

# Bioeconomy Accounting: Methods and Pilot Application to 13 Latin American Economies

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We propose a practical methodology to estimate Bioeconomic Satellite Accounts following the rules outlined in the System of National Accounts for analytical extensions. This methodology reaggregates classifications within the Supply and Use tables of this system to highlight the economic contribution of inputs and outputs driven by biological resources for all economic activities. In contrast to similar studies, we suggest that an *a priori* classification of economic activities as either “bioeconomic” or “non-bioeconomic” underestimates value added by biological resources that fall outside the predetermined activities. Instead, we assess the economic contribution driven by biological resources for all economic activities and propose direct and indirect methods to rank them according to their importance for bioeconomic policy. We exemplify the methodology with the cases of Guatemala and Costa Rica, and we provide estimates for 13 economies of Latin America and The Caribbean.

## Introduction

In 2018, the Costa Rican Government published that country’s National Bioeconomy Strategy, following an internationally agreed definition crafted in the context of the German Bioeconomy Council (German Bioeconomy Council, 2018), which states that the Bioeconomy is:

“The production, use, conservation, and regeneration of biological resources, including the knowledge, science, technology, and innovation related to these resources, to provide information, products, processes, and services to all economic sectors, with the goal of advancing toward a sustainable economy (Gobierno de Costa Rica, 2020).”

Additionally, this strategy defines “biological resources” within the framework as **i)** biomass cultivated to produce food, fodder, fibers, and energy; **ii)** biomass from marine resources and

that produced through aquaculture; **iii**) forest biomass, especially that cultivated for use in the forestry and paper industries, as well as that legally extracted from natural ecosystems; **iv**) residual biomass from the agricultural, fishing and aquaculture, forestry, and agro-industrial sectors; **v**) biomass that can be recovered from urban waste; **vi**) liquid waste from livestock and human activities; and **vii**) terrestrial and marine biodiversity, including the biodiversity of inland waters.

Public policies informed by data have been shown to provide opportunities to build upon what works and understand why it works (Bowers & Testa, 2019). While Costa Rica has a long tradition in the production of environmental accounts (BCCR, 2021b) following the System of Environmental and Economic Accounts—SEEA—(European Commission, Economic Cooperation, Development, United Nations, & World Bank, 2013), their Environmental Accounts Council identified a gap in the assessment of the direct and indirect contribution of biological resources to the economy that officials needed to close to design better policies around the subject.

Given the richness of information regarding biological resources that is collected to assess the economic performance of the country, we were granted the opportunity to close this gap by extending the System of National Accounts (SNA), the framework with which Gross Domestic Product (GDP) is measured, among many other indicators, to highlight the contribution of those resources through Bioeconomy Satellite Accounting (BSA) for Costa Rica (Vargas, Alvarado, Rodríguez, Rodríguez, & Wander, 2022). The SNA manual (European Commission et al., 2009, p. 523) provides clear guidelines on how to develop analytical extensions—specifically *Key Sector Accounts* and *Satellite Accounts*—and we chose to adhere to those guidelines to avoid deviations from SNA’s concepts and accounting rules and maintain comparability with traditional economic indicators. In particular, we focused on reaggregating classifications of the Supply and Use Tables (SUTs) that provide detail for what is known as the production account within SNA.

This strict adherence to the principles of SNA and the standardization procedure developed to handle SUT data in the case of Costa Rica, allowed us to readily extend this exercise to 13 Latin American economies. This was possible because these economies have made their Supply and Use tables publicly available and this information has been centralized in a repository (ECLAC, 2021). Relying on the SNA principles, definitions, classifications, and accounting rules also gave us an opportunity to express results related to the Bioeconomy using concepts that are easily understood by policy-makers because of their widespread use in economic performance communications and analysis.

## Data and Methods

### Supply and Use Tables as data sources

The main source of information for BSAs are SUTs from SNA (European Commission et al., 2009), which are multi-dimensional matrices that show in great detail the production and import of goods and services by economic activities in a country and how those are used, either in the production process itself as inputs, by other agents in the economy, or by the rest of the world. The different areas of these tables describe a flow of transactions in the economy. All transactions (columns) show detailed information for all products (rows) identified in a given economy. The production transaction in the Supply Table and the intermediate consumption transaction in the Use Table are further disaggregated by economic activities (columns). The detail of products is arranged according to national adaptations of the Central Product Classification—CPC—(United Nations, 2015) and economic activities are arranged according to the International Standard Industrial Classification of All Economic Activities—ISIC—(United Nations, 2008).

In the case of the Supply Table, the sequence of those transactions (columns) describes a flow where different products (rows) are produced by economic activities at basic prices (i.e., the price at the farm gate, factory, or commercial establishment). This output is then combined with imports free of insurance and freight costs to form the supply at basic prices. However, this is not the price paid by economic agents. In its way to market, taxes on products are added to the basic price supply, minus any subsidies received, followed by distribution margins (transportation and trade costs). This results in the total supply at purchaser's or market prices, found in the last column of the table, which represents what is available for purchase by the same economic agents in the use table. For these additional columns of transactions, the product detail (rows) is maintained, but not the economic activity detail.

The Use Table shows how the supply from the last column of the Supply Table is purchased by economic agents for various purposes at market prices, expressed in the form of different transactions. Similar to the production above, this table shows Intermediate Consumption, which refers to the purchase of inputs by economic activities used to produce the goods and services in the first table (essentially, the production recipe for each economic activity). The portion of the supply that does not become an input in the production process remains available on the market for other domestic and foreign economic agents. The other transactions in the remaining columns illustrate that these goods and services can be exported; consumed by households, nonprofit institutions serving households (NPISH), and the general government; or they can be used as durable goods in gross capital formation; moved in or out of storage to be consumed in a different accounting period (changes in inventories); or get sold as valuable items. It is important to note that, row by row (product detail), the Total Use column equals the last column of the Supply Table, adhering to the economic principle of equality between supply and demand.

## Characterizing the Bioeconomy using product classifications: a two step procedure

Countries use adaptations of the international classifications of economic activities and products to focus on those elements that are important to their economic structure. In most cases, there is a one-to-one correspondence between international classifications and their national adaptations. However, this is not always the case, because there might be key national activities and products unique to the country that do not have an international counterpart. In other cases, there could be a match at one level of disaggregation but not at another, due to the way some categories are combined. This is reflected, for example, in the vertical integration of certain industries where the same economic activity produces a primary sector good while it also provides services related to that production in a manner that's indistinguishable in their financial statements, making it practically impossible to separate them. This, for example, could result in a product category comprising a mix of codes from an agricultural division and a services division. For this reason, it is necessary to follow a two-step procedure:

- In the first step, we compare the different products from the CPC classification against the internationally agreed definition of the Bioeconomy shown in the introductory paragraphs (German Bioeconomy Council, 2018), in general, and that of biological resources in particular (Gobierno de Costa Rica, 2020), and we decide whether the product matches any of its parts conceptually. It should be clarified that, at the highest levels of disaggregation, certain services, which may not initially appear to be directly related to the Bioeconomy, have been taken into consideration in this first step, based on the argument that they could not exist without the prior existence of a Bioeconomic product. For example, the category *62123 Retail trade services of meat, poultry, and game in non-specialized stores* refers to a trade service, but its purpose and existence are so closely tied to bioeconomic products that it could not exist without the prior production of *21111 Fresh or chilled beef* or *21121 Fresh or chilled chicken* one step back in the supply chain, as well as *02111 Cattle* and *02151 Chickens* two steps back in the production chain. For this reason, these have been categorized as Characteristic of the Bioeconomy. This is also consistent with the Bioeconomy definition, which includes services. Nevertheless, national adaptations in the following step do not have this level of disaggregation and thus a binary approach, even with these caveats, is impossible and we resort to the creation of a partial category termed Extended Characteristic of the Bioeconomy. Resulting equivalence tables are included in the Supplementary Information (SI) section.
- In a second step, we analyze each element of the national product classification and evaluate how each corresponding code aligns with the binary identification from the international classification of previous step. Often, national classifications bundle together product categories at a level that is sensible for field or record data collection. This results in three possible outcomes 1) 100% of the products within the national category belong to the Bioeconomy, according to the international classification (Bioeconomy products); 2) only some of the products within the national category belong to the Bioeconomy, according to the international classification (we call those Bioeconomy Extended products);

and 3) none of the activities or products within the category belong to the Bioeconomy, according to the international classification (Non-Bioeconomy Products).

