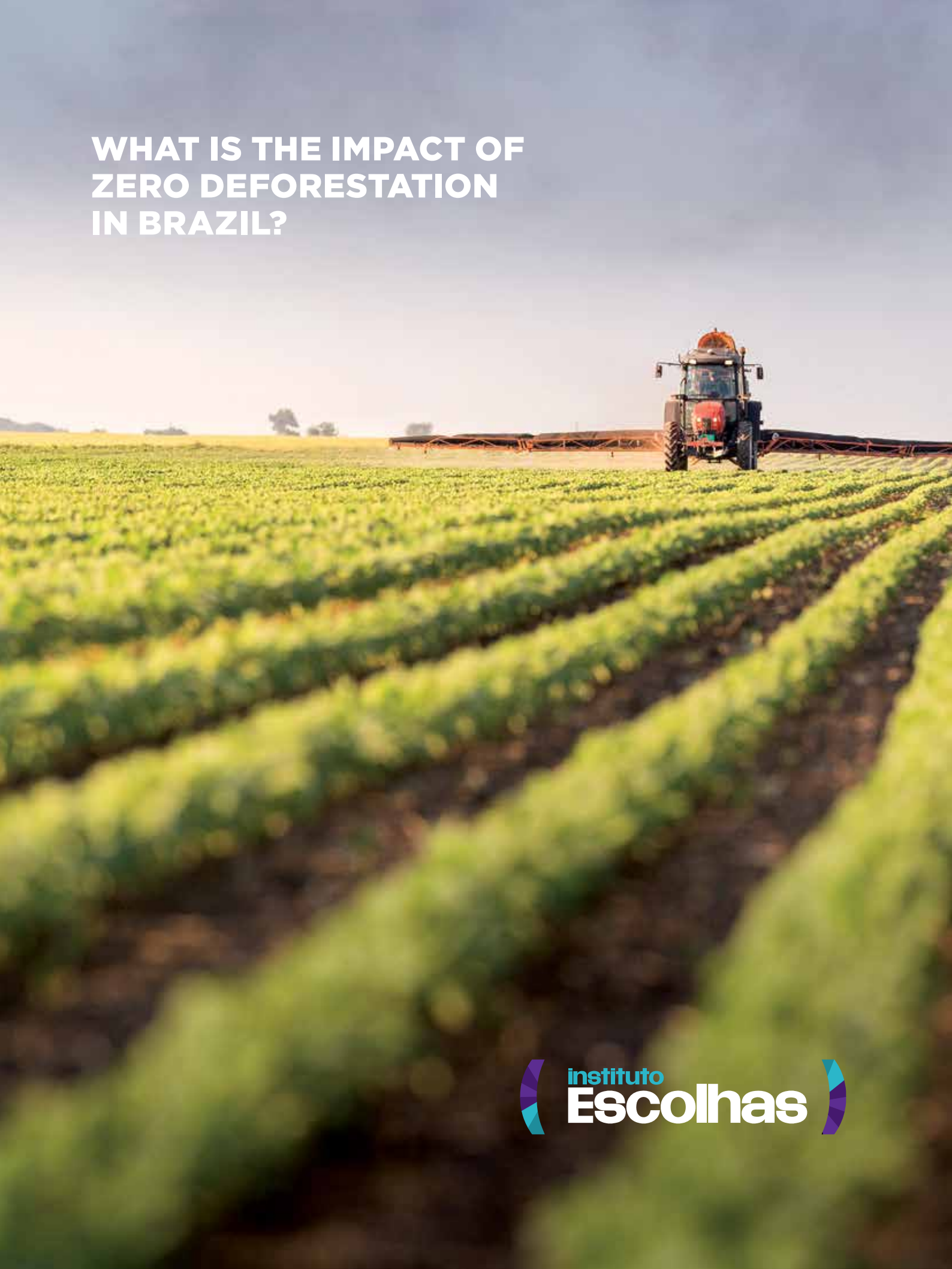
WHAT IS THE IMPACT OF ZERO DEFORESTATION IN BRAZIL?



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WHAT IS THE IMPACT OF ZERO DEFORESTATION IN BRAZIL?

Study conceptualized by the *Instituto Escolhas*

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Founded in 2015, the *Instituto Escolhas* is a think tank providing input for discussions about sustainability through translating the economic, social, and environmental impacts of public and private decisions into figures. Through studies, analyses and reports, it encourages new readings and arguments that can surmount the ideological polarization of conflicting choices inherent to planning. Only solidly-grounded arguments can underpin aware decisions and foster the construction of effective pathways to sustainable development.

PREFACE

Talking about zero deforestation in Brazil means facing the challenge of addressing a topic that triggers heated arguments over views of how Brazil can uphold its role as a global food producer while continuing to shelter one of the world`s largest rainforests.

As Brazilian agriculture becomes more productive, the role played by forests in keeping global warming under control is becoming increasingly obvious, paving the way for discussions of zero deforestation in Brazil. This would necessarily mean converting some grazing areas into croplands in order to ensure higher output, precisely because the ranching sector still works with low-intensity land use.

In a country where agricultural goods are major exports, farming sector representatives continue to ask whether it is even possible to halt deforestation while still ensuring expanding output, as Brazil`s economic track-record shows that such expansion has always been driven by converting forests into farmlands. However, as climate change surges, deforestation is seen as a sign of backwardness, a key factor in global warming that is assailing our planet as a whole. So just what are the social and economic impacts of adopting a zero deforestation policy in Brazil?

These are the main issues addressed by the study exploring *What is the Impact of Zero Deforestation in Brazil?* The intention here is mainly to measure the impacts of the deforestation, understanding its consequences on the Gross Domestic Product (GDP) and the farming and ranching sector.

