa, Amsalu. 2023. Bioenergy Potential from Crop Residue Biomass Resources in Ethiopia. Heliyon 9 (2): e13572. https://doi.org/10.1016/j.heliyon.2023.e13572.	1	0	0	gives constraint for total recoverable biomass, also has mention of economic and social barriers	N/A	0	0	0	
43	Welfle, Andrew, Robert A. Holland, Iain Donnison, and Patricia Thornly. 2020. UK Biomass Availability Modelling Scoping Report. 02/2020. Birmingham, England, UK: Supergen Bioenergy Hub. https://www.supergen-bioenergy.net/wp-content/uploads/2020/10/Supergen-Bioenergy-HubUK-Biomass-Availability-Modelling-Scoping-Report-Published-Final.pdf.	1	0	0	No sustainability	N/A	0	0	0	
44	Ramon Fernando Colmenares-Quintero, Natalia Rojas, Sandy Kerr & Diana M. Caicedo-Concha. (2020) Industry and academia partnership for aquatic renewable energy development in Colombia: A knowledge-education transfer model from the United Kingdom to Colombia. Cogent Engineering 7:1.	0	0	1	No sustainability	N/A	0	0	0	
45	Committee on Climate Change. 2020. Land Use: Policies for a Net Zero UK. Policy Suggestion. Land Use. London, UK: Committee on Climate Change. https://www.theccc.org.uk/wp-content/uploads/2020/01/Land-use-Policies-for-a-Net-Zero-UK.pdf.	1	0	0	No sustainability	N/A	0	0	0	

46	Department of Energy Security and Net Zero. 2023. Biomass Strategy 2023. Policy Document. Biomass Strategy. London, UK: Department for Energy Security and Net Zero. www.gov.uk/official-documents.	1	0	0	No sustainability	N/A	0	0	0	
47	Fritsche, Uwe R., Goran Berndes, Annette Cowie, Francis X. Johnson, Virginia Dale, Hans Langeveld, Navin Sharma, Helen Watson, and Jeremy Woods. 2017. Energy and Land Use - Global Land Outlook: Working Paper. Working Paper 10.13140/RG.2.2.24905.44648. Global Land Outlook. Abu Dhabi, United Arab Emirates: IRENA. http://rgdoi.net/10.13140/RG.2.2.24905.44648.	0	1	0	No sustainability	N/A	0	0	0	
48	FAOSTAT Bioenergy database	0	1	0	No sustainability	N/A	0	0	0	
49	D. Chiaramonti and A. Salimbeni, “BIKE Final Project Publication,” Renewable Energy - Consortium for Research and Demonstration (RE-CORD), Firenze, Italy, Final Report D7.6, Aug. 2023. Accessed: Dec. 19, 2023. [Online]. Available: https://www.bike-biofuels.eu/wp-content/uploads/2023/09/BIKE_Final-Publication-7.pdf	0	1	0	No sustainability	N/A	0	0	0	
50	H. Wenzel, “Biomass availability and sector competition.” May 17, 2022.	0	0	1	No sustainability	N/A	0	0	0	
51	S. Ladanai and J. Vinterbäck, “Biomass for Energy versus Food and Feed, Land Use Analyses and Water Supply,” Swedish University of Agricultural Sciences, Department of Energy and Technology, Uppsala, Sweden, Land Use Assessment 022, 2010.	0	0	1	No sustainability	N/A	0	0	0	