Once this rearrangement is completed, we describe the Bioeconomy using traditional macroeconomic aggregates like output, intermediate consumption, imports, exports, taxes on products, and gross capital formation disaggregated for Bioeconomy products, Bioeconomy Extended products, and Non-Bioeconomy products.

### **Bioeconomic Value Added and GDP: a divergence from other studies**

The output of every economic activity less its intermediate consumption (its inputs) leaves a remainder called Value Added, which is then available for distribution among the owners of capital, laborers, and the government. Value Added is similar in business accounting to the concept of profits, which are what remains after deducting costs from total sales. The only difference is that in National Accounts, payments to employees are not deducted as costs. The sum of the individual Value Added of all economic activities, plus taxes, less subsidies, equals GDP. One important fact about Value Added is that it is calculated by economic activity and not by product and this poses a challenge for the Bioeconomy.

Initial efforts in the nascent gray literature classify economic activities as Bioeconomic or Non-Bioeconomic *a priori* based on whether their primary production is a bioeconomic product or not, as defined in the previous section. Then they add together, either all, or a fraction of their Value Added (VA) as a proxy for the “Bioeconomic GDP”. We understand that this approach as a necessary compromise, because “biological resource” is a quality of products, but VA and GDP are aggregates that are estimated at the economic activity or total economy level. While these first approximations have provided valuable estimates of the size of the Bioeconomy, this *a priori* determination of bioeconomic activities has at least three important limitations.

1. Within SUTs economic activities can produce more than one product and, in turn, any product in the Economy can be produced by more than one activity. Bioeconomic products could be part of the secondary production of activities that have not been deemed as Bioeconomic. Since the value added of these activities is not included in the estimation of the Bioeconomy, this would lead to an under estimation of the contribution of bioeconomic products.
2. Secondary production of Non-Bioeconomic products within an activity classified as Bioeconomic *a priori* could be a non-trivial share of its output. Taking that activity’s entire Value Added as Bioeconomic would lead to an over estimation of the contribution of bioeconomic products to the total economy.
3. *A priori* classification of economic activities as Bioeconomic is based on observed values at the time of compilation. There are activities in the present that might not have biological inputs or outputs, but which could have them in the future. For example, in a given country, there might be zero biological resources used in construction, rendering that activity as non-bioeconomic, but with the advent of biomaterials and other

innovations, this could change in the future and housing could be constructed with “live” materials. Not belonging to the Bioeconomy at the time of first compilation, these future developments would be overlooked. Alternatively, reclassifying them as Bioeconomic or Bioeconomic Extended in the future would introduce inconsistencies to time series.

Instead, we propose that the Bioeconomy within an economic activity is a continuum. All economic activities might use, as part of their production recipe between 0 and 100 percent of bioeconomic inputs for the production of its output, which can itself be between 0 and 100 percent bioeconomic. We can then estimate the direct fraction of economic value that is enabled by biological resources by adjusting Value Added by any of these percentages. This leads to a more accurate estimation of the Bioeconomy by minimizing the sources of under or over estimation discussed above.

This is a criteria that we developed only after trying the first approach and finding these pockets of under or over representation of the Bioeconomy outside *a priori* determined bioeconomic activities. Our original estimates for Costa Rica (Vargas et al., 2022) showed that the bioeconomy described with this first method was of about 12.0% of Gross Value Added. Using our proposed approach allowed us to correct our under and overvalued estimation of the Bioeconomy, which resulted in a contribution of 15.7% of Gross Value Added in the case of an output based fraction estimation and 17.2% in the case of an intermediate consumption based fraction estimation.

## Results

This section presents a comparative series of results that highlight the contribution of biological resources to 13 economies of Latin America and the Caribbean, focusing on several macroeconomic aggregates. As an example of the information generated for each country, we provide a compact version of the Bioeconomy SUTs with data from Guatemala for the year 2019—the most recent year available in ECLAC’s repository (ECLAC, 2021)—and insights at economic sector level from the Costa Rican case.

### Bioeconomy SUT: The case of Guatemala

In the Supply Table (Table 1), the most important categories correspond to the output (OP) or the production of goods and services, which are divided into bioeconomy, extended bioeconomy, and non-bioeconomy. For presentation purposes, all 152 products and services from the Guatemalan economy, as published in the ECLAC repository (ECLAC, 2021), are aggregated into these three categories. In the case of the use table (Table 2), the same three bioeconomic aggregations are displayed, but this time they represent the intermediate consumption and final consumption of the same 152 products (row data). In other words, purchases of inputs by activities for production (intermediate consumption); purchases of households, nonprofit

Table 1: Guatemala: Condensed Bioeconomy Supply Table  
(Million GTQ at current prices, 2018)

Transactions	OP								IM	C/F	T/S	MR	Total
Products\ Activities	A	B	C	D - E	F	G	H - S	Subtotal	-	-	-	-	-
Bioeconomy	86,306	0	96,882	3,764	0	572	274	187,799	29,032	0	8,881	81,112	306,823
Extended Bioeconomy	2,802	0	42,884	1,963	0	38	37,906	85,593	32,379	0	5,835	21,962	145,768
Non-Bioeconomy	3,481	4,979	61,410	15,820	55,858	144,876	310,743	597,168	107,116	-9,499	18,802	-103,073	610,514
CIF/FOB Adjustment	0	0	0	0	0	0	0	0	-9,499	9,499	0	0	0
<b>Total Supply</b>	<b>92,588</b>	<b>4,979</b>	<b>201,176</b>	<b>21,548</b>	<b>55,858</b>	<b>145,487</b>	<b>348,924</b>	<b>870,560</b>	<b>168,526</b>	<b>0</b>	<b>33,518</b>	<b>0</b>	<b>1,063,106</b>

institutions, and the government as consumers; gross capital formation (i.e. the purchase of durable goods, valuable objects, and changes in inventories); and exports.

Transactions: OP. Output; IM. Imports; C/F. CIF/FOB Adjustment; T/S. Taxes less subsidies; MR. Trade and transport margins. Groups of Activities: A. Agriculture; B. Mining; C. Manufacturing; D-E Other Utilities & Water; F. Construction; G. Wholesale and Retail Trade; H-S. Other services.

The flow of Bioeconomic information from left to right in Table 1 shows output (OP) at producer prices (i.e., the price at the farm gate or factory), to which we then add imports free of insurance and freight costs to form the supply of goods and services in the economy at basic prices. The transactions in the following columns add detail on insurance and freight costs, taxes less subsidies on products, and distribution margins (i.e., transportation and marketing costs), which are added to bring these products to consumers. The last column shows, row by row, the availability of each good and service in the economy at market prices in the case of supply (Table 1), which is equal to total use (in Table 2) row by row.