This study also spotlights the relationship between deforestation and territorial issues, buttressed by a land tenure map encompassing all public and private land in Brazil, in addition to classifying areas most suitable for agriculture in the *Cerrado* savannas and the Amazon Rainforest.

It also shows what would happen to – the inventory of lands with native plantlife where deforestation is permitted under the Forest Code – in each State and biome, should current deforestation rates remain unchanged. Sadly, there is already one State where this inventory is fully depleted.

There are undoubtedly other factors to be taken under consideration in the investigation of this issue, which are already being addressed by the *Instituto Escolhas* for future studies, such as the need to quantify the benefits to Brazil of completely eliminating the deforestation of its forestlands.

IN A NATION WHOSE AGRICULTURAL OUTPUT IS A MAJOR ITEM ON ITS LIST OF EXPORTS, REPRESENTATIVES OF THIS SECTOR CONTINUE TO ASK WHETHER IT IS REALLY POSSIBLE TO ATTAIN ZERO DEFORESTATION WHILE ALSO ENSURING THE EXPANSION OF ITS OUTPUT

Starting this survey through exploring potential impacts on a sector that will immediately feel the effects of zero deforestation – precisely because it is the most likely to oppose its immediate introduction – allows society as a whole to seek out paths for cutting through political gridlocks snarled around this issue.

In a country that rarely assesses its public policies, and with widely-known shortages of quantitative data that could buttress more rational discussions of choices that must be made in order to soothe more heated disputes, the *Instituto Escolhas* hopes that this study is a step towards constructing a list of effective measures to be adopted in order to underpin the feasibility of zero deforestation in Brazil.

Sergio Leitão
Executive Director, *Instituto Escolhas*

NTRODUCTION

If all legal and illegal deforestation of public and private lands — and the resulting expansion of Brazil's agricultural frontier — were to halt immediately, the impacts on the nation's economy would be minimal: a dip of only 0.62% in its accumulated GDP between 2016 and 2030, equivalent to shrinkage of R$ 46.5 billion in its GDP over fifteen years, or R$ 3.1 billion a year. This is far less than the amount invested by the Brazilian Government in several areas rated as top priority — for instance, subsidies underpinning the Harvest Plan hovered around R$ 10 billion in 2017.

cts on the GDP may be offset merely through the current cattle-ranching intensification rate. Moreover, allowing deforestation to continue also has heavy impacts on the GDP and failure to curb it now may well cost even more.

These are among the main conclusions reached by the study entitled What is the Impact of Zero Deforestation in Brazil?, which was conceptualized and coordinated by the *Instituto Escolhas* and conducted through partnerships with researchers from the Forest and Agriculture Stewardship and Certification Institute (*Instituto de Manejo e Certification Florestal e Agrícola* — IMAFLORA) and the Luiz de Queiroz School of Agriculture, University of São Paulo (*Escola Superior de Agricultura Luiz de Queiroz da Universidade de São Paulo* — ESALQ-USP). The idea behind this study was to provide material data for discussion of one of the main components in today's agri-environmental agenda, where different views are causing conflicts.

This is because deforestation results simultaneously from extending the agricultural frontier and the shrinkage of environmental assets and services. The issue is how to unravel this deadlock at a time when Brazil's agricultural output is becoming increasingly important on the nation's economic agenda. Output in this sector accounted for 7% of Brazil's GDP in 2016. At the same time, it agreed to bring legal deforestation to a halt in the Amazon Rainforest by 2030, under the aegis of the United Nations Framework Convention on Climate Change.[1]

The study was grounded on some assumptions:
1) More intensive cattle-ranching[2] is enough to step up production and generate wealth for Brazil's farming and ranching sector, with the highest potential for blending prosperity with an agenda focused evenly on conservation together with rural economic development.

2) Ongoing deforestation is unnecessary to boost output and build up wealth for this sector, in addition to causing social and environmental impacts at the local, regional and global levels. Forest clearing is linked to the disappearance of biodiversity, climate change and the loss of environmental services, in parallel to violence, lawlessness and tax evasion, leading to heavily concentrated land ownership and personal fortunes.

Starting from here, this study strives to assess the economic effects on the Brazilian economy of bringing deforestation to an end, through isolating the constraints on boosting Brazil's agricultural output by extending croplands and measuring its impacts on the GDP at the national and state levels.

This study adopted the following approach:
1) It drew up scenarios simulating zero deforestation and the expansion of land used for farming and ranching activities.
2) It used a general economic balance simulation model with input based on the farming and ranching land inventory and land for non-agricultural uses.
3) Finally, it estimated the intensification of cattle-ranching in order to offset the reduction in the GDP resulting from zero deforestation and the expansion of croplands through converting pastures cleared from forests.

[1] UNFCCC, 2015. Paris Agreement signed at the XXI Conference of the Parties (COP-21) of the United Nations Framework Convention on Climate Change (UNFCCC) in 2015.
[2] This means making more efficient use of the land, producing more from smaller areas.

Scenarios

Brazil has more than 240 million hectares (Mha) of land already cleared for farming and grazing purposes. Several institutions in civil society have asserted that this is quite enough to ensure farming and ranching output, urging that deforestation be eliminated in Brazil, through what is called Zero Deforestation.

Three zero deforestation scenarios were constructed for this study. The impact on the GDP was estimated through blending land use and general economic balance with biophysical modeling.

The biophysical modeling was conducted in the following stages:

1 Preparation of a nationwide land tenure map representing private and public lands in Brazil.

2 Forest Code modeling for rural properties (private land polygons),identifying gaps in Permanent Preservation Areas (APPs) and Legal Reserves (LRs) as well as wilderness areas not protected by the Forest Code that could be cleared.

