

Current and future GHG emissions of tourism from Brazilians

ECOPA – Task 2.2 Tourism case study

Date	July 2015
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Conseil et recherche en politiques climatiques

A project funded by
changes”- 2012 Call.



Programme « Facing societal and environmental

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Foreword

Within the ECOPA project, TEC developed a case study on tourism, a fast growing activity and consumption area at world level and especially in emerging countries (WTTC 2009), and a growing contributor to global GHG emissions. Tourism relies on a complex set of consumption acts: accommodation, catering, transport, etc. which is another reason to select it as a case study.

The research consisted in building statistics, modeling emissions and projecting them in long term scenarios, thus enabling us to analyze what are the trends in Brazil during the past decades and what could be the figures for the next decades. What is also at stake is to show whether the correlations of the growth of tourism with the rising of upper classes and middle classes has the same effects on tourism as it had in France during the “*trente glorieuses*” (1945-1975 fast economic recovery and development). The issue of convergence is indeed a major point in ECOPA. It is interesting to see whether the influence of governance or others factors (geography, rythm of development, etc.) can influence the GHG intensity of the tourism sector (railroad systems instead of plane, etc.).

This report is the final report of ECOPA task 2.2. It was written by Jean Paul Ceron and Ghislain Dubois. Roman de Rafael (TEC) and Larissa Albino (COPPE) contributed to data collection and modeling.

Résumé

Cette recherche constitue une contribution à l'étude de la problématique des émissions des touristes résidant dans les pays émergents. Elle prend appui sur la double idée bien établie dans les recherches de ces 10 dernières années, que le tourisme apporte actuellement une contribution conséquente aux émissions de gaz à effet de serre (de l'ordre de 5 % des émissions mondiales) et que dans le futur les pays émergents apporteront une part fortement croissante de sa contribution. Le travail traite du Brésil, sans que l'on puisse prétendre généraliser ses conclusions à d'autres pays émergents : les spécificités de chacun d'entre eux sont manifestement déterminantes.

I. Les émissions actuelles.

Le travail commence par une évaluation des émissions actuelles du tourisme des brésiliens, à l'intérieur de leur pays et à l'international. Il est amplement démontré par les travaux précédents sur les émissions du tourisme que la plus grande part de celles-ci provient des transports : le travail part donc des statistiques sur les flux (nombre de touristes et distances) lesquelles sont combinées avec la répartition selon les moyens de transport et les coefficients d'émissions de gaz à effet de serre de chacun. Une évaluation des émissions de l'hébergement est également effectuée.

L'évaluation des émissions actuelles du tourisme dépend fortement la métrique utilisée : 32 ou 34 millions de tonnes en considérant le CO₂ seul ou le CO₂ équivalent, 55 millions de tonnes si on tient compte des effets spécifiques (en termes de forçage radiatif) de l'aviation.

L'interprétation de tels résultats dépend du profil très spécifique des émissions du Brésil, notamment de l'importance des émissions liées à l'usage des sols et à la foresterie (LUCF). En 2010 le tourisme représentait environ 3,2 % des émissions nationales (1034 millions de tonnes CO₂ équivalent), LUCF exclu ; la moyenne mondiale correspondante est de 4.9 %. Si l'on inclut un facteur tenant compte des effets spécifiques aviation la part des émissions atteint 5 %. En 2010 les émissions du tourisme brésilien paraissent toujours inférieures à la moyenne mondiale, laquelle est fortement impactée par le poids des pays développés. La part des émissions au Brésil, si elle reste bien inférieure à celle des pays développés n'en est pas moins déjà significative, surtout si l'impact spécifique de l'aviation est inclus.

II. Les émissions futures.

Ensuite la recherche se préoccupe des émissions futures en utilisant une approche plus affinée qu'une simple relation avec le produit intérieur brut. On part ainsi d'une analyse détaillée des principales motrices du tourisme brésilien. Un peu moins d'une dizaine de variables sont retenues : évolution de la population, nombre de personnes par ménage, proportion de population urbaine, évolution du PIB, distribution des revenus, taux de départ selon les classes de revenus, répartition modale, évolution des facteurs d'émissions. Un certain nombre de ces variables (par exemple : la distribution des revenus) traduit de fortes spécificités brésiliennes.

Un scénario de référence est ensuite construit. Il combine les hypothèses d'évolution des forces motrices les plus couramment admises ou les hypothèses centrales tirées de la littérature ou retenues par des institutions gouvernementales et internationales, selon ce qui est disponible et paraît raisonnable. Deux échéances sont considérées pour le scénario : 2030 et 2050.

Le scénario de référence : résultats.

Le scénario conduit à une multiplication des émissions par 4 et 8 en 2030 et 2050. Cette progression est bien supérieure à celle qui peut être attendue pour des pays développés. Par ailleurs les émissions par tête du tourisme des brésiliens atteindraient environ 1t en 2030 et 2t en 2050, ce qui est du même ordre de grandeur, voire légèrement supérieur au résultat d'un scénario de même nature pour la France.



Les tests de sensibilité.

On revient ensuite à l'analyse des forces motrices dans le dessein d'examiner pour chacune d'entre elles, non plus une hypothèse centrale, mais des hypothèses alternatives prenant en compte des évolutions plus marquées dans un sens ou dans l'autre, sous contrainte qu'elles restent vraisemblables. Les résultats de ces tests de sensibilité sont intéressants en eux-mêmes. On retiendra en particulier que les évolutions sont aussi sensibles à la distribution de la richesse qu'à son évolution en volume. Les modifications des durées de séjour dans un sens ou dans l'autre ont un impact comparable à ces deux premiers facteurs. Enfin l'introduction des biocarburants dans l'aviation un impact très significatif en 2050. L'impact des hypothèses faites sur les autres variables est moindre, notamment pour les modifications de la répartition modale ou l'introduction des biocarburants dans les modes de transport terrestre.

Ceci confirme à la fois que la croissance du PIB est une force motrice majeure de l'avenir des émissions du tourisme mais qu'elle est loin d'être la seule : d'autres forces comme la distribution des revenus, les modes de vie, certains facteurs technologiques font jeu égal ou presque (et on ne peut les considérer comme corrélés avec le PIB)

Les scénarios alternatifs

Enfin des scénarios alternatifs sont construits en combinant sur l'ensemble des variables des hypothèses d'évolution non contradictoires entre elles. Le but essentiel est d'examiner jusqu'à quel point de telles combinaisons d'hypothèses peuvent réduire les émissions comparativement au scénario de référence.

Trois scénarios reflétant trois perspectives de croissance sont d'abord élaborés; la première est celle retenue par le gouvernement et les organismes internationaux, la seconde est bien plus pessimiste mais à notre sens plausible, et une troisième intermédiaire... Chacune de ces variantes est associée avec une distribution des revenus égalitaires (dont l'efficacité pour la diminution des émissions a été prouvée plus haut). Les hypothèses faites pour les autres variables diffèrent selon les scénarios et sont choisies pour être compatibles avec le choix effectué pour la croissance.

Enfin nous avons construit un scénario du pire qui vise à évaluer le maximum que les émissions pourraient atteindre. Il combine une forte croissance avec une distribution inégalitaire des revenus et retient les hypothèses les plus défavorables pour les autres variables.

Le scénario du pire montre d'abord que les émissions peuvent encore plus que doubler par rapport au scénario de référence. Il est également intéressant de noter que le scénario de croissance moyenne (comportant une distribution des revenus égalitaire) aboutit à des résultats assez proches d'une version du scénario de croissance faible associé à une distribution inégalitaire des revenus.

Par rapport au scénario national de référence reflétant les engagements internationaux du Brésil (à 2030), les émissions du scénario de référence pour le tourisme représenteraient 9,7 % des émissions (15 % environ avec le forçage radiatif de l'aviation) ; les émissions du scénario de croissance moyenne représenteraient 7 % des émissions nationales.

Pour 2030 on dispose également au niveau national de deux scénarios de réduction des émissions allant au-delà du scénario de référence. Le scénario de croissance moyenne aboutit à des émissions représentant 9 et 11 % par rapport à ceux-ci, ce qui est un pourcentage du même ordre que celui qui est atteint actuellement dans les pays les plus développés.

Il n'existe pas de scénario des émissions nationales du Brésil en 2050 ; il reste clair qu'elles devraient continuer à diminuer si l'augmentation de la température mondiale doit rester limitée à 2 °C. Par rapport à cette perspective les émissions des différents scénarios pour le tourisme sont hautement problématiques : elles conduisent en effet à une augmentation des émissions par un facteur allant de 1,65 à 2,3 par rapport à 2030. S'il n'est nullement écrit que la contribution des différentes activités doit rester identique au fil du temps, il n'en est pas moins difficile d'envisager une augmentation, particulièrement pour celles qui représentent déjà un



pourcentage significatif. Le fait que la situation dans les pays développés soit encore plus préoccupante puisqu'ils atteignent déjà le niveau du Brésil en 2030 et que les émissions de leur tourisme tendent toujours à croître, ne peut être une consolation.

Que ce soit pour les pays émergents ou les pays développés, les perspectives des émissions de gaz à effet de serre de tourisme à long terme constituent une préoccupation majeure.

Abstract

This research aims at contributing to the assessment of the emissions of the tourists from emerging countries, now and in the future. It starts from a double idea often mentioned in the research of these last 10 years: i.e. that tourism currently contributes significantly to the emissions of greenhouse gases (around 5% of worldwide emissions) and that in the future such emissions will grow while emerging countries will bring a much larger contribution to them. This work deals with Brazil, but it cannot be pretended that its conclusions would be applicable to other emerging countries: specific national features highly impact the assessment.

I. Current emissions.

The first task is an assessment of the current emissions of tourism from the Brazilian population, within their country and internationally. All previous research on the emissions from tourism clearly shows that the bulk of emissions is related to travel. So, the assessment starts from statistics on flows (tourist numbers and distances: p.km) which are split according to means of transport and multiplied by the corresponding emission coefficients. An assessment of the emissions from accommodation is also done.

The evaluation of current emissions from tourism is dependent upon the metrics used: 32 or 34 million tonnes when considering CO₂ only or CO₂ equivalent, 55 million tonnes if an uplift factor taking into account the specific features of aviation (in terms of radiative forcing) is used.

The interpretation of such results strongly depends on the specificity of Brazilian emissions, i.e. the importance of the emissions linked to land use change and forestry (LUCF). In 2010 tourism represented about 3.2% of national emissions (1034 million tonnes CO₂ equivalent) LUCF excluded. The corresponding world average is 4.9% percent. If an uplift factor for aviation is included, this share reaches 5%. In 2010 the emissions of Brazilian tourism are still under world average, which is highly impacted by the weight of developed countries. The share of emissions in Brazil, whereas it remains quite inferior to that of developed countries is nevertheless already significant, the more if the specific impacts of aviation are included.