Table 1 shows an output of GTQ306.8 billion in bioeconomic products, which corresponds to 28.9% of the total supply at purchaser's prices (1.1 trillion GTQ). Products from the extended bioeconomy accounted for 145.8 billion GTQ, or 13.7% of the total supply, while non-bioeconomic products represented 610.5 billion GTQ, or 57.4% of total supply. Since SNA operates on the economic principle that supply equals demand, Table 2 shows that the consumption of each category of products matches those of the Use Table. Taxes (less subsidies) on bioeconomic products amounted to 8.9 billion GTQ and represented 26.5% of total taxes on production (33.5 billion GTQ); extended bioeconomic products accounted for 17.4%, and non-bioeconomic products made up 56.1%.

In absolute terms, non-bioeconomic products represent the largest source of tax revenue, but it is interesting to estimate the implicit tax rate for each type of product. This is done by dividing the taxes collected by the output value of each type of product. This reveals that the implicit tax rate for bioeconomic products is 4.8% of output (8.8 billion / 187.8 billion), 6.8% for extended bioeconomic products, and 3.1% for non-bioeconomic products. It is important to clarify that this estimated tax rate is not the result of an explicit fiscal policy decision targeting bioeconomic products, but rather the aggregate impact of all the different fiscal policy decisions that have been made in the country over time. Notably, the implicit tax rate

Table 2: Guatemala: Condensed Bioeconomy Use Table  
(Million GTQ at current prices, 2018)

Transactions	IC								EX	FC	CF	Total
Products\ Activities	A	B	C	D - E	F	G	H - S	Subtotal	-	-	-	-
Bioeconomy	11,827	22	52,114	172	86	1,182	19,607	85,009	41,560	178,290	1,964	306,823
Extended Bioeconomy	15,495	77	23,235	365	1,373	2,480	5,154	48,178	15,406	81,844	339	145,768
Non-Bioeconomy	13,218	1,896	48,957	8,924	28,389	36,212	82,823	220,420	33,857	282,593	73,644	610,514
<b>CIF/FOB Adjustment</b>	0	0	0	0	0	0	0	0	9,357	-9,357	0	0
<b>Total Use</b>	<b>40,540</b>	<b>1,995</b>	<b>124,306</b>	<b>9,461</b>	<b>29,848</b>	<b>39,873</b>	<b>107,584</b>	<b>353,608</b>	<b>100,180</b>	<b>533,371</b>	<b>75,947</b>	<b>1,063,106</b>
<b>Value Added</b>	<b>52,048</b>	<b>2,984</b>	<b>76,870</b>	<b>12,086</b>	<b>26,010</b>	<b>105,613</b>	<b>241,341</b>	<b>516,952</b>				<b>516,952</b>

is higher for bioeconomic and extended bioeconomic products compared to non-bioeconomic products.

Table 2 shows a condensed version of the Bioeconomy Use Table, describing all possible destinations—row by row—for the total availability of products shown in Table 1. The first seven columns show Intermediate Consumption, with the eighth column showing the subtotal for that transaction. Intermediate Consumption describes the purchase of inputs for production by economic activities. In 2018, this transaction amounted to a total of 353.6 billion GTQ, of which 24.0% corresponded to the purchase of bioeconomic products, 13.6% to the purchase of extended bioeconomic products, and 62.3% to the purchase of non-bioeconomic products. Exports amounted to 100.1 billion GTQ (net of CIF/FOB adjustments), with 41.5% corresponding to bioeconomic products, 15.4% to extended bioeconomic products, and 33.89% to non-bioeconomic products. This is understandable for a country where a significant portion of exports consists of agricultural products. Finally, out of 533.4 billion GTQ corresponding to final consumption, 33.4% accounted for bioeconomic products, 15.3% for extended bioeconomic products, and 53.0% for non-bioeconomic products.

Transactions: IC. Intermediate Consumption; EX. Exports; FC. Final Consumption; CF. Capital Formation. Groups of Activities: A. Agriculture; B. Mining; C. Manufacturing; D-E Other Utilities & Water; F. Construction; G. Wholesale and Retail Trade; H-S. Other services.

The remainder that results from subtracting intermediate consumption at purchaser's prices from production at producer's prices (which is technically known as gross output) is equal to gross Value Added (see Table 2). This is calculated for each economic activity (or column). Gross Value Added is similar to the profit that results from subtracting the cost of inputs (excluding labor) from total sales in a company, but at the level of the entire economy. The sum of the value added by all economic activities, plus total taxes on products, minus subsidies on those products, results in the Gross Domestic Product (GDP). In this case, 926.4 billion – 369.7 billion + 36.1 billion quetzales results a GDP of 592.8 billion GTQ for 2019.

If we were to abide by the *a priori* selection of Bioeconomic sectors, these would account for 17.0% of gross Value Added—i.e. the Bioeconomy's GDP—, 4.6% for extended bioeconomic activities, and 78.4% for non-bioeconomic activities. However, we have explained the limitations that come with that approach. That's why we suggest that biological resources, as



the natural resource basis of production across *all* economic activities (not just some), can be seen as a spectrum. Each activity can make greater or lesser use of biological inputs. In other words, each activity may have a higher or lower share of bioeconomic products in its intermediate consumption structure and can also produce a mix of products with a higher or lower proportion of bioeconomic content. For this reason, estimating a bioeconomic contribution of 17.0% of Value Added, or 94.8 billion GTQ, overlooks in some way the 997.5 million GTQ in bioeconomic products and the 42.2 billion GTQ in extended bioeconomic products produced by non-bioeconomic activities. It would be more accurate to say that the value added across all sectors was based on 24.0% bioeconomic inputs (as explained earlier in the intermediate consumption analysis), which is a calculation that can be done individually for each sector (for example, agriculture, manufacturing, and trade), without relying on the three bioeconomic classification categories in the columns and instead focusing on the bioeconomic content of products in the rows. The conclusion is that all economic activities can be more or less bioeconomic, whether from the perspective of production or intermediate consumption.

Table 2 also shows exports, which total 95.3 billion GTQ (excluding the CIF/FOB adjustments row), with 46.4% corresponding to bioeconomic products, 16.7% to extended bioeconomic products, and 36.9% to non-bioeconomic products. This is reasonable for a country where a significant portion of exports consists of agricultural products. Finally, of the 578.3 billion quetzales corresponding to final consumption (excluding CIF/FOB adjustments), 32.8% corresponds to bioeconomic products, 15.0% to extended bioeconomic products, and 52.2% to non-bioeconomic products.

### Disaggregation by Economic Activity

For a more detailed view of the Bioeconomy, we turn our attention to the example of Costa Rica. Bioeconomic SUTs include detailed information on hundreds of products and economic activities. Policy analysis can benefit from this level of disaggregation when conducting sectoral analyses. Table 3 shows an example of such a detailed view of the Bioeconomy for the case of the pharmaceutical sector of Costa Rica. Table 3 shows that 34.6% of the inputs of this economic activity by value depend on 24 bioeconomic products. An additional 17.5% of its Intermediate Consumption is catalogued as belonging to the extended bioeconomy, while 47.9 percent is accounted for by non-bioeconomic products.