3 Estimated deforestation rates calculated only for the following biomes – the Amazon Rainforest, ***Cerrado*** savannas and Atlantic Rainforest – as only they have regularly updated information on deforestation available[3].

4 Land classification by suitability for agriculture, in order to underpin the construction of deforestation scenarios that encompass soil, terrain and climate characteristics, in order to draw up an index of land use constraints or possibilities for annual crops, varying from 0 (very unsuitable) to 1 (very suitable). This map was used to assess aptitudes in land inventories where deforestation is legally possible on privately-held properties. It was felt that land with aptitude ratings between 0.8 and 1.0 would be better for growing annual crops, thus serving as a yardstick for clearing new wilderness areas.

All scenarios were based on the assumption that privately-held properties would be cleared legally and only within the inventories as allowed by the Forest Code (environmental assets), meaning only wilderness areas outside APPs and LRs may be repurposed[4].

[3] Data were used from the Amazon Deforestation Calculation Program (PRODES) as well Brazil's National Space Research Institute (INPE) for the Amazon Rainforest; The Integrated Deforestation Alert System for the *Cerrado* Biome (SIAD-Cerrado) for these savannas; and the Atlas of Remaining Patches of Atlantic Rainforest published by SOS Mata Atlântica and the INPE for the Atlantic Rainforest.
[4] None of the scenarios proposed compensation or rehabilitation of degraded areas in APPs and LRs (environmental liabilities).

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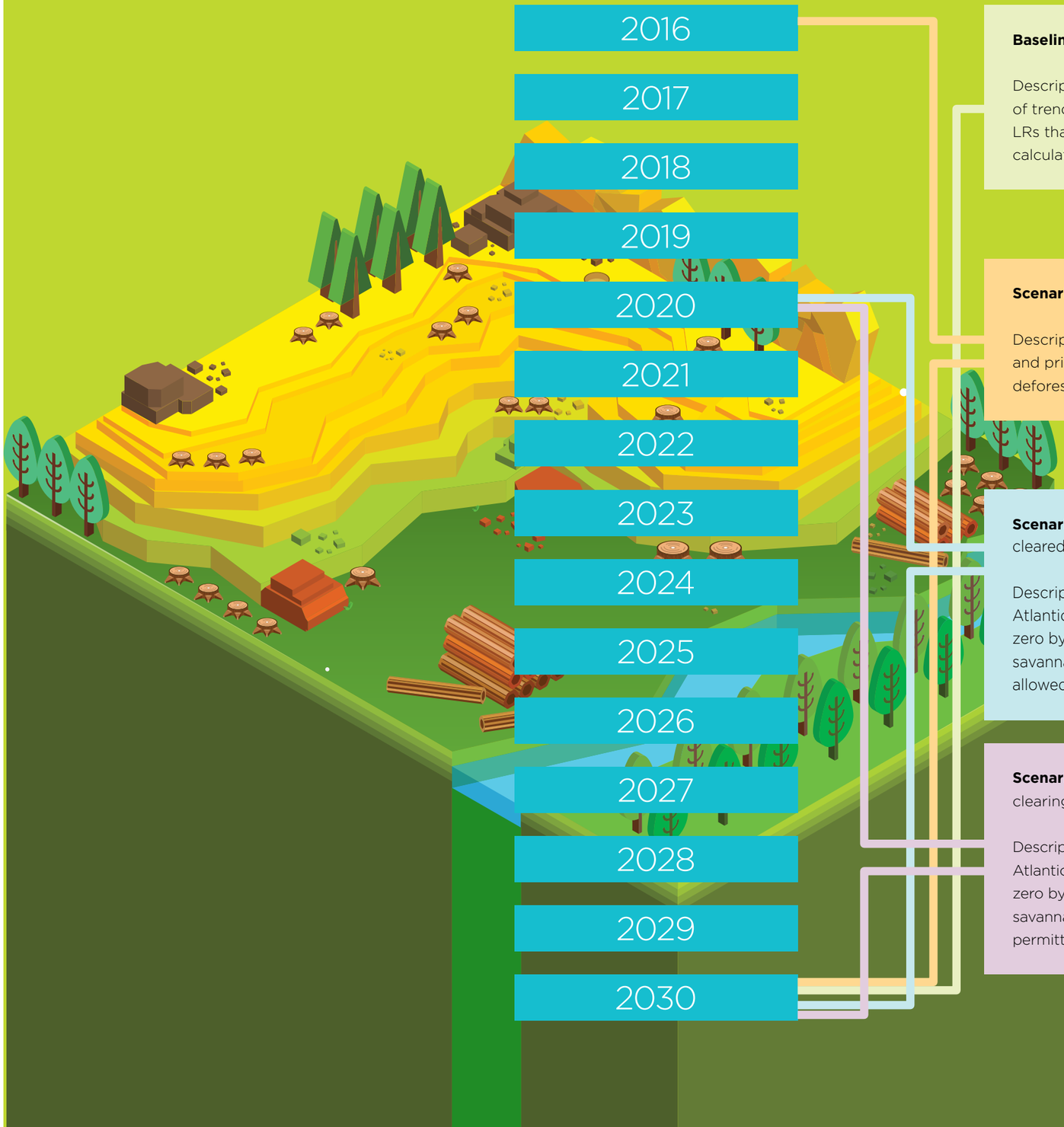

Baseline Scenario

Description: Deforestation of privately-held properties is calculated through to 2030 on the basis of trends noted during earlier years and affecting only wilderness inventories outside APPs and LRs that may be cleared legally. On government-owned land (where deforestation is illegal) this is calculated through to 2030 according to trends noted in historic datasets.