II. Future emissions.

Next, the research deals with future emissions, using a more refined approach than a mere correlation with GDP. It starts from a detailed analysis of the main driving forces of Brazilians' tourism. Near 10 variables are retained: population trends, number of people per household, proportion of urban population, GDP trends, income distribution, departure rates according to income classes, modal shares, changes in the emissions factors... Some of these variables, for example income distribution, reflect strong Brazilian specificities.

A reference scenario is then built. It combines the most usually retained hypotheses (or the central hypotheses) for the driving forces found in the literature, or those governmental and international institutions use, according to what is available and seems a reasonable. The scenarios are built for two horizons: 2030 and 2050.

The reference scenario: results.

The scenario leads to a multiplication of emissions by 4 and 8 in 2030 and 2050. This increase is by far superior to what it is expected for developed countries. Besides, the emissions per Brazilian would reach about 1 t in 2030 and 2 t in 2050, which is the same order of magnitude or even slightly over the figures of a similar scenario for France.



Sensitivity tests.

Alternative hypotheses are then defined for the driving forces so as to explore more extreme outcomes (as far as they remain realistic and make sense). The results of these sensitivity tests are interesting by themselves. In particular they show that the outcomes of some scenarios are almost as sensitive to the distribution of income as to the evolution of GDP. The modifications of the length of stay have comparable impact to the two previous variables. Lastly the introduction of biofuels in aviation has a very significant impact in 2050. The impact of the alternative hypotheses made on the other variables is less significant, notably regarding the evolution of modal shares or the introduction of biofuels in terrestrial modes of transport.

This both confirms that the growth of GDP is a major driving force for the future of emissions from tourism but also that it is not the only one: other forces such as distribution of income, length of stays, some technological factors are almost just as significant (and they cannot be said to be correlated with GDP...).

Alternative scenarios.

Lastly alternative scenarios are built by combining over all the set of variables hypotheses for change which do not contradict each other. The main goal is to assess to what extent such combinations can reduce the emissions comparatively to the reference scenario.

Three scenarios reflecting three growth perspectives are built; the first is the one retained by the government and international institutions, the second is far more pessimistic but we believe plausible, the third is intermediate between these. Each of these variants is associated with an equalitarian distribution of income (whose efficiency regarding the mitigation of emissions has been proven above). The hypotheses made for the other variables differ according to scenarios and are chosen so as to be compatible with the choice made for growth.

At last we have built a worst-case scenario which endeavours to assess the maximum emissions can reach. It combines a high growth with an inegalitarian distribution of income and the most unfavourable hypotheses for the other variables.

The worst-case scenario first shows that emissions can even more than double, compared to the reference scenario. It is also interesting to note that the medium growth scenario (associated with an equalitarian distribution of income) leads to results fairly near to a version of the low growth scenario associated with an inegalitarian income distribution.

Compared to the national reference scenario which reflects the international commitments of Brazil to 2030, the emissions of the reference scenario for tourism would represent 9.7% of emissions (roughly 15% including an uplift coefficient for aviation). The emissions of the medium growth scenario would represent 7% of national emissions.

At the national level, for 2030, two mitigation scenarios, pushing further the reduction of emissions than the reference scenario are also available. The medium growth scenario for tourism would represent 9% and 11% of emissions relative to these mitigation scenarios; this percentage is of the same order of magnitude as that currently reached in the most developed countries.

No scenario for the National emissions of Brazil in 2050 is available. It is nevertheless clear that national emissions should continue diminishing to abide by the 2°C guardrail. With that perspective, the emissions of the different scenarios for tourism in 2050 pose a serious problem: they lead to an increase of emissions by a factor from 1.65 to 2.3 relative to 2030. Whereas it is nowhere written that the contribution of different activities should stay identical through time, it is nevertheless difficult to envisage an increase, in particular for those who already represent a significant percentage. The fact that the situation of developed countries is even more problematic, since we already reach the level of Brazil in 2030 and since the emissions from their tourism still tend to increase, cannot be a consolation.

Whether for emerging or for developed countries, the prospects of greenhouse gas emissions from tourism in the long term constitute a major preoccupation.



I. Context and objectives

The contribution of tourism to GHG emissions

Tourism and climate change: adaptation and mitigation

The interface between tourism and climate change started to be considered by academics during the 1990s, e.g. (Agnew 1995; Ceron 1998; Viner and Agnew 1999). This research aimed at examining the impacts of climate change on tourism and its vulnerabilities.

A record of this work can be found in (Scott, Jones et al. 2005), a bibliography which has not been updated for some time. Chapter 10 of working group 2 of the IPCC fifth assessment report gives a more recent synthesis (Viard 2000; Arent and Tol 2014)(Viard 2000; Arent and Tol 2014)(Viard 2000; Arent and Tol 2014)(Viard 2000; Arent and Tol 2014)(Viard 2000; Arent and Tol 2014)(Viard 2000; Arent and Tol 2014)(Arent and Tol 2014).

Impacts and adaptation were the main focus of the first conference on tourism and climate change which was held in Djerba in 2003. The few interventions which pointed out that tourism was not only a potential victim of climate change but also a contributor to it e.g. (Ceron and Dubois 2003) were considered by a large part of the audience as irrelevant. Such an attitude of denial was rather common in the first half of the decade and sometimes persisted beyond. There was also a lack of interest regarding the issue. Quite significantly, despite the efforts of a network of academics familiar with the IPCC process, it was impossible to have the issue of the emissions from tourism taken up in the fourth assessment report (working group 3).

Working on the assessment of greenhouse gas emissions from tourism started at the beginning of the first decade of the century (Gössling 2002). From the start, a particular focus was put on transportation, analysing the case of particular trips, and pointing variations according to destinations (Gössling, Peeters et al. 2005). It was then shown that emissions from origin and destination transport dwarfed other issues (EPA 2000) and the particular impact of aviation was identified (Becken 2002). Case studies were followed by national or regional assessments, e.g. (Peeters, van Egmond et al. 2004; Ceron and Dubois 2006) and by an evaluation of the world's emissions in a report prepared for the Second International Conference on Tourism and Climate Change held in Davos in 2007 (UNWTO, UNEP et al. 2008).

It can be considered that at that time a stabilised and reliable picture of the issue had been drawn. Some updates followed e.g. (WTTC 2009; OECD and UNEP 2011); they do not significantly alter the results. Yet , some additional case studies have drawn attention on problematic activities that had not been studied until then, e.g. (Cruise ships: (Amelung and Lamers 2007; Eijgelaar, Thaper et al. 2010). It is also clear that the GHG emissions from tourism in developing and emerging countries are far less known than emissions of industrialised countries. Given that most of the growth should occur in the former, they deserve attention.

Current contribution of tourism

Tourism is estimated to contribute from 3.9% to 6% of global anthropogenic CO₂ emissions, with a best estimate of 4.9% (UNWTO, UNEP et al. 2008). In affluent countries this share is more important: e.g. the Netherlands (9.1%)(De Bruijn, Dirven et al. 2010), France (IFEN 2000), Switzerland (Perch-Nielsen, Sesartic et al. 2010), and Sweden (11% in 2001)(Gössling and Hall 2008).



When expressed in terms of radiative forcing (see p.41) both the share of tourism in global emissions (from 5.2% to 12.5% in 2005) and that of tourism related aviation (5.4% to 8.3% of global emissions) quite significantly increase (Scott, Peeters et al. 2010).

The emissions from accommodation represent 3.5% of global emissions from building (World Economic Forum, 2009). North America generates 40% of these (with a particularly high energy intensity), Europe 21% and Asia and Pacific 29%. The volume of cruise travel (highly intensive in emissions (Amelung and Lamers 2007; Eijgelaar, Thaper et al. 2010) and included in “other transport”) has grown at an average annual rate of 7.4% since 1990 (CLIA, 2009).

These figures represent direct emissions: taking into account indirect emissions or considering a life cycle perspective would naturally increase the volume of emissions: no such assessment has to date been done (OECD and UNEP, 2011).

Figure 1 Approximation of tourism transport emissions by region of origin and destination (2005 data).

	CO ₂ emissions (total million tonnes)	CO ₂ emissions by air transport
Total	981	515
<i>Same-day (domestic and international)</i>	133	11
Non-same-day tourists	848	506
Within regions	630	289
<i>Domestic</i>	478	185
Europe		17
Americas		123
Asia and the Pacific		42
Middle East		2
Africa		1.5
<i>International</i>	153	104
Europe		39
Americas		22
Asia and the Pacific		40
Middle East		1.8
Africa		1.2
Between regions	218	217
<i>Short haul</i>	11	10
<i>Long haul, predominantly from-to</i>	208	208
High income-developing	79	79
Developing-developing	9	9
Developing-high income	49	49
High income-high income	70	70

Source : Adapted from (UNWTO and UNEP, 2008)



Figure 2. Estimated emissions from global tourism (including same-day visitors) 2005.

	CO ₂	
	Mt	Share in tourism (%)
Air transport	515	40
Car	420	32
Other transport	45	3
Accommodation	274	21
Other activities	48	4
Total tourism	1,302	100
Total world (d)	26,400	-
Share of tourism in total world (%)	4.9	-

Note. Colours illustrate the margins of error with respect to the data and underlying assumptions: Green represents a degree of margin of error of +/-10%, blue +/- 25% and red +100%/-50%.

Source: (UNWTO and UNEP, 2008)

Out of a world total of 981 Mt of CO₂ in 2005 (UNWTO and UNEP, 2008):

- overnight stays represent 844 Mt and same day visitors 133 Mt;
- the emissions within regions account for 630 million and are dominated by domestic travel (478 Mt);
- international tourism between regions (almost exclusively by air) accounts for 218 Mt, more than two thirds of which relate to travel between high-income countries and from trips originating in high-income countries with destinations in developing countries;
- aviation accounts for 515 Mt out of the global figure of 981Mt

The greater part of emissions is generated (Gössling, Peeters et al. 2005; TEC and Direction des études et de l'évaluation Environnementale 2008; De Bruijn, Dirven et al. 2009) by a minority of travelers: frequent travelers using the plane over long distances (Gössling et al., 2009); e.g. 5% percent of the French are responsible for 50% percent of the emissions from tourism travel (TEC and Direction des études et de l'évaluation Environnementale 2008). The Netherlands survey shows that more than 90% of the growth of emissions between 2002 and 2008 is caused by holidays taken outside of Europe (de Bruijn et al., 2010). These studies also point to the large variety in the emissions intensity of various tourism segments.