Table 3: Costa Rica: Pharmaceutical Sector Bioeconomy Intermediate Consumption  
(Million CRC at current prices and percent, 2018)

Products	Value (CRC)	Percent
<b>Bioeconomy (subtotal)</b>	<b>30,307.1</b>	<b>34.61%</b>
Pharmaceutical and medicinal products	18,845.6	21.52%
Other food products n.e.c.	4,011.2	4.58%
Prepared animal feed	2,624.9	3.00%

<b>Products</b>	<b>Value (CRC)</b>	<b>Percent</b>
Paper and paper products	1,124.2	1.28%
Garments	1,063.4	1.21%
Food and beverage supply services	996.0	1.14%
Other milling products n.e.c., starches, and starch derivatives	582.7	0.67%
Soaps, detergents, perfumes, and toiletries	253.7	0.29%
Products from non-perennial and perennial plants	198.5	0.23%
Wood and cork, wood and cork products, except furniture; articles of straw and plaiting materials	174.1	0.20%
Support services for agriculture, livestock, and post-harvest activities	133.8	0.15%
Vegetable and animal fats and oils	107.9	0.12%
Leather and related products, except footwear	64.1	0.07%
Rubber products	41.3	0.05%
Cane sugar, molasses, syrups, and other sugars	39.3	0.04%
Ground coffee, soluble coffee, extracts, and concentrates	31.5	0.04%
Wastewater evacuation services	9.5	0.01%
Cocoa, chocolates, and confectionery products	1.8	0.002%
Wheat flour	1.5	0.001%
Products from forestry, wood extraction, and hunting	1.0	0.001%
Eggs	0.7	0.001%
Dairy products	0.1	0.0001%
Other fruits, nuts, and other oil-bearing fruits	0.1	0.0001%
<b>Extended Bioeconomy (subtotal)</b>	<b>15,298.4</b>	<b>17.47%</b>
Basic chemicals and fertilizers, nitrogen compounds, pesticides, and other agrochemical products	14,232.3	16.25%
Other manufactured products	555.7	0.63%
Textile products, except garments	237.9	0.27%
Waste collection, treatment, and disposal services; material recovery	107.4	0.12%
Scientific research and development services	65.6	0.07%

Products	Value (CRC)	Percent
Building cleaning and landscape care and maintenance	46.7	0.05%
Drinking water	45.2	0.05%
Waste and scraps	6.8	0.01%
Footwear	0.7	0.001%
<b>Non-Bioeconomy (subtotal)</b>	<b>41,960.0</b>	<b>47.92%</b>
Remaining 68 Non-Bioeconomy products.	41,960.0	47.92%
<b>Total Use</b>	<b>87,565.5</b>	<b>100.00%</b>

Source: Own elaboration based on Costa Rica's SUTs (BCCR, 2021a).

BSAs can be used to perform this type of exploration for sectors of interest in the context of an economic policy. For example, we can see that biological resources are very important in the case of the processed foods industry, both for *Meat Products* (Figure 1a) and *Milk and Dairy* (Figure 1b) where Bioeconomy products make up 81 and 76 percent of their intermediate consumption, respectively. In contrast, Bioeconomic products account for only 4 percent of the value of intermediate consumption in the *Residential Construction* sector (Figure 1c). Given a policy that provides incentives for the use of innovative biological materials in construction, for example, policy-makers could focus on monitoring the increase or decrease of this share over time.

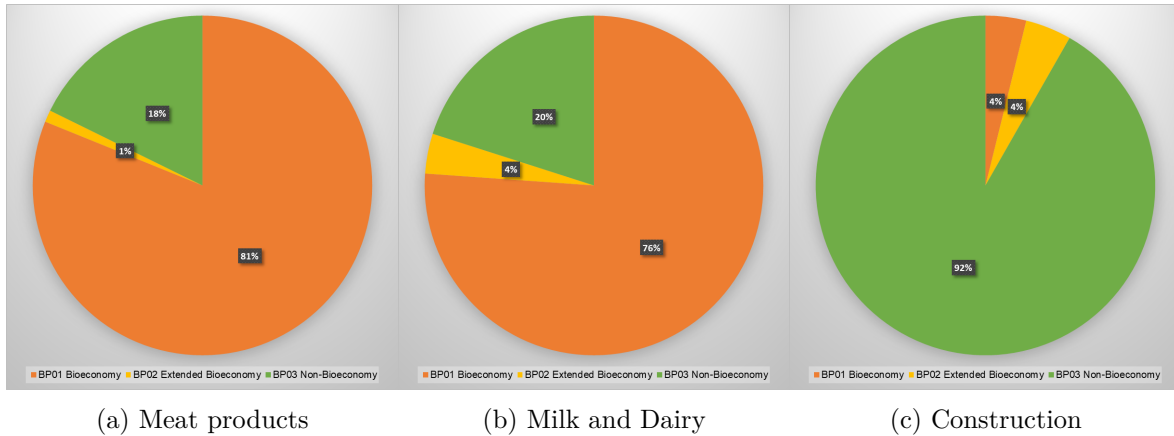


Figure 1: Bioeconomy, Extended Bioeconomy, and Non-Bioeconomy inputs for selected economic activities (Costa Rica, percent, 2018)

### Comparative analysis for 13 economies of Latin America and The Caribbean

Following the same analytical approach used in Table 1 for the case of Guatemala, the panels in Figure 2 provide a comparative analysis of the percentage contribution of the Bioeconomy to

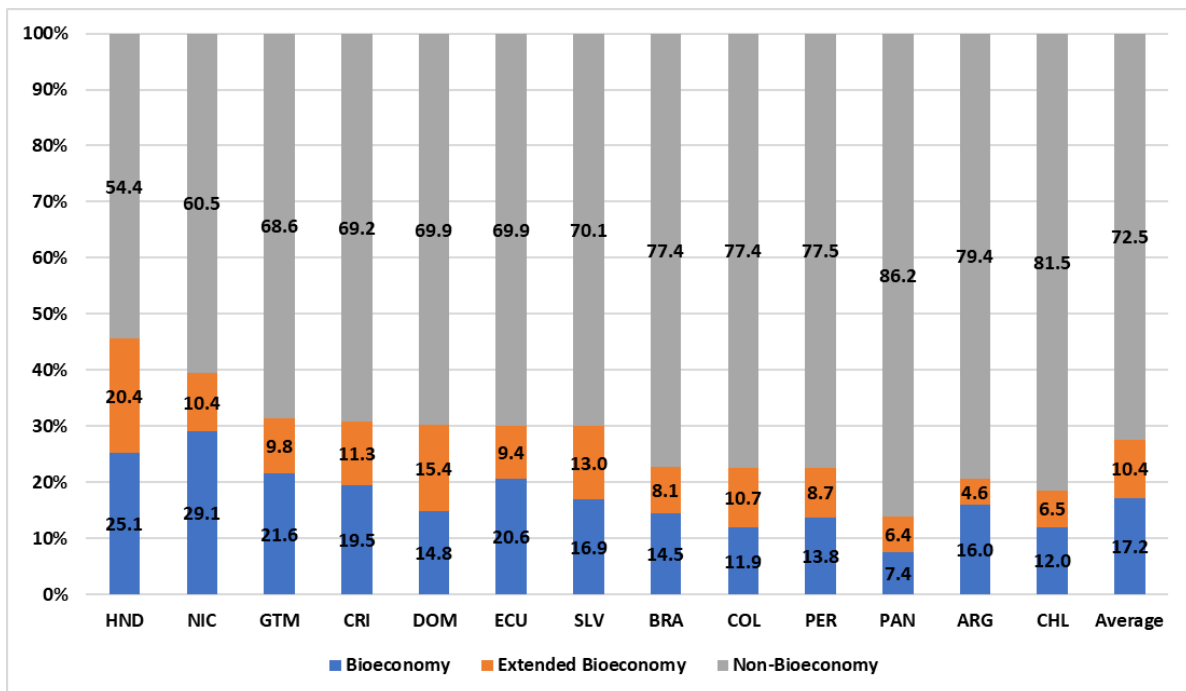
several SNA transactions for Argentina, Brazil, Chile, Colombia, Costa Rica, El Salvador, the Dominican Republic, Ecuador, Guatemala, Honduras, Nicaragua, Panama, and Peru. While the analysis for Guatemala was developed for the year 2019, the focus of this section is the year 2018, since it is the most recent year available for the majority of the countries, with the exception of the Dominican Republic and Panama, where 2016 and 2017 data, respectively, were used.

