Foundation of Support for Research of Distrito Federal

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Collaborative Partnerships to Advance Science and Policy

LULUCF treatment in top down economic analyses of climate change policies*

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1. INTRODUCTION

THE QUESTION

There is no consensus on the treatment of the Land Use, Land Use Change, and Forestry (LULUCF) category in greenhouse gas (GHG) emissions inventories.

OBJECTIVES

- Qualify the debate by means of a **top down analysis of GHG emissions and final energy consumption** of the Brazilian economy in 2009, defining the sectors responsible for LULUCF emissions based on the history of land use.

- We make the National Accounting System (NAS) data compatible with the GHG emission inventories and the energy balance with the regrouping of the economic sectors covered by the input-output matrix, making the **social distributive frame work in a SAM**.

2. RELEVANT ISSUES IN LULUCF

- **Policy makers** have **designed public policy** to control and to reduce greenhouse gas emissions (GHG), **normally with command and control policies with economic and voluntary instruments**, but these microeconomic policies are not enough.

- **Changes in macroeconomic policies** (fiscal, monetary, exchange rate, among others) **are required** in order to achieve **climate policy goals**.

- We **need to treate the Land Use and Land Use Change** (LULUCF) in climate change economic modelling

2. RELEVANT ISSUES IN LULUCF

- This methodology has been **widely used** in studies of the effects of climate change on the economy, but without accounting LULUCF emissions.

- **Thus, from the Brazilian history of LULUCF, the agricultural and forestry sectors accounted for the direct and indirect emissions of the activity, plus deforestation emissions in 2009 in the Brazilian Biomes.**

- However, **to use the Social Accounting Matrice SAM into TD models**, climate change policy makers are confronted with the **need to adapt the structure of the NAS data to the sectorial structure of GHG emission inventories**.
- **Differences** in methodological and operational **structures have challenged scholars** applying ***TD Models*** over the years.

3. METHODOLOGY APPROACH

- The **state-of-the-art in modeling mitigation policies** is divided into:

Bottom-Up (BU) Models, calculate the effects of technological replacements in microeconomic terms for specific sectors, such as energy, based upon their supply (replacement of primary inputs) and demand (replacement in the final demand) aspects.

Top-Down (TD) Models, drawn from macroeconomic aggregates intended to answer questions of economic impacts and competitiveness, employment levels related to different sectors of an economy, therefore, distributional effects into different mitigation policies.

- In this paper, we use the linear algebra procedures to macth the GHG emissions structure of IPCC with National Accounting System (**NAS**) of Brazil. Do this to make feasible *TD models* and to ask the following question:

What are the carbon intensity of productive sectors and to Brazil economy?

- The Brazilian recent emission inventories

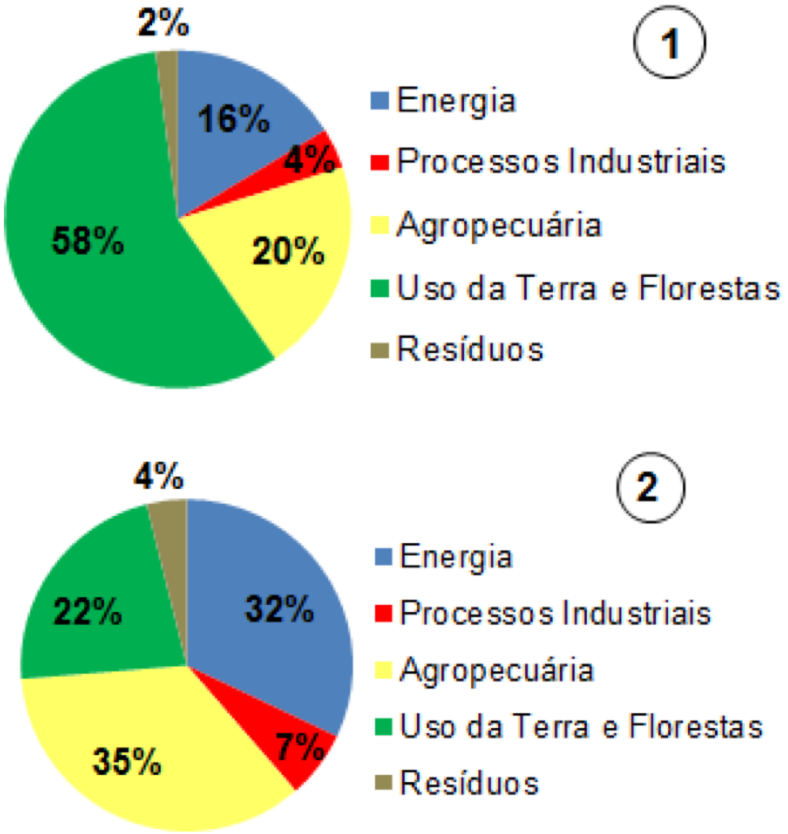


Gráfico 1. Distribuição percentual das emissões de CO_{2eq} em 2005 (1) e 2010 (2) no Brasil. Fonte: Adaptado de MCT (2013).