Scenario 1 - Absolute Zero Deforestation (ZDAbs)

Description: This scenario assumes an immediate halt in forest clearing of government-owned and privately-held properties all over Brazil, with all analyzed States and biomes posting zero deforestation rates between 2016 and 2030.

Scenario 2 - Zero deforestation on government-owned lands by 2030, with privately-held properties cleared only for inventories with high agricultural aptitude (ZD2)

Description: The deforestation rates for government-owned and privately-held properties in the Atlantic Rainforest biome will follow the current trend through to 2020, and will then taper off to zero by 2030. Deforestation of privately-held properties in the Amazon Rainforest and the *Cerrado* savannas will follow the current trend, but only for wilderness inventories where exploitation is allowed in areas with greater aptitude for agriculture (inventories with aptitudes topping 0.8%).

Scenario 3 - Zero deforestation of government-owned land by 2030, with privately-held properties clearing all inventories, regardless of their aptitude for agriculture (ZD3)

Description: The deforestation rates for government-owned and privately-held properties in the Atlantic Rainforest biome will follow the current trend through to 2020, and will then taper off to zero by 2030. Deforestation of privately-held properties in the Amazon Rainforest and the *Cerrado* savannas will follow the current trend, affecting wilderness inventories where deforestation is permitted, regardless of their aptitude for agriculture[5].

[5] This scenario is the closest to the Brazilian NDC, although more restrictive as it includes the end of illegal deforestation not only in the Amazon Rainforest, but also in the *Cerrado* savannas.

OUTCOMES FOR LAND USE

Compliance with the Forest Code

The study identified 19.4 Mha of privately-held properties cleared in defiance of Brazilian law, consisting of 8.1 Mha in APPs and 11.3 Mha in LRs.

The wilderness inventory not encompassed by APPs and LRs reaches 111 Mha, of which 8.3 Mha are Atlantic Rainforest and are hence protected by the Atlantic Rainforest Act.[6]

Aptitude for Agriculture

For the three biomes under analysis (Amazon Rainforest, *Cerrado* savannas and Atlantic Rainforest), cross-referencing the agricultural aptitude map with unprotected wilderness inventories[7] shows that 52 Mha (82% of the inventories of these biomes) are lands that are unsuitable for agriculture, with only 11.5 Mha (18%) being lands rated as more arable.

In the Amazon Rainforest, 27% of unprotected plantlife is found in the aptitude range above 0.8, with Mato Grosso, Amazonas and Rondônia States posting the highest inventories for this range. In terms of the total area, the largest inventories with the highest aptitudes are located in Mato Grosso, Amazonas and Pará States.

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In the *Cerrado* savannas, 13% of the areas where legal deforestation is possible are above the 0.8 rating, with only Mato Grosso do Sul and Bahia States having more than 20% of their wilderness inventories in this aptitude range.

In terms of total area, Bahia, Goiás, Minas Gerais, Mato Grosso and Mato Grosso do Sul States have the largest high-aptitude wilderness inventories.

Table 1 – Agricultural aptitude of wilderness inventories that may be legally cleared in the Amazon Rainforest

State	Wilderness Areas that may be legally cleared in the Amazon Rainforest				
	Aptitude between 0,0 and 0,8		Aptitude above 0,8		Total
	Hectares	% Total	Hectares	% Total	
AC	491 879	87%	74 290	13%	566 169
AM	1 272 587	59%	889 203	41%	2 161 790
AP	431 673	89%	53 449	11%	485 122
MA	162 290	99%	2 401	1%	164 691
MT	1 274 893	53%	1 150 747	47%	2 425 640
PA	2 687 582	82%	595 478	18%	3 283 060
RO	293 827	68%	140 449	32%	434 276
RR	1 917 010	90%	209 300	10%	2 126 310
TO	45 185	92%	4 159	8%	49 344
Amazon Rainforest	8 576 927	73%	3 119 476	27%	11 696 403

Table 2 – Agricultural aptitude of wilderness inventories that may be legally cleared in the *Cerrado* savannas

State	Wilderness areas that may be legally cleared in the *Cerrado* savannas				
	Aptitude between 0,0 and 0,8		Aptitude above 0,8		Total
	Hectares	% Total	Hectares	% Total	
BA	4 824 753	74%	1 734 147	26%	6 558 900
DF	26 391	91%	2 483	9%	28 874
GO	4 096 448	82%	924 232	18%	5 020 680
MA	6 498 134	94%	444 906	6%	6 943 040
MG	5 653 794	89%	723 796	11%	6 377 590
MS	2 114 020	78%	580 650	22%	2 694 670
MT	4 864 713	88%	641 717	12%	5 506 430
PI	4 205 716	93%	315 714	7%	4 521 430
PR	31	93%	2	7%	33
SP	95 256	87%	14 635	13%	109 891
TO	5 366 572	91%	506 308	9%	5 872 880
Cerrado	37 745 828	87%	5 888 591	13%	43 634 419

[6] Lei6 Law Nº 11,428/2006,.which forbids the deforestation of wilderness areas in biomes
[7] These are wilderness areas on privately-held properties that are not encompassed by the protective rules established in the Forest Code and may thus be cleared legally.

In the Atlantic Rainforest, inventories with the highest agricultural aptitudes account for 30% of the total, with the largest relative inventories found in Mato Grosso do Sul, Goiás, Rio Grande do Sul and Espírito Santo States.

By total area, the largest inventories rated as high-aptitude for agriculture are located in Minas Gerais, Santa Catarina, Rio Grande do Sul and Bahia States.