Figure 2b shows that, on average, 17.5% of gross output in the analyzed countries corresponds to bioeconomic products, 10.6% to extended bioeconomic products, and 71.9% to non-bioeconomic products. Nicaragua has the highest proportion of bioeconomic products, with about a third of its output (29.1%) falling into this category. This highlights a broader agricultural base in their economy. Panama, on the other hand, ranks the lowest, with 11.5% of bioeconomic products in its national production structure. However, its proportion of extended bioeconomic products reaches 9.9%, and when combined, these two categories account for one-fifth of its production based on biological resources.

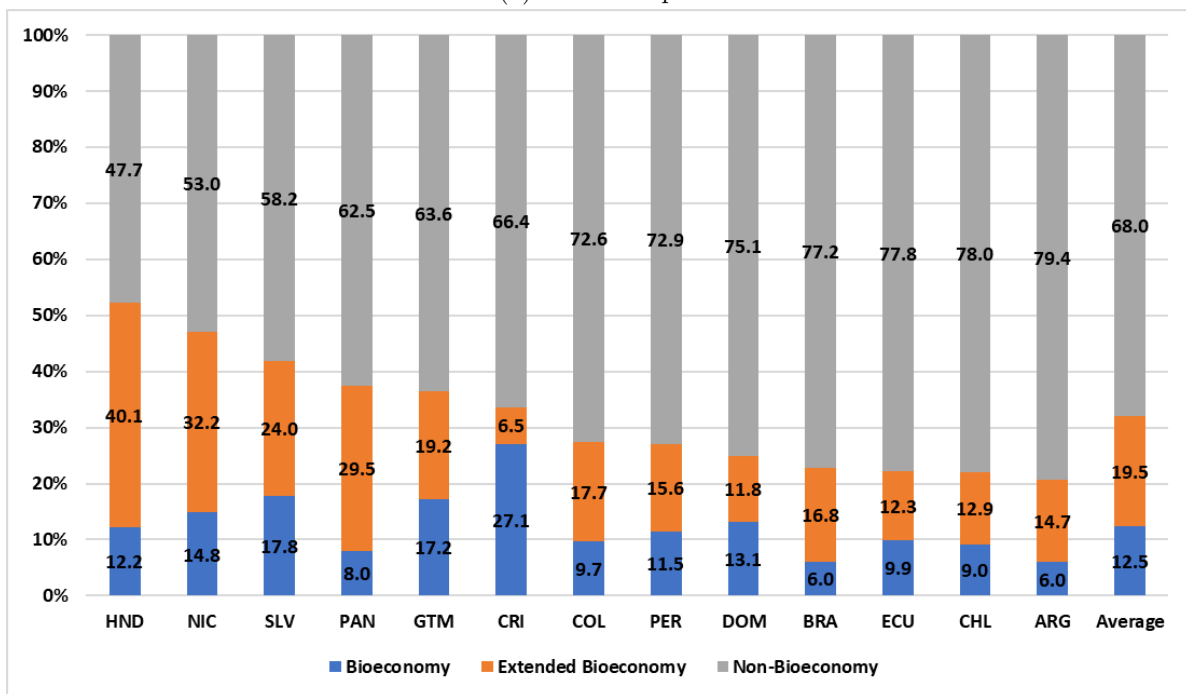
The importance of the bioeconomy in imports is illustrated in Figure 2b, which shows that Costa Rica has the highest level of bioeconomic imports, representing 27.1% of its total imports. In contrast, Argentina and Brazil have the lowest levels, with 6.0% of their imports being bioeconomic products. It's worth examining the combined participation of bioeconomic and extended bioeconomic products in some cases, though caution is advised when interpreting extended bioeconomic products, as it is not always possible to determine the purely biological share due to the aggregation level of product classification in national accounts. For example, Honduras sits in the middle of the chart with 12.2% of its imports being bioeconomic, but 40.1% of its imports fall under extended bioeconomic products. Combined, half of its imports are based on biological resources (52.3%). On average, across all the countries analyzed, bioeconomic products represent 12.5% of imports, extended bioeconomic products 19.5%, and non-bioeconomic products 68.0%.

Costa Rica is the country that derives the highest fiscal revenue from bioeconomic products, which account for 32.7% of taxes minus subsidies on products, as shown in Figure 2c. At the other end of the spectrum, bioeconomic products in Panama are responsible for 13.9% of that revenue. It's also worth comparing the combined total for bioeconomic and extended bioeconomic products. In that case, Panama reaches 37.4%, while Costa Rica, which has only 4.3% attributable to extended bioeconomic products, totals 37.0%. On average, across the analyzed countries, 24.5% of taxes come from bioeconomic products, 16.0% from extended bioeconomic products, and 59.5% from non-bioeconomic products.

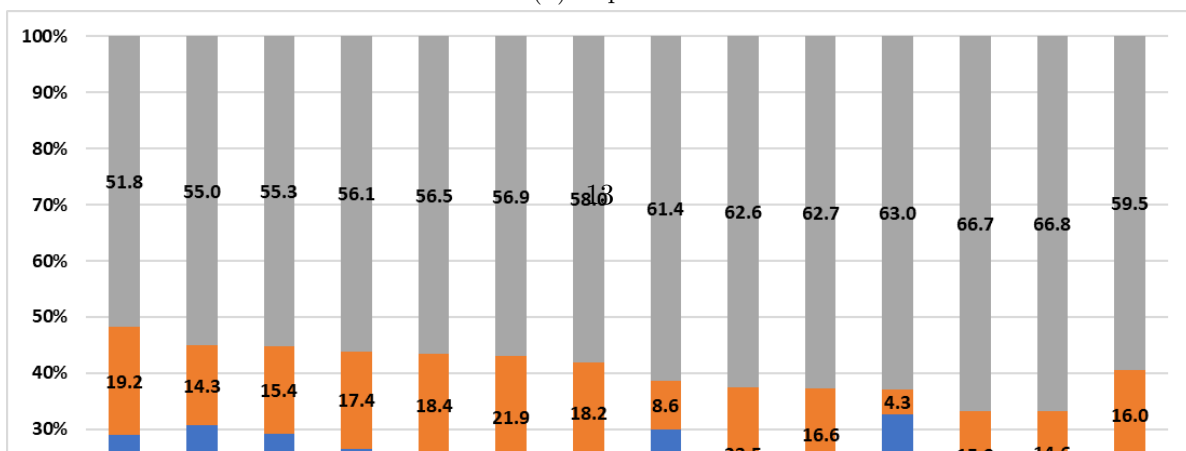
At this point, it's helpful to revisit the concept of the implicit tax rate on bioeconomic products, as explained earlier for the case of Guatemala. Figure 3 shows these rates, along with the implicit rates for extended bioeconomic products and non-bioeconomic products for the 13 countries analyzed, as well as the group average. These rates are calculated by dividing total tax revenue for a specific type of product by the total production of that same product type. As explained earlier, it's important to understand that these rates are not the result of a deliberate fiscal policy regarding the bioeconomy but simply the current net outcome



(a) Gross Output



(b) Imports



across the three product types from various tax instruments implemented at different times for diverse purposes. Argentina has the highest tax rate on bioeconomic products, with an implicit rate of 17.8%, which is 2.4 times higher than the 7.3% rate on non-bioeconomic products. This disparity, which imposes significantly higher taxes on bioeconomic products compared to non-bioeconomic ones, is observed in at least 11 of the 13 countries analyzed (Argentina, Brazil, Chile, El Salvador, the Dominican Republic, Peru, Colombia, Costa Rica, Nicaragua, Guatemala, and Panama), as well as in the overall average, where bioeconomic products have an implicit tax rate of 8.2%, extended bioeconomic products 9.1%, and non-bioeconomic products 4.5%. The case of Honduras is interesting, where the trend is reversed, and bioeconomic products have a lower implicit rate (4.3%) than non-bioeconomic products (5.3%). A similar situation occurs in Ecuador (3.8% and 4.1%, respectively).