Mitigation potentials

Mitigation options for tourism include technical, behavioral and organizational aspects. Many mitigation options and potentials are the same as those identified for transport, buildings (accommodation), food (catering) etc. Yet the manner tourism uses the products and services provided by the subsectors can be specific in some aspects. Some literature deals with this specificity: e.g. for food (Gössling, Garrod et al. 2011), for accommodation (Ayuso 2006; Bohdanowicz and Martinac 2007) or for transport (Dubois, Peeters et al.).



Much of this literature is closely linked to the assessment of energy-saving potentials (e.g. accommodation). It should be noted that the assessment of potentials is usually a step towards the production of scenarios exploring the possible futures of tourism under climate change mitigation (see below).

The general lack of awareness of professionals regarding climatic change and its weakness among other local stakeholders explains the current paucity of mitigation actions other than those derived from energy savings. The literature on good practices dealing with climate change (including adaptation) largely draws on the work on sustainable development in tourism (Becken 2005; Becken and Hay 2007; UNWTO, UNEP et al. 2008).

At a higher geographic level, approaches to mitigation in the tourism sector vary across regions (OECD and UNEP, 2011). Some reduction targets have been put forward by the WTTC: -25% to -30% by 2020, -50% in 2035 compared to 2005. Such targets are supported by the European Tourism Commission and UNWTO “*as a minimum requirement for progress on effective emissions reductions*” (Scott et al., 2010). These targets contrast with the trends in emissions growth and reveal a gap of more than 100% between the projected emissions for 2035 and the target (Scott et al., 2010). While some tourism organizations favor reducing the emissions from tourism in line with the reductions required of other sectors, some governments continue fixing objectives for tourism that are incompatible with such a prospect, thus putting implicitly an additional burden on the reduction in other sectors.

In the field of tourism mitigation first faces a general lack of sensitivity and awareness of :

- stakeholders for whom it is far from being an important concern (Becken and Hay, 2007) ;
- tourists who generally are not aware of the emissions neither from transport nor from accommodation and activities, and are attracted by the behavior of a minority of hypermobile and wealthy tourists (Gössling et al., 2009);
- governments who pursue contradicting objectives, developing aviation and long haul tourism markets while they seek to reduce emissions (OECD and UNEP, 2011).

These factors tend to increase the lock-in of tourism to the most emitting modes of transport at the expense of the development of rail infrastructure (Paul Peeters et al., 2006). Should large-scale mitigation emerge, it would surely be confronted with financial barriers (high investment in infrastructure and facilities) particularly in developing countries (Becken, 2005).

An OECD review of national tourism-related policies (OECD and UNEP, 2011) found that only one third of countries had identified tourism-related mitigation options (often countries that can only be reached through long haul travel, or small islands states highly dependent on oil). In only five countries out of 55, measures are currently implemented. Nowhere has a comprehensive strategy been defined so far..

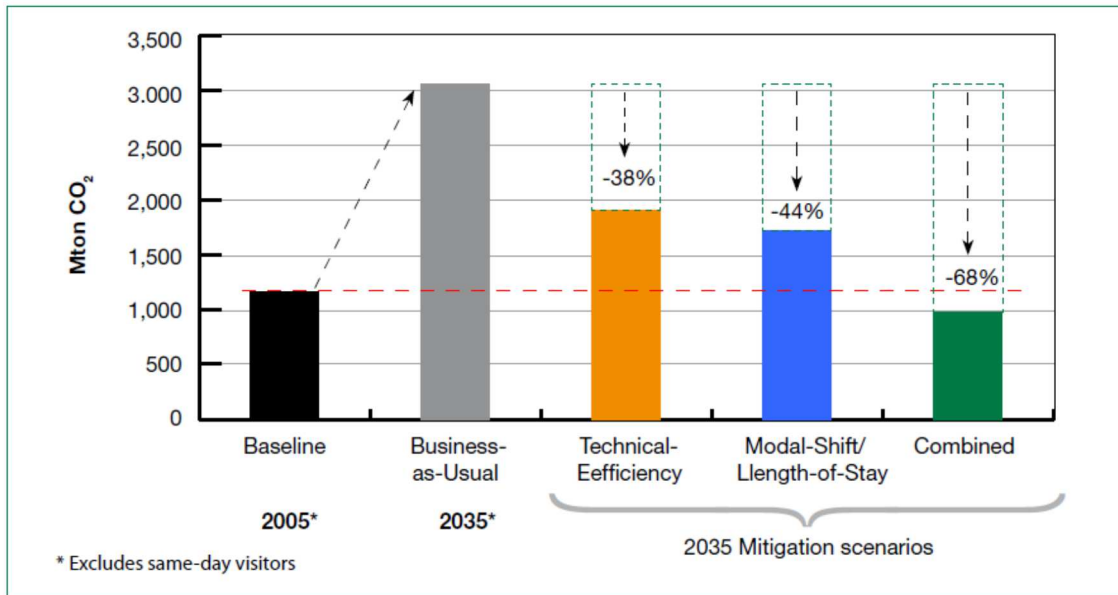
The contribution of tourism to mitigation in the future: scenarios.

Tourism can be given as an example of a sector where mitigation potentials have been integrated into scenarios exploring its capacity to meet certain levels of mitigation goals and the transformation pathways they would imply for the activity.

Several studies show that an unrestricted growth of tourism would by 2050 consume the whole carbon budget compatible with the +2°C guardrail (Bows et al., 2009; Scott et al., 2010). A worldscale business as usual scenario (UNWTO and UNEP, 2008) projects emissions to grow by 130% from 2005 to 2035, notably the emissions of air transport and accommodation triple. At world level compared to the business as usual projection, two scenarios, one reflecting technological potentials and the other behavioral potentials, have been built (UNWTO and UNEP, 2008), as shown in Figure 3.



Figure 3 Scenarios of CO₂ mitigation potential from global tourism in 2035



Source: (UNWTO and UNEP, 2008)

These scenarios show both that the contribution of technology is not sufficient and that even when combining technological and behavioral potentials, the 50% reduction target in 2035 compared to 2005 is far from being reached. Insufficient technological potential and the need for drastic changes in the forms of tourism (reduction in long haul travel (Peeters and Dubois 2010)) and in the place of tourism in the uses of leisure time implying changes in lifestyles (Dubois and JP Ceron, 2006; Dubois et al., 2010).

The role of emerging countries in the future of global emissions

The assessment of emissions has up to now been done by researchers from advanced countries whose fieldwork essentially covers the developed world. Though they have achieved several case studies on the emissions related to distant and exotic destinations e.g.(Gössling, Peeters et al. 2005; Ceron and Dubois 2011), to date no assessment of emissions has concerned major emerging countries (the BRICS...). The assessment of world emissions of the Davos conference does include estimates for emerging and less developed countries but they were based on rather coarse statistics, approximations, and educated guesses. This can be seen as a first step.

One can indeed feel frustrated by this gap in research, the more as some available data (see below) clearly suggest that emerging countries should emit a much greater share of the emissions from tourism than they do now, and furthermore than they did a decade ago when the first world assessment was done. This concern relates both to the role of emerging countries in international and domestic tourism.

International tourism

For a certain number of years UNWTO has been dealing with the prospects for tourism around 15 years ahead, and so we have projections of tourism for 2030, including scenarios around a central projection. This work only deals with inbound and outbound international tourism.

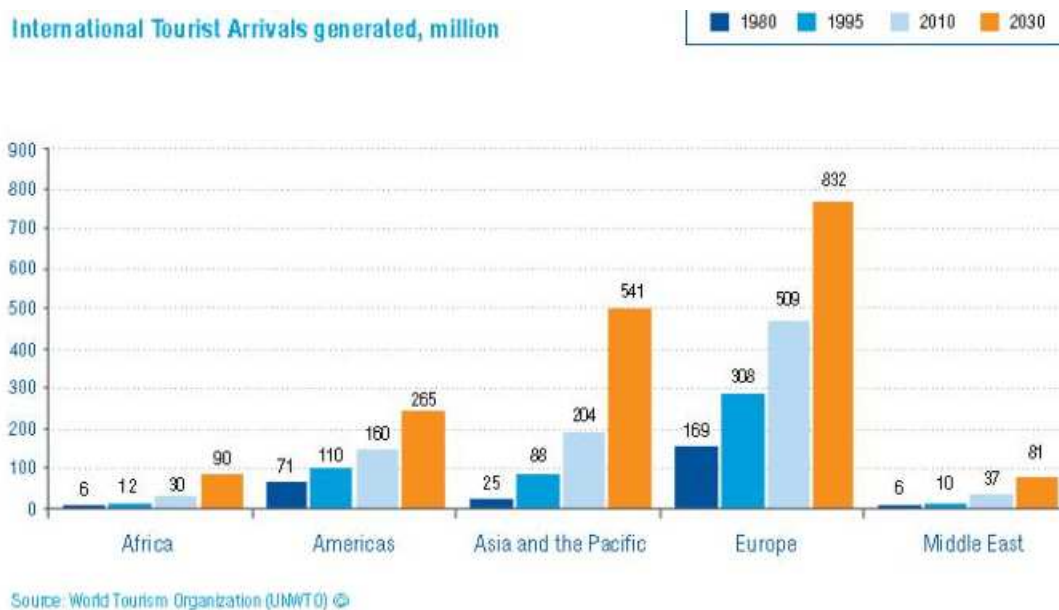


The work by UNWTO distinguishes between emerging and advanced economies, and between regions of the world. However, within each region, it does not distinguish between emerging and advanced economies, so for the Americas it is not possible to obtain figures for the USA and Canada on the one hand, Central, and South America (including Brazil) on the other.

It must also be remembered that international tourism simply implies crossing a border, independently of the size of countries and of the distances covered. The underlying view on the geography of tourism is thus disputable, at least regarding the topic our study deals with (Peeters and Landré 2012).

The projections for outbound tourism (figures below) show a dramatic increase for Asia and the Pacific (mainly emerging countries) but also a very strong growth for Europe, which is largely explained by the small size of the countries.

Figure 4. Outbound tourism by region of origin



Source : (UNWTO 2013)

Figure 5. International tourist arrivals generated (million)

	actual data						projections	
	1980	1990	1995	2000	2005	2010	2020	2030
World	277	435	528	674	797	940	1,360	1,809
from:								
Africa	5.7	10.6	12.3	15.7	20.6	29.9	53	90
Americas	71.1	100.5	110.1	132.5	139.8	169.9	212	265
Asia and the Pacific	24.7	59.7	87.6	115.7	154.7	204.5	368	541
Europe	169.2	265.2	307.8	395.3	458.3	508.7	681	832
Middle East	5.9	8.6	9.9	14.8	23.9	37.2	67	81

Source: (UNWTO 2013)



It must also be noted that in terms of trips per inhabitant, the regions including a large share of emerging countries, though they show higher rates of growth than Europe, still lag far behind in 2030. Even if we keep in mind the relative size of countries, it appears that the process of a hypothetical convergence worldwide between emerging and advanced economies will still be far from being completed in 2030¹.