- **On the one hand**, the vast majority of ***TD Models*** **depend on traditional social accounting matrix (SAM)**. As it is well known, SAM structure **follows** the accounting and economic **rules of national accounting systems** (NAS).

- **On the other hand**, the **Intergovernmental Panel on Climate Change (IPCC) establish the structure of emissions inventories of GHG emissions** that each country must publish your national contributions to reduce and control emissions.

Social Accounting Matrice Principles and Structure

- The SAM (Stone, 1953) is a simple and efficient framework for the organization of economic data wich embodied two principles:

  i. The **circular flow of rent and consumer** (Quesnay, 1758; Keynes, 1936) and
  ii. **Input-Output matrix** (I-O) formulated by Leontief (1936).

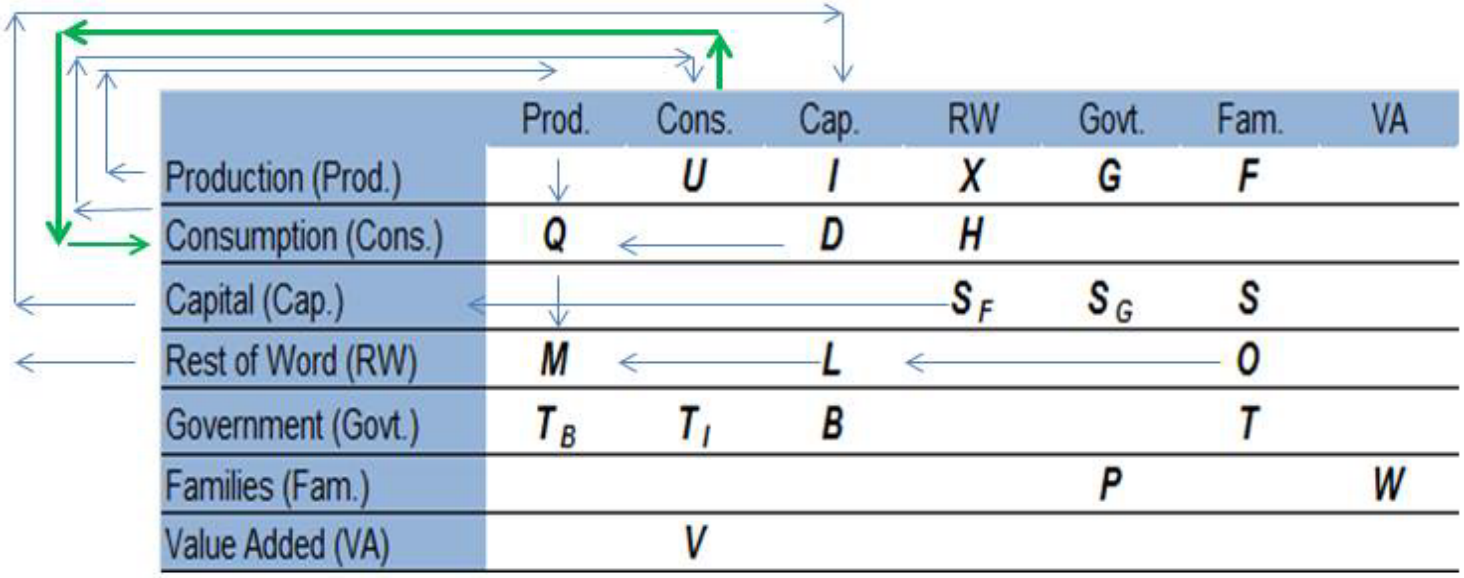
- **SAM follows** the **proportionality and homogeneity principles** and the **same mathematical proposition and constructive statements of I-O matrix**.