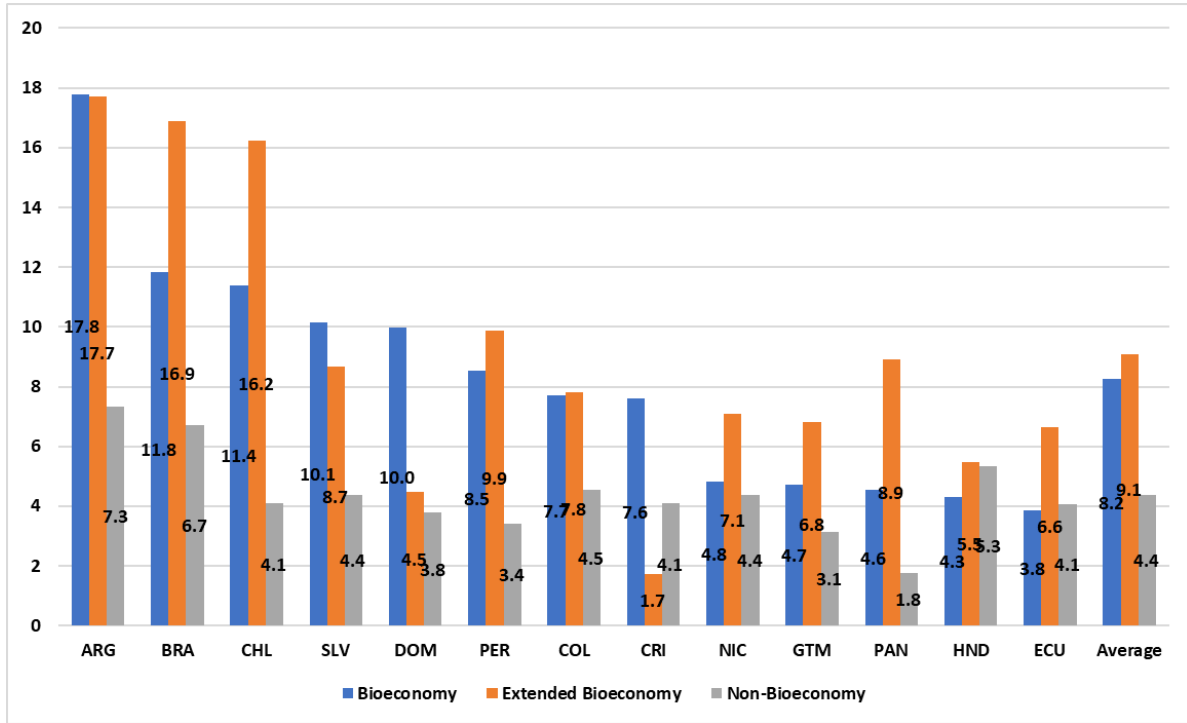


Figure 3: Implicit Tax Rate (13 Latin American Economies, percent, 2018)

Figure 4 compares three use-side transactions across the analyzed countries. First, in Figure 4a, bioeconomic products represent, on average, 18.6% of intermediate consumption, extended bioeconomic products 13.3%, and non-bioeconomic products 68.0%, across the 13 countries analyzed. Nicaragua is the country whose production relies most heavily on a bioeconomic base, with its intermediate consumption of these products reaching 26.5%, followed by Guatemala (24.0%) and Ecuador (23.0%) at the top of the chart. In contrast, Colombia (12.2%), Chile (12.2%), and Panama (12.0%) occupy the last three positions. Once again, it's worth highlighting the case of Honduras, where the share of extended bioeconomic products (29.3%),

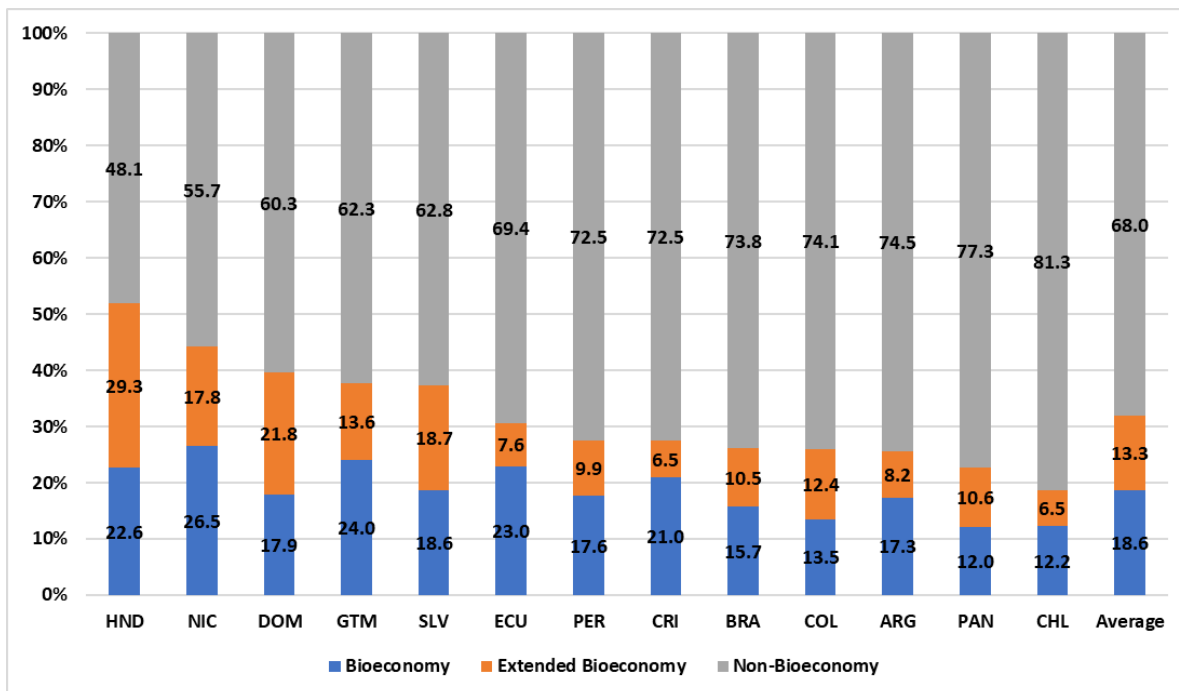
combined with bioeconomic products (29.3%), means that more than half of the country's intermediate consumption (51.9%) is linked to biological resources.