Figure 6. International tourist arrivals generated per 100 of population

	actual data						projections	
	1980	1990	1995	2000	2005	2010	2020	2030
World	6	8	9	11	12	14	18	22
By UNWTO regions:								
Africa	1	2	2	2	2	3	4	6
Americas	12	14	14	16	16	17	21	24
Asia and the Pacific	1	2	3	3	4	5	8	12
Europe	21	30	36	46	52	57	74	89
Middle East	6	6	6	9	12	17	21	26

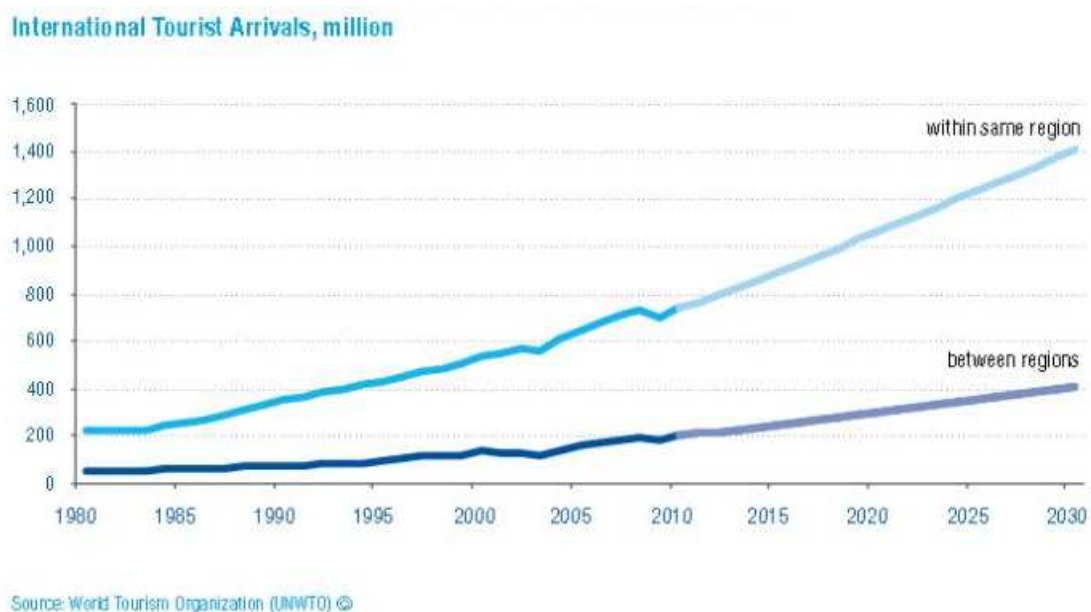
Source: World Tourism Organization (UNWTO) ©

Source: (UNWTO 2013)

Two other features from the UNWTO study can be noted:

- the increase in international trips within regions is larger than between regions,
- the share of motives is predicted to remain much the same, though it is shown that in emerging countries the share of business travel is significantly higher.

Figure 7. International tourism by region of destination and origin



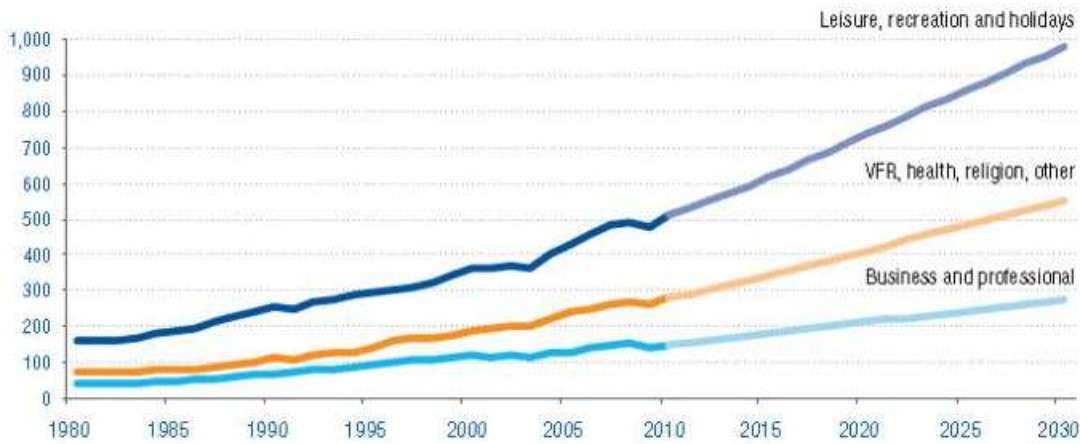
¹ Our work will show that this might not be true for Brazil.



Source:(UNWTO 2013)

Figure 8. International tourism by purpose of visit

International Tourist Arrivals, million



Source: World Tourism Organization (UNWTO) ©

Source: (UNWTO 2013)

As a whole, though the UNWTO study does not allow a focus on those emerging countries (BRICS) whose tourism should impact the most the increase of emissions, it does largely justify the hypothesis of an upsoaring contribution of emerging countries to the emissions of international tourism.

Domestic tourism

Worldwide, statistics on domestic tourism are less available and of poorer quality than those on international tourism. This, to some extent, reflects the priorities of stakeholders including governmental bodies see for example the French strategy for tourism to 2020 (Atout France 2010). Yet it is clear that the number of domestic tourists worldwide largely exceeds that of international tourists. The study for the Davos conference (UNWTO, UNEP et al. 2008) roughly estimated that in 2005, international tourists amounted to 750 million and domestic tourists to 4000 millions, of these almost a half were in developing countries. Looking at individual countries,



Figure 9 clearly shows how much domestic tourism can exceed international tourism. The ratio approximates 1 only for small countries.



Figure 9 Domestic versus international outbound travel

Country	Ratio Domestic: International	Area (sq. km's)	Square root of area (km's)
Netherlands	1.02 : 1	41,528	204
United Kingdom	1.51 : 1	242,900	493
Poland	3.39 : 1	312,685	559
Belgium	0.96 : 1	30,528	174
Austria	0.42 : 1	83,872	290
France	3.5 : 1	674,843	821
Italy	3 : 1	301,338	549
Spain	2.18 : 1	504,030	710
Portugal	1.12 : 1	92,345	304
Greece	2.5 : 1	131,990	363
Germany	1.53 : 1	357,022	598
China	38 : 1	9,596,961	3,098
USA	19 : 1	9,629,091	3,103
Russia	3.57 : 1	17,075,000	4,132
Australia	14.9 : 1	7,741,220	2,782
India	58 : 1	3,287,240	1,813
Canada:	11.47 : 1	9,984,670	3,160
Japan:	15.15 : 1	377,873	615
New Zealand	9.6 : 1	268,680	518
Peru	9.9 : 1	1,285,216	1,134
Indonesia	2.7 : 1	1,912,988	1,383

Sources: EU-countries: UNWTO figures year 2000; China: Table 5 year 2004; Russia: (WTTC 2006b) year 2004; USA: (WTO 2005 and US Department of Commerce 2008a) year 2004; Australia: (Australian Bureau of Statistics 2007) year 2006; India: (Ministry of Tourism 2004) year 2003; Canada: UNWTO figures year 2006; Japan: UNWTO figures year 2004; New Zealand: UNWTO figures year 2007; Peru: UNWTO figures year 2006, and Indonesia: UNWTO figures year 2006

source: (Eijgelaar and Peeters 2008)

Though the UNWTO prospective study does not deal with domestic tourism, the drivers and trends it calls upon to model future international tourist flows are also relevant for domestic tourism, and in the first place the correlation with GDP.



Figure 10 gives an insight into the potential developments of domestic tourism following GDP growth in major emerging countries.



Figure 10. Actual and projected top20 economies ranked on GDP in PPP terms

PPP rank	2011		2030		2050	
	Country	GDP at PPP (2011 US\$bn)	Country	Projected GDP at PPP (2011 US\$bn)	Country	Projected GDP at PPP (2011 US\$bn)
1	US	15,094	China	30,634	China	53,856
2	China	11,347	US	23,376	US	37,998
3	India	4,531	India	13,716	India	34,704
4	Japan	4,381	Japan	5,842	Brazil	8,825
5	Germany	3,221	Russia	5,308	Japan	8,065
6	Russia	3,031	Brazil	4,685	Russia	8,013
7	Brazil	2,305	Germany	4,118	Mexico	7,409
8	France	2,303	Mexico	3,662	Indonesia	6,346
9	UK	2,287	UK	3,499	Germany	5,822
10	Italy	1,979	France	3,427	France	5,714
11	Mexico	1,761	Indonesia	2,912	UK	5,598
12	Spain	1,512	Turkey	2,760	Turkey	5,032
13	South Korea	1,504	Italy	2,629	Nigeria	3,964
14	Canada	1,398	South Korea	2,454	Italy	3,867
15	Turkey	1,243	Spain	2,327	Spain	3,612
16	Indonesia	1,131	Canada	2,148	Canada	3,549
17	Australia	893	Saudi Arabia	1,582	South Korea	3,545
18	Poland	813	Australia	1,535	Saudi Arabia	3,090
19	Argentina	720	Poland	1,415	Vietnam	2,715
20	Saudi Arabia	686	Argentina	1,407	Argentina	2,620

Sources: World Bank estimates for 2011, PwC estimates for 2050

source:(PWC Economics 2013)

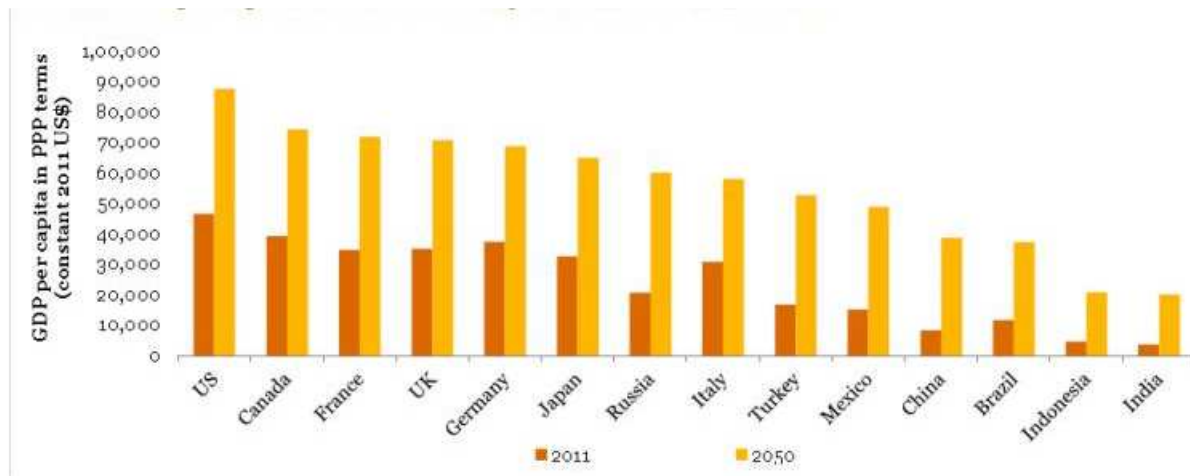
In 2050, out of the four largest economies, three are emerging ones: China, India and Brazil. In terms of GDP per inhabitant, the picture is rather different (see



Figure 11). Currently advanced economies keep a quite serious advantage over China and Brazil with a GDP per inhabitant about twice as high. India lags well behind China and Brazil according to this criterion. Yet it remains that for the three of them, owing to the high degree of income inequalities within their population, this means highly expanding tourism. Considering the size of these countries, their domestic tourism will tend to imply long distances and call for aviation just as an important share of the international tourism of European countries (remaining internal to Europe or outbound to the Mediterranean countries) currently does.