Table 3 – Agricultural aptitude of wilderness inventories in the Atlantic Rainforest.*

State	Wilderness inventories on privately-held properties outside LRs and APPs				
	Aptitude between 0,0 and 0,8		Aptitude above 0,8		Total
	Hectares	% Total	Hectares	% Total	
AL	43 936	72%	16 696	28%	60 632
BA	478 563	72%	185 859	28%	664 422
ES	280 176	68%	131 697	32%	411 873
GO	17 973	53%	16 200	47%	34 173
MG	1 422 418	70%	622 528	30%	2 044 946
MS	105 787	47%	121 505	53%	227 293
PB	9 184	84%	1 756	16%	10 940
PE	63 934	77%	18 924	23%	82 858
PR	347 075	68%	165 284	32%	512 359
RJ	390 280	70%	165 112	30%	555 392
RN	11 794	73%	4 416	27%	16 210
RS	715 310	67%	358 713	33%	1 074 023
SC	1 201 049	75%	394 166	25%	1 595 215
SE	51 083	77%	15 249	23%	66 332
SP	694 505	70%	295 938	30%	990 443
Atlantic Rainforest	5 833 067	70%	2 514 042	30%	8 347 110

* In the Atlantic Rainforest biome, wilderness inventories are protected by the Atlantic Rainforest Act. However, these inventories were subject to deforestation in the analyzed scenarios, as illegal forest clearing still continues in this biome.

Deforestation Scenarios

The simulated scenarios present individual deforestation rates for government-owned and privately-held properties in each State and biome. In the ZDAbs scenario, deforestation is eliminated between 2016 and 2030. The ZD2 and ZD3 scenarios present variable effects in each State and biome, depending on the amount of government-owned land in each geographical segment and unprotected wilderness inventories, as well as areas with high agricultural aptitude.

Amazon Rainforest: The baseline scenario forecasts total deforestation of over 7.4 Mha between 2016 and 2030, with Mato Grosso and Pará States accounting for 64% of this total.

The ZD3 scenario presents an 11% reduction in deforestation compared to its baseline counterpart, while the ZD2 scenario indicates a 46% drop in accumulated deforestation over the period.

Table 4 – Forecast deforestation under each scenario for the Amazon Rainforest biome

States	Ownership	Annual Mean Deforestation (2011-2015)	Accumulated Deforestation: 2016 –2030			
			Baseline	ZD3	ZD2	Absolute ZD
AC	Private	19 269	289 039	289 039	74 290	0
	Public	8 601	129 014	81 709	81 709	0
AM	Private	32 380	485 705	485 705	485 705	0
	Public	17 640	264 606	167 584	167 584	0
AP	Private	721	10 818	10 818	10 818	0
	Public	869	13 031	8 253	8 253	0
MA	Private	22 424	164 691	164 691	2 401	0
	Public	5 881	88 220	55 872	55 872	0
MT	Private	91 965	1 379 474	1 379 474	1 150 747	0
	Public	17 350	260 245	164 822	164 822	0
PA	Private	151 602	2 274 034	2 274 034	595 478	0
	Public	56 725	850 870	538 884	538 884	0
RO	Private	52 442	434 276	434 276	140 449	0
	Public	31 412	471 176	298 411	298 411	0
RR	Private	9 045	135 677	135 677	135 677	0
	Public	3 943	59 144	37 458	37 458	0
TO	Private	4 237	49 344	49 344	4 159	0
	Public	938	14 076	8 915	8 915	0
Forecast Total Mean Deforestation		**527 444**	**7 373 437**	**6 584 964**	**3 961 631**	**0**

***Cerrado* savannas:** In the baseline scenario, forecast deforestation reached 6 Mha, mainly in the States forming what is known as the Matopiba agricultural frontier – Maranhão (0.5 Mha), Tocantins (1.5 Mha), Piauí (1 Mha) and Bahia (0.9 Mha) – accounting for 66% of the total figures.

Ranked second for accumulated deforestation is Mato Grosso State (1 Mha), behind only Tocantins. ZD2 indicates a 34% drop in accumulated deforestation in the *Cerrado* savannas between 2016 and 2013. As privately-held properties prevail to a significant extent, ZD3 shows little effect on this biome, with accumulated deforestation dipping by only 1%, compared to ZD2.

Table 5 – Forecast deforestation under each scenario for the *Cerrado* savannas biome

States	Ownership	Annual Mean Deforestation (2013-2015)	Accumulated Deforestation: 2016 –2030			
			Baseline	ZD3	ZD2	Absolute ZD
BA	Private	61 255	918 825	918 825	918 825	0
	Public	22	330	209	209	0
DF	Private	87	1 300	1 300	1 300	0
	Public	0	0	0	0	0
GO	Private	26 147	392 199	392 199	392 199	0
	Public	53	794	503	503	0
MA	Private	32 173	482 599	482 599	444 906	0
	Public	1 891	28 365	17 965	17 965	0
MG	Private	30 869	463 029	463 029	463 029	0
	Public	120	1 805	1 143	1 143	0
MS	Private	14 290	214 351	214 351	214 351	0
	Public	21	308	195	195	0
MT	Private	63 791	956 859	956 859	641 717	0
	Public	1 930	28 949	18 334	18 334	0
PI	Private	63 332	949 975	949 975	315 714	0
	Public	1 880	28 195	17 857	17 857	0
PR	Private	273	33	33	2	0
	Public	0	0	0	0	0
SP	Private	1 085	16 273	16 273	14 635	0
	Public	0	0	0	0	0
TO	Private	99 100	1 486 495	1 486 495	506 308	0
	Public	3 547	53 204	33 696	33 696	0
Forecast Total Mean Deforestation		**401 863**	**6 023 885**	**5 971 837**	**4 002 886**	**0**

Atlantic Rainforest: Due to its relatively low annual deforestation rate, high-aptitude inventories are sufficient to cope with accumulated deforestation through to 2030, with no differences between the ZD2 and ZD3 scenarios.