Social Accounting Matrice Principles and Structure

- In an I-O matrix, there are **accounts who represent the productive sectors in the columns and rows**.
- By **adding other accounts** who represent **another economic agents** (government, families, rest of world…) we have the **SAM matrix**.
- The **columns contain** the spents of a sector (**demand side**) and the **rows contain** the rents of one (**supply side**) and the locking up of I-O and SAM matrix occur with the iguality between the same sector/institution colums's and row's.

Social Accounting Matrice Principles and Structure

- Circular flow of income and consumption.



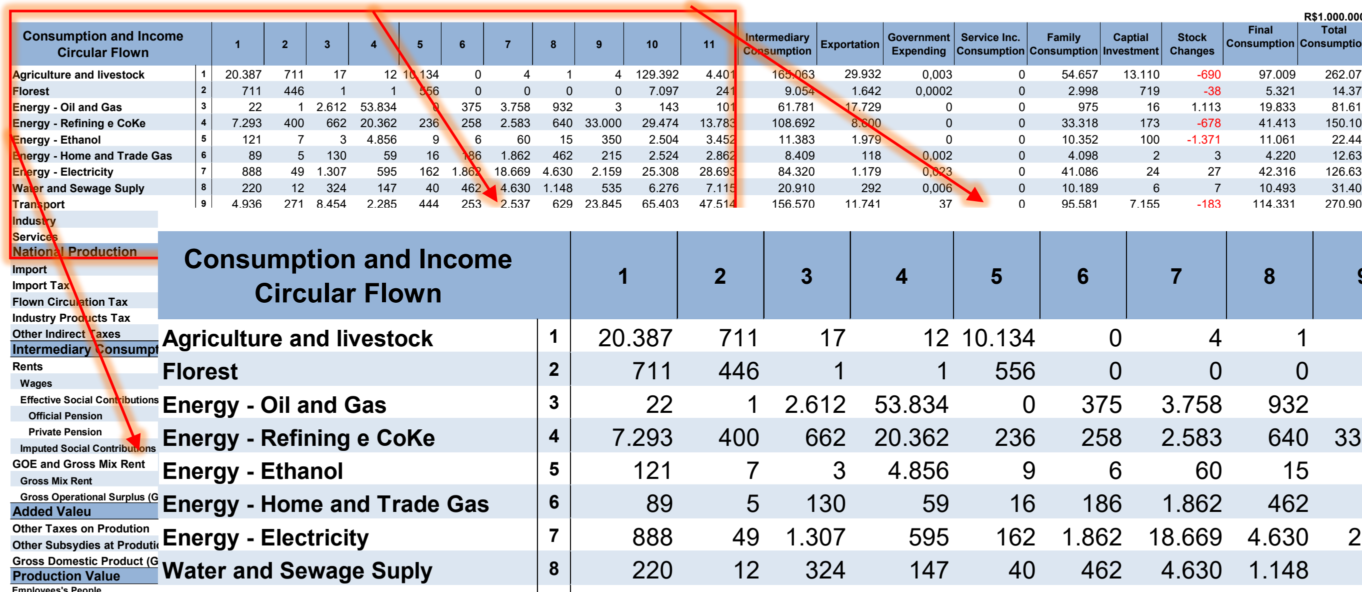
	Prod.	Cons.	Cap.	RW	Govt.	Fam.	VA
Production (Prod.)	↓	*U*	*I*	*X*	*G*	*F*	
Consumption (Cons.)	*Q*	←	*D*	*H*			
Capital (Cap.)	↓			S_F	S_G	*S*	
Rest of Word (RW)	*M*	←	*L*	←		*O*	
Government (Govt.)	T_B	T_I	*B*			*T*	
Families (Fam.)					*P*		*W*
Value Added (VA)		*V*					

F = total of family **consumption** of goods and services in the economy; **I** = total **investment** in capital goods; **X = total exports** of goods and services; **G = government spending**; **Q = total income** generated in the economy; **D = depreciation or consumption of capital goods**; **H = external income generated**; **S = total savings**; **M = Total imports** of goods and services; **O = The transfers** of foreign capital; **L = net sales** of external resources; **T= Total direct taxation** of consumers; B = government deficit; **S_G = government savings**; **S_F = foreign savings**; **P = government transfers to social security and welfare**.

Source: Modificated from Miller and Blair (2009).

Social Accounting Matrice of Brazil – 2009 (em R$ 1.000.000)

Matrix format, your circular flow of income and consumption and aggregation into 11 sectors results.