Figure 11. GDP per capita levels in PPP terms for the G7 and E7 economies



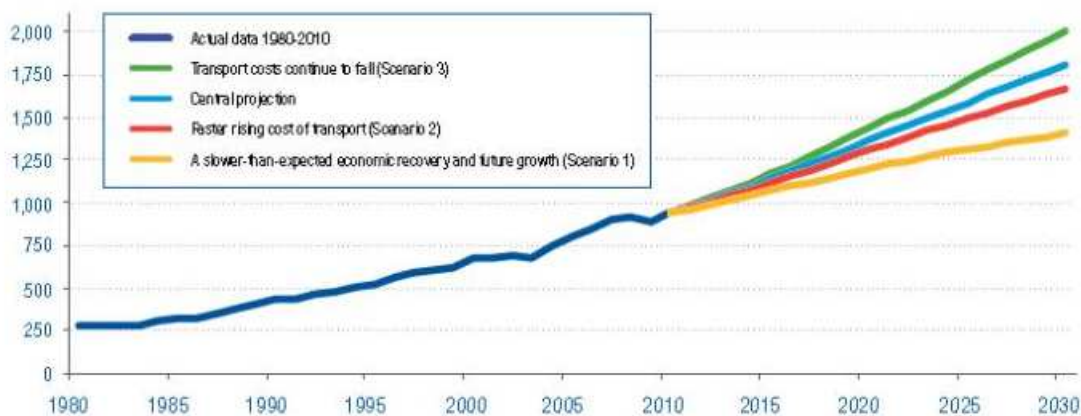
source:(PWC Economics 2013)

Two remarks can be added. First, the GDP per inhabitant projections show that two other emerging economies appear in the picture with a high potential of tourism development: Turkey and Mexico. Secondly it must be remembered that GDP projections to 2030 and furthermore to 2050 imply important uncertainties. In particular there could well be an overestimation of how long high rates of growth can be maintained in emerging economies (Piketty 2013). The slowing down of the rate of growth of Brazil these last years could be coherent with such a prospect.

Figure 12 gives an idea of the sensitivity of future tourism to the growth of economies worldwide as seen by the UNWTO projections to 2030; it appears greater than the sensitivity to transport costs.

Figure 12. Tourism towards 2030 : global projection and sensitivity analysis

International Tourist Arrivals, million



Source:(UNWTO 2013)



Understanding Brazilian tourism

The aim of what follows is not to give a comprehensive outlook (integrating geographic, economic and sociological points of view) of Brazilian tourism, but just to highlight some elements, that we deem indispensable to understand, further in the text, the analysis on the future of Brazilian tourism and of its emissions. The sources we called upon to build such a synthetic view were limited but we hope relevant. Our work is done in France with a distant access to Brazilian sources, a poor knowledge of Portuguese. Moreover, Brazilian tourism is a rather new topic from an academic point of view and regarding the type of topic we deal with (in particular with a lack of relevant references in English-speaking academic literature). Therefore the views we develop mainly stem from discussions with French academics who have worked recently on Brazilian tourism (and from their writings (Le Brazidec 2010; Théry 2015 (to be published)) on the one hand, from the assessments of Brazilian domestic tourism made by FIPE in 2006 and 2010 (FIPE 2012), and from a field trip conducted in February 2014, in the framework of ECOPA.

Brazil is not a major destination of international tourism flows: it ranks 38th in 2012 with 5.6 million international visitors (compared to over 80 for France). Yet, we are not interested in Brazil as a destination for foreign tourists, but in the tourism of Brazilians going abroad (the same order of magnitude as international arrivals) and inside Brazil. The order of magnitude of domestic tourism is in terms of trips around 30 times that of tourism abroad, but far less in terms of emissions as our calculations with show (see Part III).

The importance of travel in the history of Brazil seems to have been rather underestimated. Yet it is quite clear that the development of tourism in Brazil lagged behind other neighboring countries notably Argentina. In the 1990s, Uruguay used to receive more international tourists than Brazil and Argentina twice as many. The explanation of this situation is said to be found in a lack of interest of the public and private sector and in the political unrest of that period (the latter seems a rather unsatisfactory explanation since political difficulties also existed elsewhere in South America).

Key figures.

- Direct contribution of tourism to Brazilian GDP in 2014: 3.5% (in 2004: 4.2%), world average: 2.9%.
- Direct contribution of tourism to employment in 2014: 3.5%.
- 95% of spending from Brazilians, 5% from international visitors. Leisure: 85.7%, business: 14.3%.

Source (WTTC 2014)

Whereas tourism is not a recent phenomenon in Brazilian society, mass tourism certainly is. The upper classes of Brazilian society (one of the most unequal in the world) have been familiar with tourism for a long time. Traditionally they have been attracted by Europe and somewhat more recently by the USA. Moreover they started reproducing in their own country, several decades ago, the models they had encountered in Europe: socially selective seaside resorts (e.g. Camboriu, Ilha Grande...) or destinations in the hills (Gramado) (Le Brazidec 2010). Such prestige destinations still exist and others have appeared (e.g. Fernando de Noronha) following the extension of the richer segments of the society (with priceless accommodation, private jets and helicopters as means of transport...).

The forms tourism takes in Brazil, just as in richer countries, is partly driven by social status. The social groups just below try to imitate the forerunners: being seen in some places is highly



valued and this leads to the upsoar of second homes in some seaside resorts. A small portion of a highly inegalitarian population reaching 200 million is quite enough to generate massive flows of tourists to some destinations. This massification follows a similar track to what has been seen in Europe: seaside resorts near São Paulo look much like some of those on the Costa Brava. In one of them, sand has been brought on the beach to extend it because of the shade of buildings built too near the shore! During the long Easter weekend in 2014, two million cars headed from São Paulo to the seashore: as usual in such circumstances, the motorways were set one way, a single lane was maintained for the opposite traffic (Théry 2015 (to be published)).

This development of tourism is not accompanied by strong public policies. In the beginning of the 1990s the government of F.H. Cardoso ambitioned to define a national tourism policy. Embratur was given the task to professionalize the sector and to promote destinations (touristic poles) within the country both for domestic and international tourism (Le Brazidec 2010). From 2003, with the arrival of Lula, the role of Embratur has been redefined and its task is now to sell Brazil as a destination for international tourism. Currently the development of domestic tourism in Brazil appears to be left to the spontaneous trends of the society and to market forces.

During the presidency of Lula, the minimum salary was multiplied by 2 in 10 years time, which generated 90 million new consumers with new purchase behaviors including an increased access to car ownership, adequate for leisure and short distance tourism.

This new situation meets some strong features of Brazilian culture. Brazilians have a culture valuing free time and leisure, which is much nearer to that of European (notably Latin) countries than to that of North America or Asian countries. Leisure time is highly valued and recognized and will not be jeopardized to the benefit of overwork: Brazilians will take all the holidays they are entitled to and try to maximize the benefits of long weekends or various celebrations.

The leisure of Brazilians is largely driven by the 3S (Sun, sea and sand). This can be satisfied by leisure at home when living on the seashore (e.g. the beaches of Rio de Janeiro) and can also imply some relatively short distance tourism: 80% of the Brazilian population lives at less than 200 km from the sea.

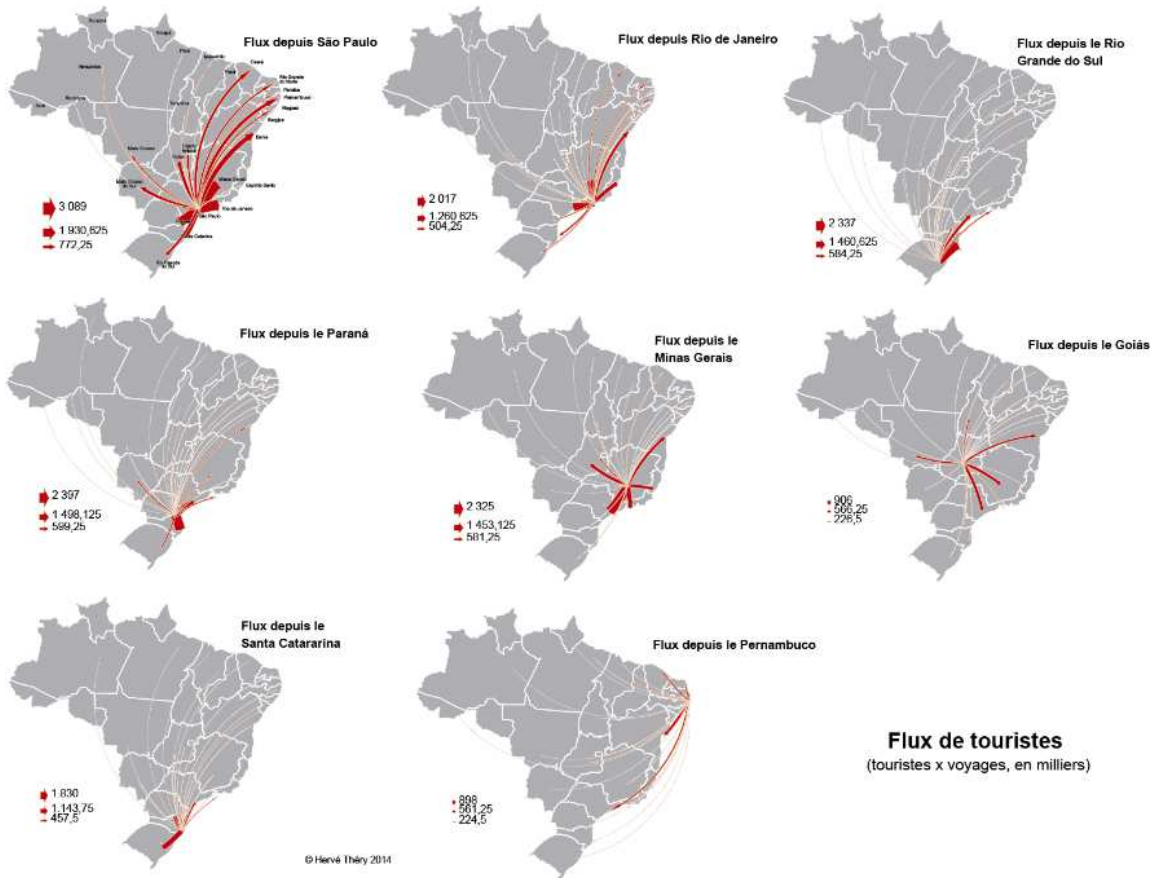
The combination of wealth with the cultural features above explains the flows of domestic tourism as shown in



Figure 13: they originate in rich states whether inland or on the seaside and essentially head towards the sea.