Total deforestation forecast through the baseline scenario for 2016 through to 2030 was 0.3 Mha, mainly in Minas Gerais, Bahia and Piauí States, which respectively accounted for 39%, 23% and 18% of the total area.

Table 6 – Forecast deforestation under each scenario for the Atlantic Rainforest biome

State	Ownership	Annual Mean Deforestation (2013-2015)	Accumulated Deforestation: 2016 –2030			
			Baseline	ZD3	ZD2	Absolute ZD
AL	Private	27	398	252	252	0
BA	Private	4 529	67 942	43 030	43 030	0
CE	Private	269	4 042	2 560	2 560	0
ES	Private	115	1 725	1 093	1 093	0
GO	Private	35	532	337	337	0
MG	Private	7 728	115 925	73 419	73 419	0
MS	Private	369	5 538	3 508	3 508	0
PB	Private	19	283	179	179	0
PE	Private	71	1 064	674	674	0
PR	Private	1 685	25 279	16 010	16 010	0
RJ	Private	245	3 676	2 328	2 328	0
RN	Private	33	489	309	309	0
RS	Private	108	1 623	1 028	1 028	0
SC	Private	669	10 037	6 357	6 357	0
SE	Private	181	2 720	1 723	1 723	0
SP	Private	138	2 073	1 313	1 313	0
PI	Private	3606	54 090	34 257	34 257	0
Forecast Total Mean Deforestation		**19 829**	**297 436**	**188 376**	**188 376**	**0**

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End of wilderness land inventories

The figures obtained in this study provided input for an analysis that identified the end of wilderness land inventories – where clearing is permitted under the Forest Code – in each State and biome, should current deforestation rates continue unchanged.

This is the first time an analysis of this type has been conducted, and its findings are disturbing:

- In the Amazon Rainforest, wilderness inventories would peter out by mid-2135, with similar States exhausting their inventories before 2030.

- In the *Cerrado* savannas, the mean date for total inventories to vanish is 2157, brought forward to 2034 for The worst situation is found in Paraná State, with no remaining vegetation that can be cleared legally under the Forest Code.

Table 7 – Forecast depletion dates for wilderness inventories that can be legally cleared in States sheltering the Amazon Rainforest biome

State	Scenario 3	Scenario 2
AC	2044	2019
AM	2082	2042
AP	2688	2089
MA	2022	2016
MT	2041	2028
PA	2037	2019
RO	2023	2018
RR	2250	2038
TO	2027	2016

Table 8 – Forecast depletion dates for wilderness inventories that can be legally cleared in States sheltering the *Cerrado* savannas biome

State	Scenario 3	Scenario 2
BA	2122	2043
DF	2348	2044
GO	2207	2050
MA	2231	2029
MG	2222	2038
MS	2204	2056
MT	2101	2025
PI	2086	2020
PR	2016	2016
SP	2116	2028
TO	2074	2020

Due to the assumptions adopted for constructing the scenarios and its relatively low deforestation rates, the wilderness inventories in the Atlantic Rainforest that may be legally cleared would not be depleted.

ECONOMIC OUTCOMES

This study was conducted on the basis of a Computable General Equilibrium (CGE) Model[8] designed to conduct economic and environmental analyses in Brazil, used to examine the impacts of zero deforestation scenarios nationwide.

The model database was updated through to 2015, with the forecast period running between 2016 and 2030, generating a baseline for the Brazilian economy through trend growth.
The main baseline characteristics are:

Population growth by State (IBGE), with **20.1%** growth for the Brazilian population between **2016** and **2030**.

Projected real GDP growth for Brazil at **2.5%** p.a.

Deforestation of **13.7 Mha** through to **2030**, with **7.4 Mha** in the **Amazon Rainforest**, **6 Mha** in the ***Cerrado* savannas** and **0,3 Mha** in the **Atlantic Rainforest.**

Cropland expansion is paced to the mean rate recorded between **2011** and **2015**, expanding at **2.5 Mha** a year, with total croplands expanding by **37.7 Mha** between **2016** and **2030**. These figures are applied to the model by State and by biome (Amazon Rainforest, *Cerrado* savannas and Atlantic Rainforest).

Expansion of reforestation areas (eucalyptus and pine plantations, or commercial forests) at **0.49 Mha** p.a. through to **2030**, for total expansion of **7.1 Mha** in planted forests during the period.[9]

Grazing lands were selected as the variable that changes with the elimination of deforestation. Thus, zero deforestation means halting the expansion of the agricultural frontier in order to open up pastures. Farmlands remain stable, with pastures shrinking, as crops and forestry expand more rapidly than grazing lands during the baseline year. The baseline forecasts are consistent with grazing land shrinkage of 31.1 Mha between 2016 and 2030, with projected deforestation aligned within this drop. Furthermore, massive current inventories of grazing lands make this adjustment possible.

[8] Computable General Equilibrium (CGE) Models can capture the effects of phenomena with widespread impacts on economies, meaning with repercussions broad-ranging enough to affect economic sectors interconnected with those that are directly affected by such effects.
[9] Calculated on the basis of observations reported by Transparent World (2015) and the declarations of the President of the Brazilian Trees industry – IBÁ (http://celuloseonline.com.br/2014-criacao-da-iba- industria-brasileira-de-arvores/).

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Macroeconomic Variables

As noted, the drop in the GDP is minor, in relative terms. The heaviest loss will be in the ZDAbs scenario (0.60% dip in the accumulated GDP through to 2030). This amount may be considered as the social cost[10] of avoided deforestation (or lost grazing lands), encompassing all associated economic losses.