In the case of exports, shown in Figure 4b, Ecuador (47.0%), Argentina (45.8%), and Nicaragua (44.0%) are the three countries with the highest percentage of exports consisting of bioeconomic products, while Colombia (14.2%), the Dominican Republic (13.1%), and Panama (4.0%) have the lowest values. This is closely tied to the importance of agricultural products in the export structure of each country.

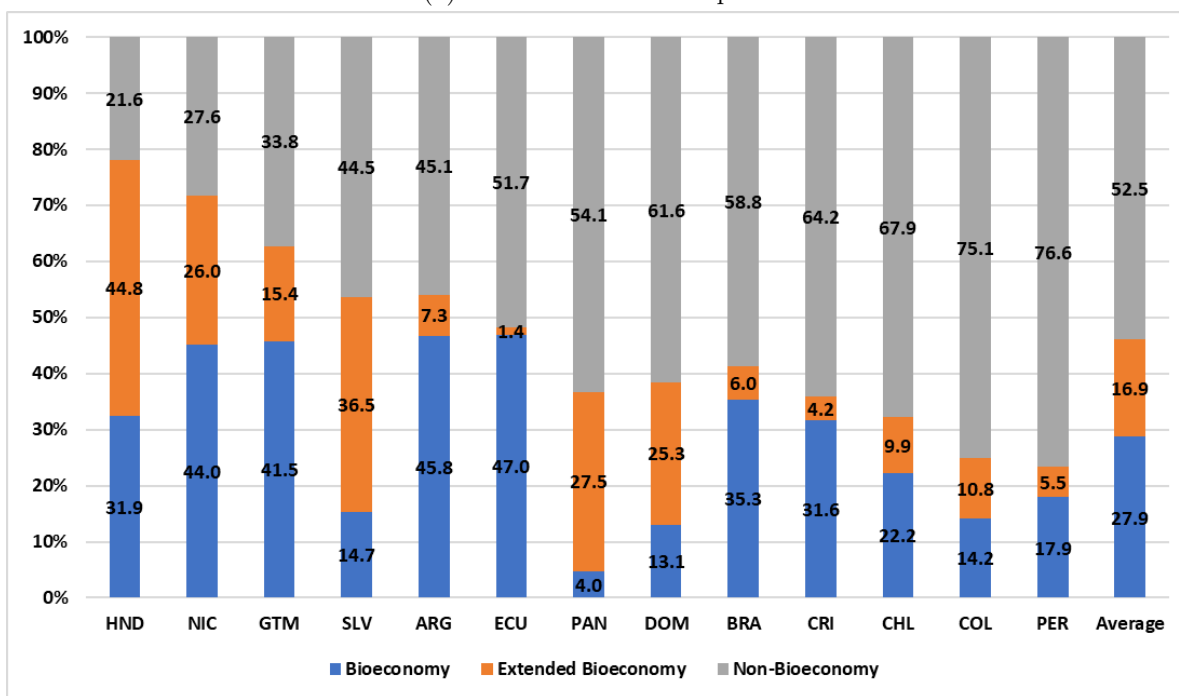
Finally, the final consumption shown in Figure 4c, which includes household consumption, government consumption, and nonprofit institutions' consumption, plays a key role as a driver of the economy, directly and indirectly influencing production and import decisions in economic activities. In this case, Costa Rica has the highest proportion of its consumption attributed to bioeconomic products (36.4%), followed by Guatemala (31.7%) and Honduras (31.7%) at the top. Panama and Brazil (both at 18.9%), Colombia (18.5%), and Chile (18.2%) occupy the lowest positions.

If we consider that intermediate consumption is the input base for producing all the goods and services in the economy, the percentages shown for this transaction suggest that between 12.0% and 26.5% of the value added in the region's countries is based on biological resources, with an average of 18.6%. This analysis can also be applied at a sectoral level, identifying the shares of intermediate consumption that correspond to the bioeconomy for each major sector group, as shown in Figure 5. This reveals that, for the years analyzed and on average for the countries, 44.3% of the value added in agriculture is generated based on the intermediate consumption of bioeconomic products. Following this, 34.8% of the value added in manufacturing industries is based on bioeconomic resources. Other services ranks third, with 11.2% of its intermediate consumption corresponding to bioeconomic products, supporting its value-added generation. In contrast, mining, utilities, construction, and trade have between 0.6% and 2.0% of their intermediate consumption made up of bioeconomic products, suggesting that these products play a less direct role in generating value added in these sectors.

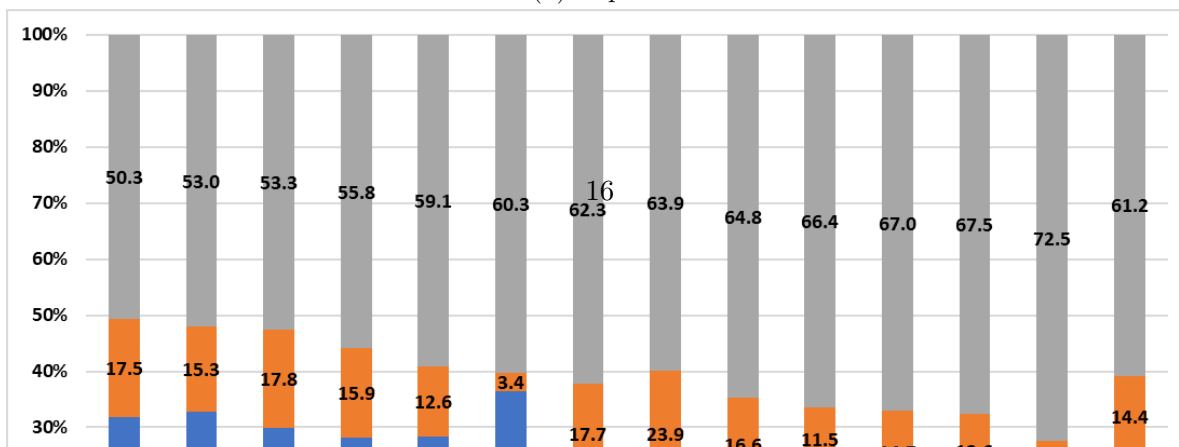
Finally, we explore the contribution of the bioeconomy to GDP. To provide some context, the sum of the value added by economic activities, plus taxes net of subsidies, makes up the Gross Domestic Product (GDP). Value added is a measure calculated at the level of economic activities, not at the product level. For this reason, it is common for studies determining the contribution of the bioeconomy to the economy to classify economic activities as "bioeconomic" a priori and then simply add up their value added to determine their contribution to GDP. In fact, we have also replicated this approach in our own work. However, we have realized that, given that in the national accounts system, products can be produced by more than one activity and each activity can produce more than one product, choosing bioeconomic sectors a priori leads to excluding the contribution of products that we have identified as bioeconomic but are not produced or consumed by activities classified as bioeconomic. In most cases, this leads to an underestimation of the contribution of the bioeconomy.