Figure 13. Domestic tourism flows for the main regions of origin



Source: (Théry 2015 (to be published))

The mass of new tourists do with the financial constraints they have. This partly explains that they do not go too far, however vast their country may be. They also largely use the bus even for long trips and stay often at friends and relatives. Quite differently to what has been seen in several European countries, the Brazilians do not seem to have any nostalgia of the countryside and do not intensively visit relatives who have remained in rural areas. The population is young and has no such benchmarks, besides, rural Brazil where their ancestors have been starving farm workers is not a directly appealing destination.

This means that visiting the whole of their own country (e.g. the Amazon region) is not for Brazilian tourists the first rank priority compared to, for instance, tourism abroad. Yet some pioneering efforts are made in the direction of ecotourism or farm tourism (fazendas in the South...).

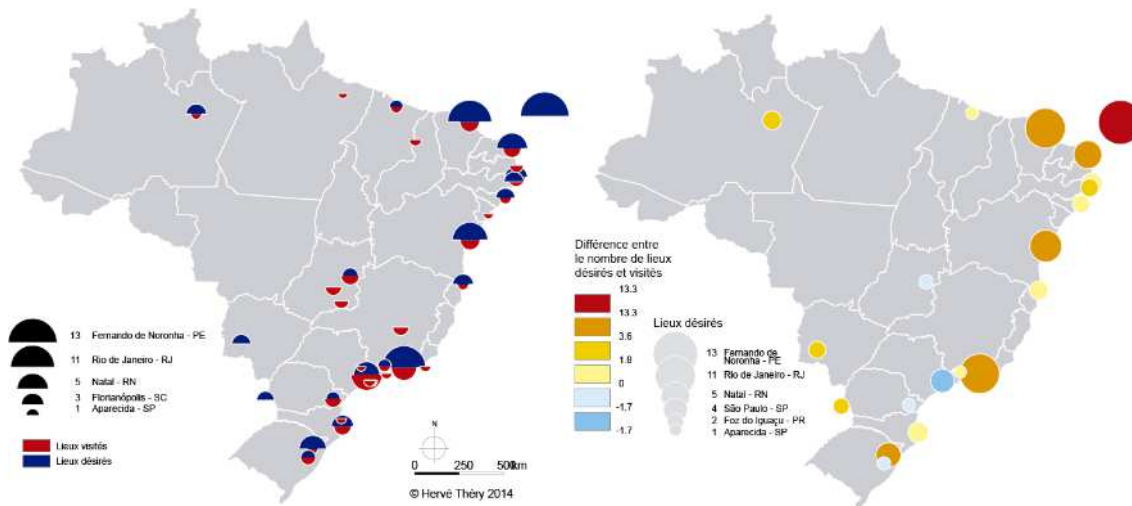
The FIPE enquiry (FIPE 2012) allows to distinguish for domestic tourism between the destinations Brazilian tourists wish to visit and those they in fact go to (see



Figure 14).



Figure 14 The destinations Brazilians wish to go to and those they visit.



Source: (Théry 2015 (to be published))

This somewhat nuances the dominant impression expressed above: there is a strong appeal for exotic destinations which have a strong image. This concerns currently places such as Fernando de Noronha and other destinations in the Northeast, probably other places tomorrow, which means there is a real potential for long-distance domestic tourism.

Regarding the international tourism of Brazilians, we have already mentioned the traditional attraction by Europe. This tourism has an important cultural content: a major part of the tourists come from southern Brazil which has been populated by European immigration (Germany, Italy, etc).



Figure 15 .

2010	
USA	1 197 870
Argentine	1 005 230
France	813 199
Uruguay	343 927
Espagne	320 491
Portugal	299 123
Italie	258 844
Chili	249 484
Allemagne	204 187
Royaume-Uni	181 354
Paraguay	143 667
Mexique	109 013
Chine	80 506
Colombie	71 221
Suisse	68 808
Angola	67 881
Canada	65 007
Afrique du Sud	64 433
Bolivie	57 946
Israël	44 530
Monde	6 517 893

Source: World Bank.

There are different segments in this flow: for instance students using self-organised rather cheap tourism and Brazilian elites with a high spending potential which explains the Brazilian tourists are on average among the nations that spend the most in European countries (see



Figure 16). The Brazilian upper class also increasingly goes to the USA, and in particular to the nearest destinations such as Miami: this tourism is motivated first by shopping, with a fascination by US shopping malls. Finally, an important flow of Brazilian tourists head for Argentina which is the second destination country of Brazilian international tourists. This is explained by relative proximity and also by cultural reasons: Argentina and notably Buenos Aires are to some extent seen as a near and less expensive substitute to Europe.



Figure 16. Daily expenditure of Foreign tourists in France according to the country of origin

	Dépense par nuitée (en euros)		Évolution 2012/2011 (en %)
	2011	2012	
Europe	59,0	59,1	0,1
Allemagne	63,9	64,0	0,3
Russie	65,3	72,7	11,4
Autres	57,8	57,6	-0,2
Amérique	65,0	79,4	22,1
États-Unis	63,1	77,5	22,9
Canada	61,6	69,7	13,2
Brésil	87,5	107,9	23,4
Asie	61,7	66,3	7,4
Chine	63,4	58,6	-7,6
Japon	70,0	84,3	20,4
Inde	44,0	74,4	69,0
Océanie	66,4	89,7	35,1
Afrique	54,3	57,4	5,6
Afrique du Nord	49,6	51,6	4,0
Total	59,6	61,9	3,8

Source : EVE (Dgcis, Banque de France), résultats 2012 provisoires.

Source: (Francastel, Gonzalez et al. 2013)

On average the tourism of Brazilians has to face long distances. This is obvious for international travel, even to neighbouring countries, but also for a significant part of domestic tourism: about 30% of domestic tourists cross a regional ("state") border. Hitherto, for a large part of the population, the bus has been used to cover medium and long distances. The use of the plane is limited to a minority, for financial reasons. Increasing wealth allows the access to car transport, which is a solution for medium distances even if this is bound to face difficulties with infrastructures. The plane is also getting more affordable. The share of the bus in tourism transport is currently falling down significantly. All this seems to indicate a trend towards a focus on car transport for short and part of medium distances, leaving the rest to air transport.

Objectives of the research

Current, future and alternative tourism

The aim of this research is to contribute to fill the research gap on current and future emissions of domestic and outbound international tourism of emerging countries. Brazil is taken as a case study.

The first task is to assess the current emissions of Brazilian tourists. Here we start from scratch, no such assessment as ever been done from Brazil, and global assessments (UNWTO, UNEP et al. 2008) do not help (with the exception of accommodation). This sets quite a number of questions to be clarified and thus intermediate goals to identify the dynamics (drivers) of both tourism and emissions in various domains, such as:

For domestic tourism

- what are the shares of merchant and non-merchant tourism in Brazil?



- what share (and dynamics) of visiting friends and relatives (VFR) in Brazilian tourism
- what about the development of second homes?
- What are the developing trends regarding domestic tourism? Short stays? Beach tourism etc?
- What is the social stratification and dynamics of domestic and outbound tourism in Brazil ?

Concerning outbound international tourism

- which rates of departure (trends and dynamics)?
- which motivations ?
- which destinations and what underlying logics?

Concerning transport

- what is the current modal distribution of tourism transport, how did it evolve through time, where does the specificity of Brazil lie?
- What are the emission coefficients of transport modes in Brazil?

The second step relates to future emissions

- Where do the current trends identified from Brazilian tourism lead and what are the consequences in terms of emissions ? To answer such a question, understanding the specificities of Brazilian tourism is a prerequisite (the challenge is all the more important as the authors are not Brazilian researchers). Similar work previously done in other geographic contexts suggest as a working hypothesis that the outcome will be found to be unsustainable i.e; not compatible with the country's pledge to reduce its GHG emissions under the UNFCCC.
- We also want to check whether the path the tourism of Brazilians tends to follow is similar to that which has been taken by higher income countries such as France. Alternatively, do Brazilian economic, cultural, geographical features divert from such similarity, and to what extent? The underlying question is whether the futures of tourism in "advanced" and emerging countries converge in the long term or not.

The third step is to examine alternatives :

- how can more sustainable futures be imagined ?

how could tourism contribute to the mitigation efforts necessary to maintain climate change within manageable boundaries. What modifications in drivers and trends does this imply? What are the levers that can be used to achieve this goal?

Limits

Yet it must be noted that the research will not deal with the barriers and obstacles the policy orientations above could be confronted with.

As interesting as such an exercise can be, it remains that a case study on Brazil shows some limits in contributing to the assessment of current and future emissions from emerging countries.