In monetary terms, GDP losses accumulated through to 2030 and expressed in 2016 values are estimated at R$ 46.5 billion (R$ 3.1 billion p.a.) for the ZDAbs scenario; R$ 16.9 billion (R$ 1.1 billon p.a.) for the ZD2 scenario; and R$ 2.3 billion (R$ 153.4 million p.a.) for the ZD3 scenario.[11] By order of magnitude, total credit volumes available in 2016 topped R$ 162 billion.

Table 9 - Findings of the model, macro-economic variables in percentage variables, aggregated in 2030

Variável	ZDAbs	ZD2	ZD3
Actual family consumption	-0,58	-0,21	-0,03
Actual investments	-3,32	-1,35	-0,22
Actual government consumption	-0,58	-0,20	-0,03
Exports volume index	1,94	0,76	0,13
Imports volume index	-0,85	-0,36	-0,06
Actual GDP	-0,62	-0,22	-0,03
Actual wages	-1,23	-0,48	-0,08

[10] Social costs are the amounts that must be borne by society as a result of the implementation of a public policy.
[11] Brazilian Central Bank, 2017.

Impacts on Production

Domestic production of major exports, meaning primary products as well as processed goods (or even imports) has increased. This is because Brazil's political meltdown undermined the value of the Real, boosting exports (mainly soybeans, coffee and forest goods) as well as segments with significant imports (wheat, whose price increased).

These products tend to benefit from a zero deforestation policy, as their output expands in Brazil, to the detriment of other sectors.

Table 10 - Percentage variations in output compared to baseline, accumulated to 2030

Variable	ZDAbs	ZD2	ZD3
1 Wholegrain rice	-1,51	-0,55	-0,08
2 Corn	-1,47	-0,55	-0,08
3 Wheat and others	1,74	0,82	0,11
4 Sugarcane	-0,45	-0,16	-0,02
5 Soybeans	2,06	0,74	0,12
6 Other harvested goods and services	0,61	0,25	0,04
7 Manioc	-1,32	-0,48	-0,07
8 Tobacco	0,42	0,16	0,03
9 Cotton	-0,65	-0,22	-0,03
10 Citrus	-1,08	-0,38	-0,06
11 Coffee beans	1,67	0.62	0.10
12 Forest goods and operations	1,32	0,54	0,08
13 Cattle and others	-8,54	-3,41	-0,56
14 Dairy	-4,83	-1,82	-0,30
15 Hogs and others	-1,61	-0,60	-0,09

Regional Impacts

In all these scenarios, States on the agricultural frontier would lose more than the South and Southeast Regions, as the deforestation baseline is progressing mainly along this frontier, with the States most severely affected being Rondônia, Acre, Pará and Mato Grosso.

Table 11 - Percentage variations in Regional GDPs (accumulated to 2030)

PIB real	ZDabs	ZD2	ZD3
1 RO	-3,07	-1,53	-0,59
2 AC	-4,53	-2,88	-0,54
3 AM	-0,55	-0,12	-0,06
4 RR	-1,47	-0,32	-0,14
5 PA	-2,05	-1,35	-0,23
6 AP	-0,64	-0,19	-0,05
7 Matopiba (MA, TO, PI & BA)	-1,04	-0,45	-0,04
8 PE & AL	-0,40	-0,15	-0,02
9 CE, RN, PB & SE	-0,44	-0,15	-0,02
10 MG	-0,48	-0,13	-0,03
11 SP	-0,38	-0,13	-0,01
12 ES e RJ	-0,17	-0,06	0,00
13 PR, SC & RS	-0,65	-0,21	-0,02
14 MS	-1,11	-0,30	-0,04
15 MT	-3,17	-0,91	-0,14
16 GO & DF	-0,99	-0,29	-0,04

Impacts on Wages

The simulations indicate a dip in actual wages for all three scenarios, due to slowdowns in economic activities, reflected in the drop in GDP. The wages of less skilled workers show more real shrinkage than the pay of better qualified employees. This is because the farming and ranching sector makes relatively more intensive use of largely unskilled labor than the Brazilian economy as a whole. s curbing deforestation primarily affects the farming and ranching sector, less skilled workers (OCC1) tend to see their real wages shrink more than the pay of their better qualified counterparts (OCC10).

Table 12 - Percentage variations in actual wages by job type (accumulated to 2030)

Job Type	ZDabs	ZD2	ZD3
1 OCC1	-2,61	-1,08	-0,15
2 OCC2	-2,60	-1,12	-0,16
3 OCC3	-1,70	-0,67	-0,11
4 OCC4	-1,63	-0,64	-0,09
5 OCC5	-1,73	-0,70	-0,11
6 OCC6	-1,59	-0,62	-0,10
7 OCC7	-1,48	-0,58	-0,09
8 OCC8	-1,36	-0,53	-0,09
9 OCC9	-1,09	-0,41	-0,07
10 OCC10	-1,06	-0,40	-0,06

Note: Jobs are rated in rising order from the least skilled (1) to the most highly qualified. (10).

Variations in Productivity

The figures presented here do not take any technical progress (or technological changes) into consideration in the cattle-ranching system. However, the model allows for an estimate of these effects, through calculating the extent to which land productivity (output per hectare) would have to increase in order to keep production at the level noted for the baseline year, in order to avoid minor estimated losses to the GDP.