(a) Intermediate Consumption



(b) Exports





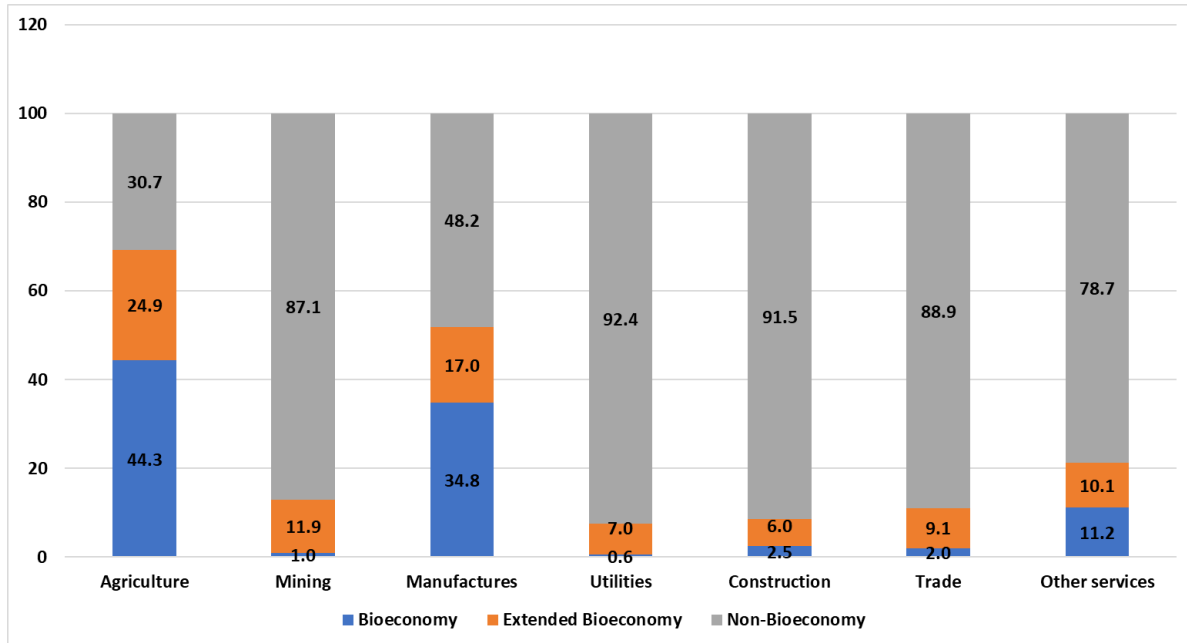


Figure 5: Average bioeconomic content value in intermediate consumption by aggregated groups of economic activity (13 Latin American Economies, percent, 2018)

As we explained earlier, we suggest it is more useful to consider the bioeconomic status of activities as a spectrum, making them more or less dependent on bioeconomic products depending on the amount of bioeconomic inputs present in their intermediate consumption. Figure 6 presents a comparative analysis of the percentage of the economy that can be attributed to the bioeconomy, depending on whether the value added is adjusted as a percentage of intermediate consumption, weighted by each sector's contribution to the total (via Intermediate Consumption in the table), or if the entire value added of sectors considered a priori to be bioeconomic or extended bioeconomic is taken (via sector catalog in the table). What is revealing is that in most cases, except for Chile, Ecuador, and Nicaragua, the estimation obtained by assigning sectors a priori underestimates the contribution of the bioeconomy to GDP by several percentage points.

## Closing arguments

We have shown the results of applying a standardized methodology for constructing Bioeconomy Satellite Accounts to the Supply and Use Tables of the National Accounts Systems of 13 countries from Latin America and The Caribbean Argentina, Brazil, Chile, Colombia, Costa Rica, El Salvador, the Dominican Republic, Ecuador, Guatemala, Honduras, Nicaragua, Panama, and Peru.

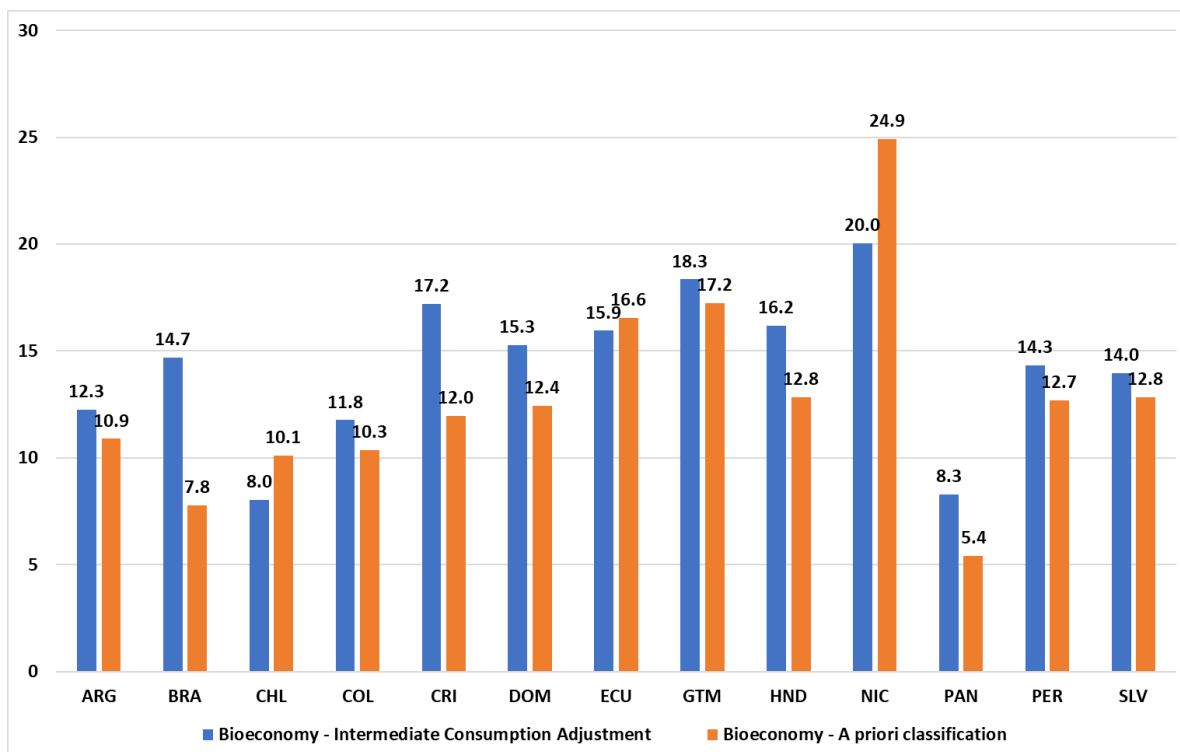


Figure 6: Comparison of Bioeconomy contribution to Value Added by method of adjustment (13 Latin American Economies, percent, 2018)

Among the key findings of this exercise, we find that, in the region, bioeconomic products account for 17.5% of production, 12.5% of imports, 24.5% of product-related taxes, 8.6% of intermediate consumption, 27.9% of exports, and 25% of household final consumption on average.

A significant share of fiscal revenue from product taxes comes from bioeconomic products (ranging from 13.9% to 32.7% for the countries analyzed). By dividing tax revenue by product type and the gross production value of those goods, it is possible to estimate the implicit tax rate. It's important to note that for most countries, this implicit rate is considerably higher for bioeconomic products than for non-bioeconomic ones. This disparity is not intentional but rather the combined result of different fiscal policy instruments created at various times for diverse purposes. In the context of developing public policies related to the Bioeconomy, it is crucial to explore this issue further in order to create incentive mechanisms that foster bioeconomic development while balancing public finance objectives.

One limitation of the National Accounts data for studying the bioeconomy is related to the difficulty in quantifying bioeconomic gross capital formation through economic surveys and business financial statements. A significant portion of innovation in the Bioeconomy is related to intellectual property, and companies in the region still face challenges in tracking their intellectual assets and accurately accounting for them. Another challenge in quantifying bioeconomic Gross Capital Formation arises from the fact that some infrastructure projects may not be easily identified as bioeconomic, such as the construction of bioprocessing plants to reuse biological waste. These would typically appear under construction services and would be excluded by the methodology during the classification process. This indicates that there is still work to be done in developing national accounting standards to address these limitations.

## Acknowledgments

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