R$1.000.000

Consumption and Income Circular Flown		1	2	3	4	5	6	7	8	9	10	11	Intermediary Consumption	Exportation	Government Expending	Service Inc. Consumption	Family Consumption	Captial Investment	Stock Changes	Final Consumption	Total Consumption
Agriculture and livestock	1	20.387	711	17	12	10.134	0	4	1	4	129.392	4.401	165.063	29.932	0,003	0	54.657	13.110	-690	97.009	262.072
Florest	2	711	446	1	1	556	0	0	0	0	7.097	241	9.054	1.642	0,0002	0	2.998	719	-38	5.321	14.375
Energy - Oil and Gas	3	22	1	2.612	53.834	0	375	3.758	932	3	143	101	61.781	17.729	0	0	975	16	1.113	19.833	81.614
Energy - Refining e CoKe	4	7.293	400	662	20.362	236	258	2.583	640	33.000	29.474	13.783	108.692	8.600	0	0	33.318	173	-678	41.413	150.105
Energy - Ethanol	5	121	7	3	4.856	9	6	60	15	350	2.504	3.452	11.383	1.979	0	0	10.352	100	-1.371	11.061	22.444
Energy - Home and Trade Gas	6	89	5	130	59	16	186	1.862	462	215	2.524	2.862	8.409	118	0,002	0	4.098	2	3	4.220	12.630
Energy - Electricity	7	888	49	1.307	595	162	1.862	18.669	4.630	2.159	25.308	28.693	84.320	1.179	0,023	0	41.086	24	27	42.316	126.636
Water and Sewage Suply	8	220	12	324	147	40	462	4.630	1.148	535	6.276	7.115	20.910	292	0,006	0	10.189	6	7	10.493	31.403
Transport	9	4.936	271	8.454	2.285	444	253	2.537	629	23.845	65.403	47.514	156.570	11.741	37	0	95.581	7.155	-183	114.331	270.901
Industry																					
Services																					
National Production																					
Import																					
Import Tax																					
Flown Circulation Tax																					
Industry Products Tax																					
Other Indirect Taxes																					
Intermediary Consumpt																					
Rents																					
Wages																					
Effective Social Contributions																					
Official Pension																					
Private Pension																					
Imputed Social Contributions																					
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Other Subsydies at Produtio																					
Gross Domestic Product (G																					
Production Value																					
Employees's People																					

R$1.000.000

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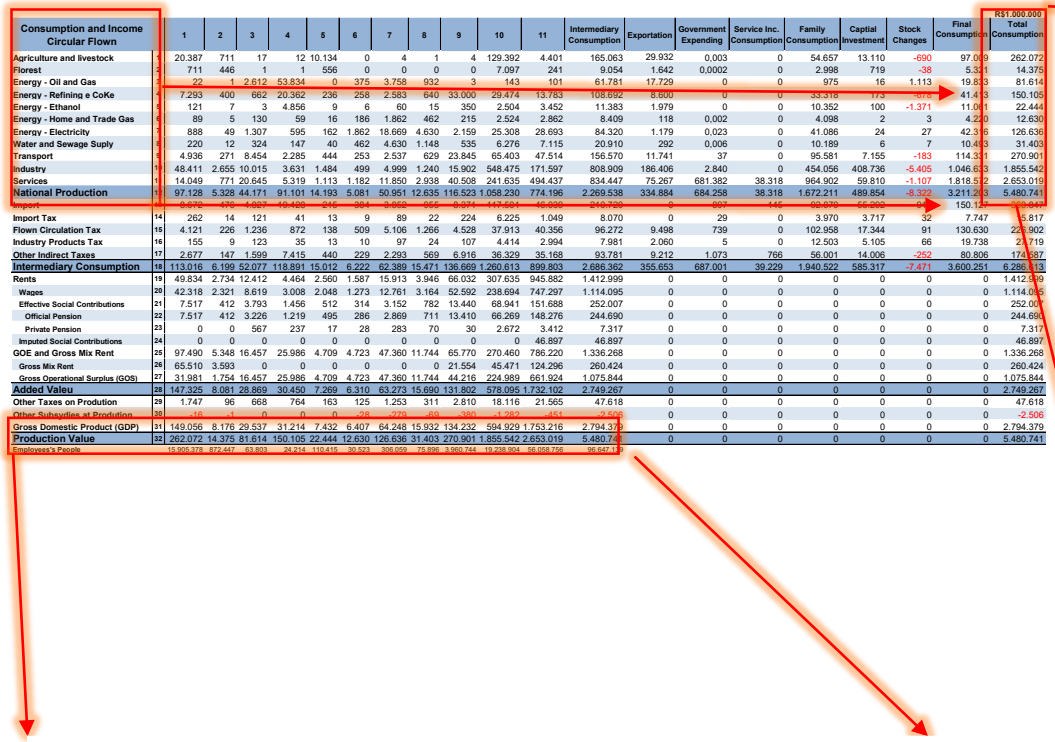
Industry	10	48.411	2.655	10.015	3.631	1.484	499	4.999	1.240	15.902	548.475	171.597	808.909
Services	11	14.049	771	20.645	5.319	1.113	1.182	11.850	2.938	40.508	241.635	494.437	834.447
National Production	12	97.128	5.328	44.171	91.101	14.193	5.081	50.951	12.635	116.523	1.058.230	774.196	2.269.538