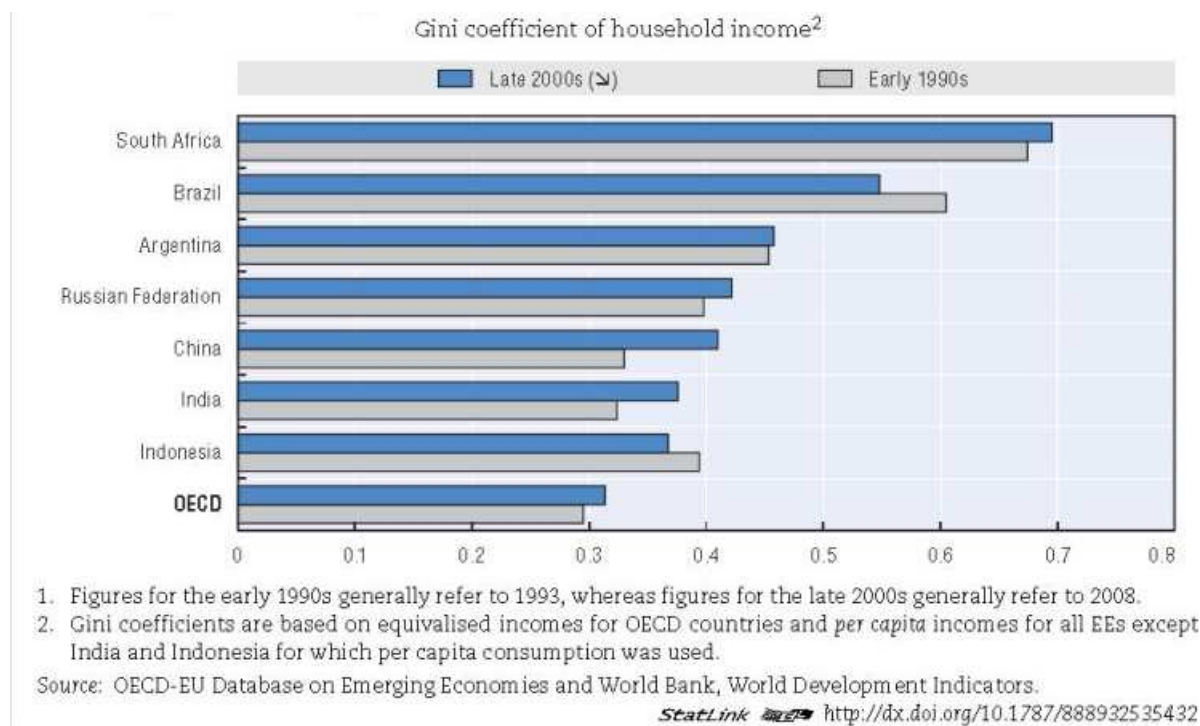
In terms of population and GDP, Brazil is not as important as China or India, whose tourism should have larger impacts. Brazil is a "second rank" emerging country with Mexico, Indonesia... Yet it is well worth studying.



It shares with most emerging countries the fact of having a large territory, implying travel on long domestic distances: the size of Brazil is comparable to Europe.

Brazil shows like other emerging countries a very high degree of income inequalities. Income inequalities are larger in emerging countries than on average in OECD (even the most inegalitarian OECD countries, e.g. the USA are significantly more equalitarian than emerging countries). Brazil ranks second after South Africa in Figure 17. In terms of dynamics it is yet one of the two (with Indonesia) where income inequalities diminished over the last decades; note that trend is completely opposite in India and China.

Figure 17 . Change in inequality levels, early 1990s revenues versus late 2000s



Source: (OECD 2011)

Emerging countries exhibit very large differences in culture, leisure and lifestyles, which influence the place tourism takes and will take in their societies. The attitudes towards work, free time and leisure are particularly important. Brazil possesses strong specificities: Brazilians do not seem ready to sacrifice values of free time or leisure to comply with the ideal of a competitive neo-liberal society, which seems to be less the case in some emerging societies in Southeast Asia e.g. Korea. Leisure on the beach, festive events are not clichés and they contribute to some extent to social inclusiveness.

For all these reasons, it will be impossible to generalize the conclusions of such a study to emerging countries as a whole. We will still need to work specifically on each of these countries (at least half a dozen of them) before general conclusions can be drawn on emerging countries.



II. Methods



We have pointed above (p.12) the various studies that previously assessed emissions on the world and country levels and for specific tourist activities, as well as scenarios exploring the future. We shall go deeper into the results of some of those in parts III and IV in order to situate our results for Brazil with those obtained in other geographical contexts. Here we just describe the main features of the methods previous studies have used, the problems relating to methods and sources they have encountered, and how they have dealt with them. This is meant to feed and justify the methods we apply and which we describe in detail in parts III and IV for the calculation of current emissions and for future scenarios.

Overall methodological framework

Tourism related emissions: two different approaches

The assessment of greenhouse gas emissions from a country's tourism, and their attribution in national inventories², depend on the boundaries of the exercise. Two options can be considered:

- the first amounts to calculating the emissions of the residents of the country (foreigners living in the country or foreign tourists emitting greenhouse gases during their stay may be added to the nationals). With that option the scope is the emissions of domestic tourism plus those from outbound tourism of residents;
- the second option considers the emissions of domestic tourism plus a share of the emissions of the residents going abroad as well as part of the emissions from the international travel of foreign tourists. The idea underpinning this approach is that the emitting and the receiving countries share the benefits from tourism and thus the responsibility of its emissions. Their respective shares can be of course discussed, usually an equal share is retained for both countries (for a discussion on this point see: (Ceron and Dubois 2006)).

The results of both approaches can significantly differ when the outbound and inbound flows of international tourists are unbalanced. The number of residents going abroad is much less than international tourists arrivals for countries such as Seychelles or even France; conversely North European countries such as Sweden emit far more tourists than they receive. Regarding this issue Brazil seems in a rather balanced situation (see part III).

Each approach has its interest. The second one gives a fair view of the responsibilities and could be used in international negotiations, should there be some including this topic. The first one focuses on the national dynamics of tourism, and in particular on domestic consumption patterns, which is more in line with the goal of our study.

Both approaches are useful when thinking in terms of allocating a carbon budget for the future. In terms of national policies and scenarios, which are further step in this work, the first approach seems more convenient. Actions on some components of lifestyles, transport or tourism policies are Brazilian responsibilities. It is the responsibility of each country to manage its citizens' tourism, the more as the majority of the drivers of emissions are related to domains on which public authorities and civil society have a strong influence. Conversely, taking into account incoming international tourists implies making hypotheses on variables largely out of reach for Brazilian policies (e.g. the dynamics of tourism in foreign countries, the future of passenger air transport). Furthermore it renders more complex the exercise.

² In the current UNFCCC framework, emissions for international transport (air and maritime), are accounted separately, as international bunkers fuels, and not attributed to national budgets. As such, they are not subject to emissions caps, even if attempts were made in that direction, such as the inclusion of international aviation in the European tradable permits system (EUTS), abandoned following pressures of countries like China, India or the US.



At first glance, a fairly simple calculation method...

Emissions from tourism can be sorted into:

- the emissions of transport from origin to destination,
- the emissions from accommodation,
- the rest, which includes the emissions from other tourism-related activities and emissions from on-site transport.

This partition is the one used in the UNWTO report for the Second Conference on Tourism and Climate Change in Davos, Switzerland, in 2007 (UNWTO, UNEP et al. 2008). Its relevance lies in the facts that the greater part of emissions is due to origin to destination transport (see part I), that the emissions from accommodation can be more or less conveniently derived from the data on building and housing, and that the rest comprises heterogeneous sources of emissions for which it is only possible to find anecdotic data.

Regarding transport from the origin to destination, which is the core of this work the calculation scheme is:

$$\text{Emissions} = (\text{number of trips}) \times (\text{distances}) \times (\text{modal share}) \times (\text{emission factors of transport})$$

...with tricky issues behind it

Tourism: a social phenomenon, not a sector...

Tourism is not a "sector" like steel-making or construction. In fact it is never identified as such in national accounts, which is quite normal since its activity comprises contributions from numerous sectors: transportation, construction, services etc. This implies that constructing statistics from a top-down approach the tourism is not an easy task since this demands knowing the part tourism takes in each activity it comprises : e.g. how to divide the activity of catering between tourism and eating-out for leisure or work purposes? Nevertheless, satellite accounts for tourism exist and the data they yield can occasionally be helpful for calculation and to build hypotheses for scenarios (Ceron and Dubois 2009).

The definition of tourism: inadequate to our purpose?

Tourism is defined by UNWTO as "*a social, cultural and economic phenomenon which entails the movement of people to countries or places outside their usual environment for personal or business/professional purposes. These people are called visitors (which may be either tourists or excursionists; residents or non-residents)...*"³. This marks an evolution from the previous understanding (before 2007) which excluded from tourism those who could not spend at least one night away from home. Tourism is now defined as a phenomenon which includes both tourists and excursionists...

Since we are interested in this research with the emissions from tourist trips (whatever their duration, providing they exceed vicinity) this definition is more convenient than the previous one. We yet have to be sure that the data match the definition (see below).

As stated in the definition, tourism refers to trips both for personal and professional motives. The profiles, drivers and dynamics of these two categories can differ, though more than occasionally, professional and personal motives overlap (Hoyer and Noess 2001). Since our interest focuses on personal motives (the uses of free time, leisure, visiting friends and relatives etc.) we can face difficulties with data that do not always separate business and personal motivations (see below). It should be noted that business tourism currently represents slightly more than 15 % of the total of international tourism (UNWTO 2013).

³ <http://media.unwto.org/en/content/understanding-tourism-basic-glossary>



"There are three basic forms of tourism: *domestic tourism*, *inbound tourism*, and *outbound tourism*. *International tourism* comprises *inbound tourism* plus *outbound tourism*"⁴. International tourism simply implies crossing of a border. As it has been pointed out, this category is rather inadequate for a research exercise mainly concerned with distances and does not facilitate the comparison between countries of various sizes.

Data and sources

An important body of literature analyses the drivers of tourism (considered as a social practice or an economic activity) in Western affluent societies, e.g. (Corbin 1995; Urry 1995; Commissariat général au Plan 1998). French academic studies in that field, though highly interesting have the particularity of not being available in English e.g. (Urbain 2002; Viard 2002). Less literature is available for emerging economies, notably on the drivers of domestic tourism which is just starting to appear (Taunay and Violier 2011). International tourism towards these countries has been more studied e.g. (Cazes 1992; UNWTO 2004)

The main source of data lies in surveys and statistics specifically aiming at building some knowledge of tourism; e.g. surveys on destinations or accommodation: where do tourists go? In what type of accommodation do they stay? For how long? Etc. Additionally, some data can be drawn from surveys on other activities, such as transport surveys: e.g. passenger transport according to motivations etc.

The data sources that can be called upon are quite diverse in scope and quality.

The UNWTO has been providing data on International tourism for several decades. It has just started these last years to provide data on domestic tourism, which probably should be handled cautiously. This is quite a problem since domestic tourism is, in terms of trips, far more important than international tourism, and is expected to develop quite fast in some emerging economies. Moreover, these categories (international and domestic) are not really adapted for the assessment of emissions and their future: a trip from Luxembourg to Paris is considered as international, whereas one from New York to Los Angeles is domestic (see above).