52	J. O'Malley, N. Pavlenkok, and S. Y. Searle, "Estimating sustainable aviation fuel feedstock availability to meet growing European Union demand Working Paper," International Council on Clean Transportation, Working Paper 2021–13, Mar. 2021.	0	1	0	No sustainability	N/A	0	0	0	
53	World Bioenergy Association, "Global Bioenergy Statistics 2022," World Bioenergy Association, Stockholm, Sweden, 2023. Accessed: Dec. 19, 2023. [Online]. Available: https://www.worldbioenergy.org/uploads/221223%20WBA%20GBS%202022.pdf	0	1	0	No sustainability	N/A	0	0	0	
54	International Energy Agency Bioenergy, "Implementation of bioenergy in Brazil – 2021 update," International Energy Agency Bioenegy, Paris, France, Update, Oct. 2021. Accessed: Dec. 20, 2023. [Online]. Available: https://www.ieabioenergy.com/wp-content/uploads/2021/11/CountryReport2021_Brazil_final.pdf	0	1	0	No sustainability	N/A	0	0	0	
55	L. Cozzi and T. Gül, "Net Zero by 2050 - A Roadmap for the Global Energy Sector (4th edition)," International Energy Agency, Directorate of Sustainability, Technology and Outlooks, Paris, France, Strategic Plan, Oct. 2021. Accessed: Dec. 19, 2023. [Online]. Available: https://iea.blob.core.windows.net/assets/deebef5d-0c34-4539-9d0c-10b13d840027/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf	0	1	0	No sustainability	N/A	0	0	0	
56	J. Liebetrau et al., "Potential and utilization of manure to generate biogas in seven countries," IEA Bioenergy: Task 37, 2021. [Online]. Available: https://www.ieabioenergy.com/wp-content/uploads/2021/07/Potential-utilization_WEB_END_NEW.pdf	0	1	0	No sustainability	N/A	0	0	0	
57	International Energy Agency, "Renewable Energy Market Update: Outlook for 2023 and 2024," International Energy Agency, Paris, France, Market Update, Jun. 2023. [Online]. Available: https://iea.blob.core.windows.net/assets/63c14514-6833-4cd8-ac53-f9918c2e4cd9/RenewableEnergyMarketUpdate_June2023.pdf	0	1	0	No sustainability	N/A	0	0	0	

58	IRENA, “Renewable Energy Statistics 2023,” International Renewable Energy Agency, Abu Dhabi, United Arab Emirates, Statistics, 2023. [Online]. Available: https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2023/Jul/IRENA_Renewable_energy_statistics_2023.pdf	0	1	0	No sustainability	N/A	0	0	0
59	P. Cazzola, F. Gerard, M. Gorner, M. Gibbs, and K. Young, “Research for TRAN Committee: Assessment of the potential of sustainable fuels in bike”.	0	1	0	No sustainability	N/A	0	0	0
60	A. P. C. Faaij, “Securing sustainable resource availability of biomass for energy applications in Europe; review of recent literature.” University of Groningen, Netherlands, Nov. 2018. Accessed: Dec. 19, 2023. [Online]. Available: https://energy.nl/wp-content/uploads/bioenergy-europe-eu-biomass-resources-andre-faaij-final-3.pdf	0	0	1	No sustainability	N/A	0	0	0
61	European Commission. Directorate General for Energy., “Sustainable and optimal use of biomass for energy in the EU beyond 2020,” PricewaterhouseCoopers EU Services EESV’s consortium, Belgium, Final Report, May 2017. [Online]. Available: https://energy.ec.europa.eu/publications/sustainable-and-optimal-use-biomass-energy-eu-beyond-2020_en	0	1	0	No sustainability	N/A	0	0	0
62	C. Mort, “Unlocking the UK’s biomass resources as a feedstock for Chemical Manufacturing,” Innovate UK KTN, London, UK.	1	0	0	No sustainability	N/A	0	0	0
63	Air Transport Action Group, “Waypoint 2050: An Air Transport Action Group Project - Second Edition,” Air Transport Action Group, Geneva, Switzerland, Strategic Plan, Sep. 2021. Accessed: Dec. 19, 2023. [Online]. Available: https://aviationbenefits.org/media/167417/w2050_v2021_27sept_full.pdf	0	1	0	No sustainability	N/A	0	0	0

64	IRENA, “World Energy Transitions Outlook 2023: 1.5°C Pathway Volume 1,” International Renewable Energy Agency, Abu Dhabi, United Arab Emirates, Global Assessment, 2023. [Online]. Available: https://mc-cd8320d4-36a1-40ac-83cc-3389-cdn-endpoint.azureedge.net/-/media/Files/IRENA/Agency/Publication/2023/Jun/IRENA_World_energy_transitions_outlook_v1_2023.pdf?rev=cc4522ff897a4e26a47906447c74bca6	0	1	0	No sustainability	N/A	0	0	0	