3. RESULTS



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Transport	9	4.936	271	8.454	2.285	444	253	2.537	629	23.845	65.403	47.514	156.570	11.741	37	0	95.581	7.155	-183	114.331	270.901
Industry	10	48.411	2.655	10.015	3.631	1.484	499	4.999	1.240	15.902	548.475	171.597	808.909	186.408	2.840	0	454.056	408.736	-5.405	1.046.633	1.855.542
Services	11	14.049	771	20.645	5.319	1.113	1.182	11.850	2.938	40.508	241.635	494.437	834.447	75.267	681.382	38.318	964.902	59.810	-1.107	1.818.572	2.653.019
National Production	12	97.128	5.328	44.171	91.101	14.193	5.081	50.951	12.635	116.523	1.058.230	774.196	2.269.538	334.884	684.258	38.318	1.672.211	489.854	-8.322	3.211.203	5.480.741
Import	13	9.972	376	1.827	10.429	845	864	3.952	955	8.974	117.501	45.939	210.720	0	907	145	92.070	55.202	-94	150.129	360.849
Import Tax	14	262	14	121	41	13	9	89	22	224	6.225	1.049	8.070	0	29	0	3.970	3.717	32	7.747	15.817
Flown Circulation Tax	15	4.121	226	1.236	872	138	509	5.106	1.266	4.528	37.913	40.356	96.272	9.498	739	0	102.958	17.344	91	130.630	226.902
Industry Products Tax	16	155	9	123	35	13	10	97	24	107	4.414	2.994	7.981	2.060	5	0	12.503	5.105	66	19.738	27.719
Other Indirect Taxes	17	2.677	147	1.599	7.415	440	229	2.293	569	6.916	36.329	35.168	93.781	9.212	1.073	766	56.001	14.006	-252	80.806	174.587
Intermediary Consumption	18	113.016	6.199	52.077	118.891	15.012	6.222	62.389	15.471	136.669	1.260.613	999.803	2.686.362	355.653	687.001	39.229	1.940.522	585.317	-7.471	3.600.251	6.286.613
Rents	19	49.834	2.734	12.412	4.464	2.560	1.587	15.913	3.946	66.032	307.635	945.882	1.412.999	0	0	0	0	0	0	0	1.412.999
Wages	20	42.318	2.321	8.619	3.008	2.048	1.273	12.761	3.164	52.592	238.694	747.297	1.114.095	0	0	0	0	0	0	0	1.114.095
Effective Social Contributions	21	7.517	412	3.793	1.456	512	314	3.152	782	13.440	68.941	151.688	252.007	0	0	0	0	0	0	0	252.007
Official Pension	22	7.517	412	3.226	1.219	495	286	2.869	711	13.410	66.269	148.276	244.690	0	0	0	0	0	0	0	244.690
Private Pension	23	0	0	567	237	17	28	283	70	30	2.672	3.412	7.317	0	0	0	0	0	0	0	7.317
Imputed Social Contributions	24	0	0	0	0	0	0	0	0	0	0	46.897	46.897	0	0	0	0	0	0	0	46.897
GOE and Gross Mix Rent	25	97.490	5.348	16.457	25.986	4.709	4.723	47.360	11.744	65.770	270.460	786.220	1.336.268	0	0	0	0	0	0	0	1.336.268
Gross Mix Rent	26	65.510	3.593	0	0	0	0	0	0	21.554	45.471	124.296	260.424	0	0	0	0	0	0	0	260.424
Gross Operational Surplus (GOS)	27	31.981	1.754	16.457	25.986	4.709	4.723	47.360	11.744	44.216	224.989	661.924	1.075.844	0	0	0	0	0	0	0	1.075.844
Added Valeu	28	147.325	8.081	28.869	30.450	7.269	6.310	63.273	15.690	131.802	578.095	1.732.102	2.749.267	0	0	0	0	0	0	0	2.749.267
Other Taxes on Produtction	29	1.747	96	668	764	163	125	1.253	311	2.810	18.116	21.565	47.618	0	0	0	0	0	0	0	47.618
Other Subsydies at Produtction	30	-16	-1	0	0	0	-28	-279	-69	-380	-1.282	-451	-2.506	0	0	0	0	0	0	0	-2.506
Gross Domestic Product (GDP)	31	149.056	8.176	29.537	31.214	7.432	6.407	64.248	15.932	134.232	594.929	1.753.216	2.794.379	0	0	0	0	0	0	0	2.794.379
Production Value	32	262.072	14.375	81.614	150.105	22.444	12.630	126.636	31.403	270.901	1.855.542	2.653.019	5.480.741	0	0	0	0	0	0	0	5.480.741
Employees's People		15.905.378	872.447	63.803	24.214	110.415	30.523	306.059	75.896	3.960.744	19.238.904	56.058.756	96.647.139								