Table 13 - Annual percentage variations in land productivity between 2016 and 2030) required to maintain beef and dairy cattle-ranching activities at the baseline levels in Scenario 2

Region	Beef Cattle	Dairy Cattle
1 RO	0,49	0,49
2 AC	1,03	1,04
3 AM	0,45	0,45
4 RR	0,21	0,21
5 PR	0,79	0,80
6 AP	0,12	0,11
7 Matopiba (MA, TO, PI & BA)	0,45	0,45
8 PE & AL	0,00	0,00
9 CE, RN, PB & SE	0,00	0,00
10 MG	0,00	0,00
11 SP	0,00	0,00
12 ES & RJ	0,00	0,00
13 PR, SC & RS	0,00	0,00
14 MS	0,00	0,00
15 MT	0,52	0,52
16 GO & DF	0,00	0,00
Brazil	0,29	0,13

The greatest variations in land productivity would be required in some States in Northern Brazil (Rondônia, Acre, Amazonas and Pará), in the Matopiba region (Maranhão, Tocantins, Piauí and Bahia) and Mato Grosso State.

HIGHLIGHT: PARÁ AND MATO GROSSO STATES

The two States with the highest current deforestation rates are Pará and Mato Grosso, where projected land clearing is clustered in the Amazon Rainforest biome. Of the 5.75 Mha to be cleared in these two States under the baseline scenario, only 0.99 Mha would be in the *Cerrado* savannas, which is a biome in Mato Grosso State. Only the Matopiba region would post higher deforestation rates than these two States in the baseline scenario.

Table 14 - Baseline deforestation: Pará, Matopiba and Mato Grosso States (Mha, 2016-2030)

Region	Amazon Rainforest	*Cerrado* Savannas	Atlantic Rainforest	Total
Pará	3,12	0,00	0,00	3,12
Matopiba	0,32	3,95	0,12	4,39
Mato Grosso	1,64	0,99	0,00	2,63

Although projected deforestation is more widespread in Pará State, Mato Grosso would have a relatively higher GDP loss in the ZDAbs scenario, which is reflected in the other macroeconomic aggregates analyzed. This is because ranching (beef and dairy cattle-raising) accounts for a larger percentage of the total production value in the baseline year (5.4%) in Mato Grosso than in Para (4.2%).

Furthermore, the mining sector (which benefits from exports, as seen previously) is also relatively more important in Pará State (10.6% of the total value of its output in the baseline year) compared to Mato Grosso (0.4%).

Table 15 - Regional macroeconomic variables. Percentage variations, accumulated to 2030

Variable	Pará			Mato Grosso		
	ZDAbs	ZD2	ZD3	ZDAbs	ZD2	ZD3
Actual family consumption	-1,90	-1,13	-0,17	-2,23	-0,55	-0,10
Actual GDP	-2,05	-1,35	-0,23	-3,17	-0,91	-0,14
Aggregate employment	-0,11	-0,10	-0,01	-0,19	-0,02	0,00
Actual wages	-2,29	-1,21	-0,19	-2,29	-0,70	-0,13

However, in the ZD2 scenario — where deforestation would progress only in areas with high and very high aptitude for agriculture — the outcomes are reversed: the GDP drops more in the State with the most deforestation. What happens is that there is relatively more deforestation in Pará than in Mato Grosso: in the ZDAbs scenario, the Pará/Mato Grosso deforestation ratio is 1.2, while in the ZD2 scenario it rises to 2.8. This means that there is still more land available in Mato Grosso State with high and very high aptitudes for agriculture than in Pará State. The ZD3 scenario ranks between the other two, with GDP losses that are also fairly low.

CONCLUSIONS AND RECOMMENDATIONS

The findings of this study show that eliminating or even lessening deforestation and curbing the expansion of Brazil's agricultural frontier would have minimal impacts on the nation's economy and almost no negative consequences for society.

In terms of cattle-ranching, technological progress may offset simulated pasture losses. Although only minor to moderate, additional gains in productivity would in most cases counterbalance the effects of grazing land shrinkage caused by zero deforestation. Historical datasets show that these gains would be possible and are probably under way already.

The path leading to the scenario (ZD3) closest to the Brazilian Nationally Determined Contribution (NDC) requires only the implementation of command and control mechanisms already in place for halting illegal deforestation. Repurposing government-owned lands not earmarked for protection might also help usher in this scenario.

The middle-of-the-road scenario (ZD2) that imposes constraints on legal deforestation and privately-held properties with poor possibilities for agriculture may also be achieved under the current legal and regulatory frameworks (such as Ecological-Economic Zoning). sHowever, the manner in which these regulatory frameworks are currently deployed and the implementation speed of those still under construction — such as Environmental Regularization Programs (PRAs) and economic incentives linked to the Forest Code — would need to be fast-tracked with higher priority.

The scenario exploring an immediate halt to all types of deforestation (ZDAbs) requires a new legal framework and an innovative approach to governance that would depend on a blend of public and private policies. Developing new financial tools and applying large-scale compensation mechanisms for environmental services would buttress this process.

Links between the national and international dimensions would also be crucial in terms of a multilateral regulatory framework, together with capital flows and market arrangements underpinning outcomes that would contribute to the goals, commitments and aspirations of the Brazilian State and its society as a whole, as well as the international community at the global level.

At the domestic level, States whose economies are more deeply vested in farming and ranching activities or with large land inventories where legal deforestation is possible, would see steeper drops in their GDPs. These asymmetrical aspects may also be corrected by public policy tools that are already in place, such as the State Participation Fund.

All three scenarios indicate dips in the take-home wages of less skilled workers employed by this sector, highlighting the need to explore social policies offsetting these losses, although minor.

Finally, it is important to underscore that this study adopted a conservative stance in this model and its parameters, with the intention of spotlighting the negative economic impacts of zero deforestation. However, these findings indicate an analysis that is fairly close to the maximum — and thus improbable — potential impacts of zero deforestation on the Brazilian economy. For example, these simulations did not explore the impacts of potential changes on the trend towards more intensive agriculture, which may already be under way but are not yet numerically detectable.

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