R$1.000.000

Consumption and Income Circular Flown		Total Consumption
Agriculture and livestock	1	262.072
Florest	2	14.375
Energy - Oil and Gas	3	81.614
Energy - Refining e CoKe	4	150.105
Energy - Ethanol	5	22.444
Energy - Home and Trade Gas	6	12.630
Energy - Electricity	7	126.636
Water and Sewage Suply	8	31.403
Transport	9	270.901
Industry	10	1.855.542
Services	11	2.653.019
National Production	12	5.480.741

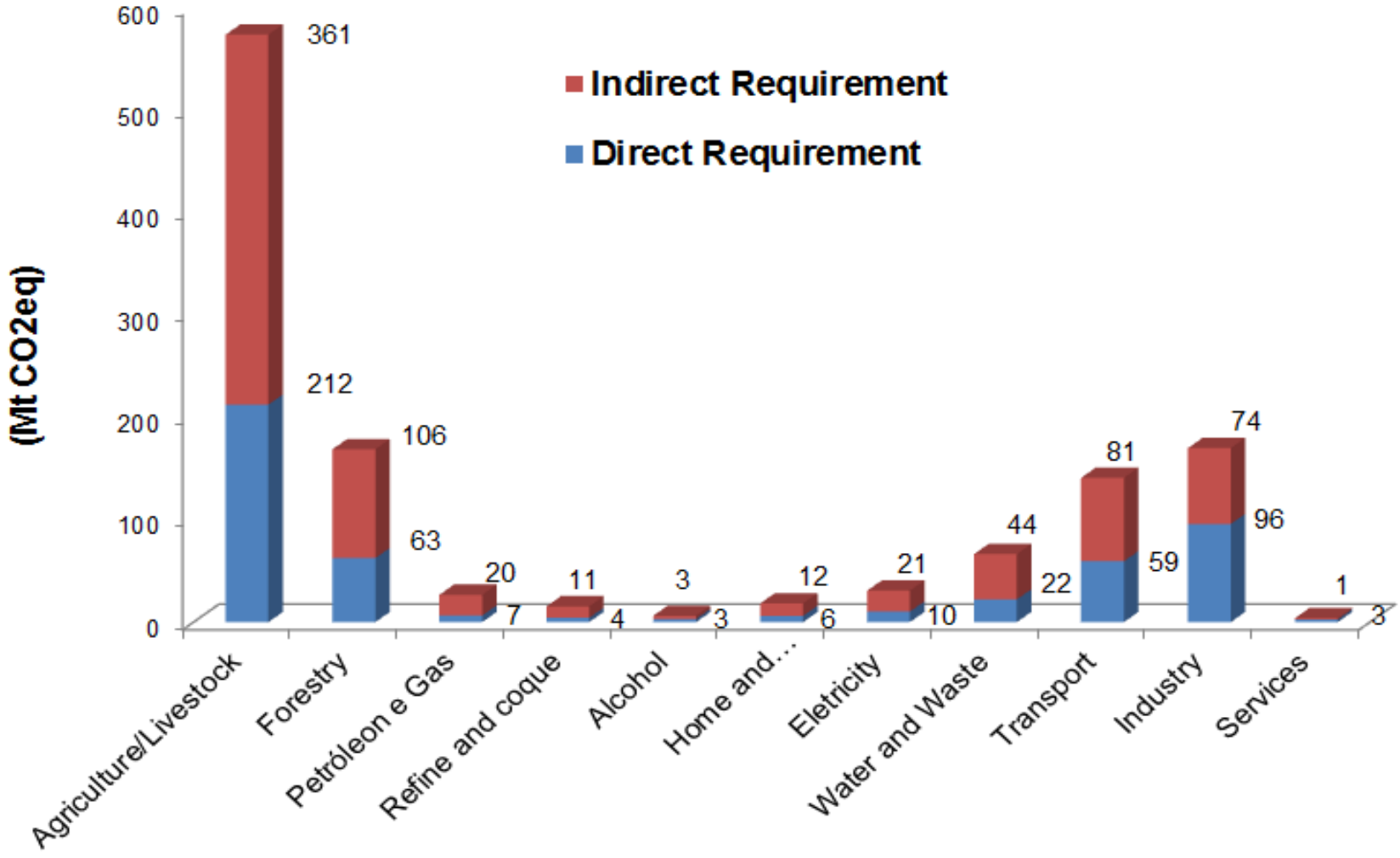
R$1.000.000

Consumption and Income Circular Flown		1	2	3	4	5	6	7	8	9	10	11	Intermediary Consumption
Production Value	1	262.072	14.375	81.614	150.105	22.444	12.630	126.636	31.403	270.901	1.855.542	2.653.019	5.480.741
Employees's People		15.905.378	872.447	63.803	24.214	110.415	30.523	306.059	75.896	3.960.744	19.238.904	56.058.756	96.647.139

4. RESULTS

Productive Sectors and Residential	Emissões ($Mt\ CO_{2eq}$[1])	Energy (1,000 toe[2])	GDP (US$ bilhão)	E_{PIB} (toe/US$ milhão)	C_E ($t\ CO_{2eq}$/toe)	C_{PIB} ($t\ CO_{2eq}$/US$ mil)
	C	E	Y	E/Y	C/E	C/Y
Agriculture and livestock	573.74	9,453.00	65.74	143.78	0.061	8.73
Forest	168.92	2,267.07	3.61	628.65	0.075	46.84
Energy - Oil and Gas	26.79	11,043.13	13.03	847.65	0.002	2.06
Energy - Refining and Coke	15.45	738.59	13.77	53.65	0.021	1.12
Energy - Ethanol	6.27	1,383.54	3.28	422.06	0.005	1.91
Energia - House and Trade Gas	18.38	818.78	2.83	289.72	0.022	6.50
Energy - Electricity	30.82	8,162.89	28.34	288.06	0.004	1.09
Water and Sewage Suply	66.60	-	7.03	-	-	9.48
Transport	140.91	62,687.00	59.21	1,058.79	0.002	2.38
Industry	169.99	76,686.00	262.41	292.24	0.002	0.65
Services	3.91	9,896.00	773.30	12.80	0.000	0.01
Residential (toe/thousand household)	-	23,227.00	-	401.74	-	-
TOTAL	1,221.79	206,363.00	2,794.38	73.85	5.9	0.4

4. RESULTS


Indirect Requirement
Direct Requirement
(Mt CO2eq)
600
500
400
300
200
100
0
361
212
106
63
20
7
11
4
3
3
12
6
21
10
44
22
81
59
74
96
1
3
Agriculture/Livestock
Forestry
Petróleon e Gas
Refine and coque
Alcohol
Home and…
Eletricity
Water and Waste
Transport
Industry
Services

5. CONCLUSIONS AND REMARKS

- The **carbon and energy intensities** of the industrial and electricity sectors responded to the 0.65 and 1.09 tCO2eq/US$ thousand and 292.2 and 288.1 toe/US$ million of value added, respectively, compatible with those found in the literature.

- The agricultural and forestry sectors was accountable for 8.73 and 46.84 tCO2eq/US$ thousand and 143.8 and 628.7 toe/US$ million.

- These results demonstrate the dilemma involved in assigning responsibility for LULUCF emissions, which would greatly raise production costs if emissions pricing becomes a public policy to mitigate climate change in Brazil.

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FIM

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