Some rather satisfactory databases can be used at the regional level (e.g. in Europe), but the most detailed and sophisticated databases are to be found at the country level (e.g. for France, the Netherlands etc). Such databases are basically devoted to the monitoring of the activity, yet when associated to distances and emission coefficients they can allow to unpack tourism and its different segments regarding emissions (Ceron and Dubois 2009; Dubois and Ceron 2009).

The data sources and the problems they pose differ according to the issues tackled, to each source of emissions (transport, accommodation, others) and to the drivers of the emissions (e.g. distances, number of trips etc).

The main source used for this study was the Brazilian national survey on domestic tourism (FIPE 2012), published by the ministry of tourism based on data for 2010 and 2011, and implemented by the "Fundação Instituto de Pesquisas Econômicas- FIPE":

- Only urban (or near-urban) households were investigated.
- The population was stratified in 57 geographic groups, based on the 2000 demographic census. 37000 households were investigated;
- The revenues classes were defined with reference to the minimum salary : 0 to 4 MS, 4 to 15, 15+.

⁴ <http://media.unwto.org/en/content/understanding-tourism-basic-glossary>



What metrics for emissions ?

The question of the metrics to be used for the emissions of tourism is a quite specific issue, owing to the important share of emissions related to aviation.

In the atmosphere, CO₂ is the most important greenhouse gas but not the only one: CH₄, NO_x etc. need also to be considered. For these gases which remain for a long time in the atmosphere, a CO₂ equivalent can be calculated. The warming potential of each gas can be determined relatedly to CO₂ over a defined period: usually a 100 years is retained (GWP100). A CO₂ equivalent can only be calculated for gases persisting over 10 years (Shine, Berntsen T. K. et al. 2005).

Aviation is specific in that it produces water vapor at high altitudes, which is source of linear contrails and induced cirrus-clouds. These emissions are short lived, local as they do not mix well in the atmosphere and have an impact on climate change whose importance cannot be neglected but which is not well-known in the absence of physical process models and adequate observational data for aviation-induced cirrus effects.

Taking into account this type of effect calls for the use of an alternative metric: radiative forcing which is defined as *“the net change in the energy balance of the Earth system due to some imposed perturbation. It is usually expressed in watts per square meter averaged over a particular period of time and quantifies the energy imbalance that occurs when the imposed change takes place”*⁵.

“Total aviation RF (excluding induced cirrus) in 2005 was ~55 mW m⁻² (23-87 mW m⁻², 90% likelihood range), which was 3.5% (range 1.3-10%, 90% likelihood range) of total anthropogenic forcing. Including estimates for aviation-induced cirrus RF increases the total aviation RF in 2005 to 78 mW m⁻² (38-139 mW m⁻², 90% likelihood range), which represents 4.9% of total anthropogenic forcing (2-14%, 90% likelihood range)” (Lee, Fahey et al. 2009). This assessment illustrates both the difference between CO₂ only and radiative forcing: a ratio of 1 to 2 approximately, and points the high range of uncertainty concerning radiative forcing.

The radiative forcing index *“is the ratio of all radiative forcing caused by aviation since 1945 and the radiative forcing caused by CO₂ emissions from aviation over the same period. The RFI can however only be applied to calculate accumulated radiative forcing, and not for emissions occurring in any single year”* (UNWTO, UNEP et al. 2008).

The Davos report (UNWTO, UNEP et al. 2008) stated that *“In 2000, the radiative forcing caused by non-carbon emissions from aviation was estimated to be almost equal to the accumulated warming effect of all aviation-related CO₂ emissions since 1945, i.e., corresponding to an RFI of 1.9. i However, there is considerable uncertainty regarding the impact of contrail-induced cirrus clouds, and 1.9 may be seen as the confirmed minimum, with a possible RFI of up to 5.1”*. The same report rightly points that *“the RFI is not a constant, as it develops over time as a function of the growth rate of aviation-related CO₂ emissions in comparison to the overall RF - i.e., the development of emissions in other sectors. The future RF is thus dependent upon the development of aviation as well as development in other sectors. A RFI can thus not be used as an ‘uplift’ factor for CO₂ emissions”*.

Abiding by the scientifically correct position above should not lead to assimilate in assessments the impact of aviation to its expression in terms of CO₂ only or CO₂ equivalent, and thus minimize it quite significantly. This is exactly what aviation and tourism dominant lobbies wish; they claim aviation represents only around 2.5% of world CO₂ emissions, suggesting that the proportion of the total impact on climate change is identical (see for example the calculators air companies propose). In such a context, we believe it makes sense to use the RFI as an uplift factor. Quite roughly, this increases the emissions from tourism by some 50% and those of

⁵ https://www.ipcc.ch/pdf/assessment-report/ar5/wg1/WG1AR5_Chapter08_FINAL.pdf



aviation by a factor of 2 (which is a rather conservative choice). This locates the responsibilities for emissions where they really are, enhancing those of long distance travel.

Yet, we have to compare in a reasonable way the emissions we obtain for tourism to the total emissions of the country. Such official assessments are given in terms of CO₂ or CO₂ equivalent. If we use an uplift factor for aviation, uplift factors for other activities should be also used. Yet it appears that these factors are considerably inferior to that of aviation and do not significantly change the emissions of the other sectors. Thus it can be maintained that the assessment of tourism using an uplift factor gives a better idea of its importance than CO₂ or CO₂ equivalent.

For all these reasons in the assessments, we express the emissions according to the three metrics: CO₂, CO₂ equivalent, CO₂ equivalent using an uplift factor. This allows both rigorous comparisons and comparisons which are not so rigorous but quite relevant.

Previous attempts to assess future emissions.

The assessment of current emissions shows a significant contribution of tourism to world emissions. The drivers and trends clearly show that they are bound to grow dramatically in the future decades. These basic findings are robust and well documented on the world level (UNWTO, UNEP et al. 2008), for countries e.g (Ceron and Dubois 2006; Ceron and Dubois 2011), and for specific components of tourism such as air transport e.g.(Bows, Anderson et al. 2009). This leads to identifying tourism both as a major problem and an important lever in the goal to mitigate emissions worldwide and maintain climate change within manageable boundaries.

In the current literature this concern is explored in two manners.

- The first type of work points to the deadlocks, discrepancies, logical impossibilities that trends of emissions from tourism lead to in the future, at world level(Gössling, Hall et al. 2010; Scott, Peeters et al. 2010), country level (Gössling and Hall 2007; Gössling and Hall 2008)... The demonstration can simply be done by focusing on the most problematic drivers regarding emissions (economic growth, cultural change, increasing use of aviation...) and facing them with mitigation goals.
- The second type of work tries to give a more integrated picture of the issue by articulating the trends and drivers (Dubois and Ceron 2005) through more or less complex models (Ceron and Dubois 2006; Dubois and Ceron 2007; Peeters 2010; Peeters and Dubois 2010). This type of exercise can be qualified as bottom-up and as an engineer type of modeling as opposed to an economic type of modeling which in similar domains is rather top-down and would ideally attempt to integrate tourism into a general equilibrium of the economy. This is not the case for the modelling on tourism done up to now, even if the models take into account macroeconomic variables such as GDP etc.

This second type of work can either be done in a forecasting perspective, projecting trends into the future or in backcasting perspective, or both. Forecasting directly shows the unsustainability of current trends, which is also a demonstration can be made through the first type of work above. During the last decade, this demonstration has been done a high number of times and this point is no longer a stake for research, except for countries where no such work has been done (e.g. emerging countries). Backcasting sets a goal (i.e. a contribution of tourism to mitigation objectives) and explores the means to reach it.

The basic way for forecasting emissions is to consider the correlation with GDP of the volume of tourism (this is the case with the UNWTO projections to 2030 (UNWTO 2013), and to apply some evolution of emission coefficients. This scheme can work both in economic top-down



models (providing they can identify and isolate tourism) as well as in bottom-up engineering models.

Such an approach can be refined in several ways.

First by associating income classes and their evolution to GDP; tourism is of course quite sensitive to income levels...

Secondly, other easy to quantify variables can also be introduced e.g. population, modal shift... Bottom-up engineering models will easily accept changes in coefficients, commonly some evolution in percentages (Peeters and Dubois 2010), leading to exponential phenomena with in some cases a capping of their evolution.

Thirdly, qualitative variables can also be introduced into the exercise (Dubois and Ceron 2005). They allow to elaborate richer storylines. Despite their qualitative nature, they can frequently be taken into account in the model, being represented by some quantitative indicators. For the articulation of qualitative and quantitative features into scenario building for tourism see (Dubois and Ceron 2007; Dubois 2012).

Modeling Brazilian tourism demand

In order to calculate GHG emissions from tourism and to project them in the future, we built an *ad hoc* model. This model is therefore adapted to the availability of the data supply on domestic tourism.

The rationale of GHG calculation and projections are as follow (see also Figure 18)

1. Hypotheses on growth and demography in the future enable to calculate

- a total number of trips in 2030 and 2050 by distance class (intra-state, intra-state, international), using a number of trips/ GDP elasticity
- they also permit to dispatch Brazilians amongst social classes (0-4, 4-15, 15+ minimum salary of 2010)
- therefore, assuming that social classes with the same revenue keep the same travel behavior in the future, to propose a breakdown of trips per class of income.

2. The evolution of trips in 2030 and 2050 are also corrected with the evolution of a) the number of households, b) the average length of trips (within a total number of overnight stays that remains constant: when the length of trips increases, the number of trips decreases)

3. Calculations are then made as follow: "raw data" spreadsheets recuperate the results of evolution of trips from "hypo trips, length and distance". Then the results for trips and distances are dispatched across Brazilian states.

4. The results of this unpacking process are converted in CO₂-e in all the "calcul" spreadsheets : INTRA within each State , INTER between different States, International for travel abroad. These spreadsheets take into account all the hypotheses for emission factors and modal share.

5. Furthermore, we add the results obtained for emissions from accommodation ("Hypo residential")

6. The results spreadsheets ("Results table" / "Results") propose aggregated and detailed results, for control and comment, and a set of pre-determined graphs allowing a better inter-scenarios comparison.

7. A graphic interface ("hypothesis") facilitates the parameterization of the model. It gathers all settable parameters in a single spreadsheet (see box), and therefore helps building scenarios.



Parameters of the model

Demography

- Population
- Urban population rate
- Persons per household

Economy

- Economic growth
- Breakdown of economic classes

Tourism growth

- Share of economic classes in international trips (2010)
- Share of economic classes in domestic trips (2010)
- Number of tourism trips elasticity to GDP (inner state, intra states, international)
- Length of stays (and their effects on number of trips)

Emissions of accommodation and stay

- GHG Emissions by domestic night
- Annual rate of improvement of GHG emissions per domestic night (%)
- GHG Emissions by international night
- Annual rate of improvement of GHG emissions per international night (%)

Travel

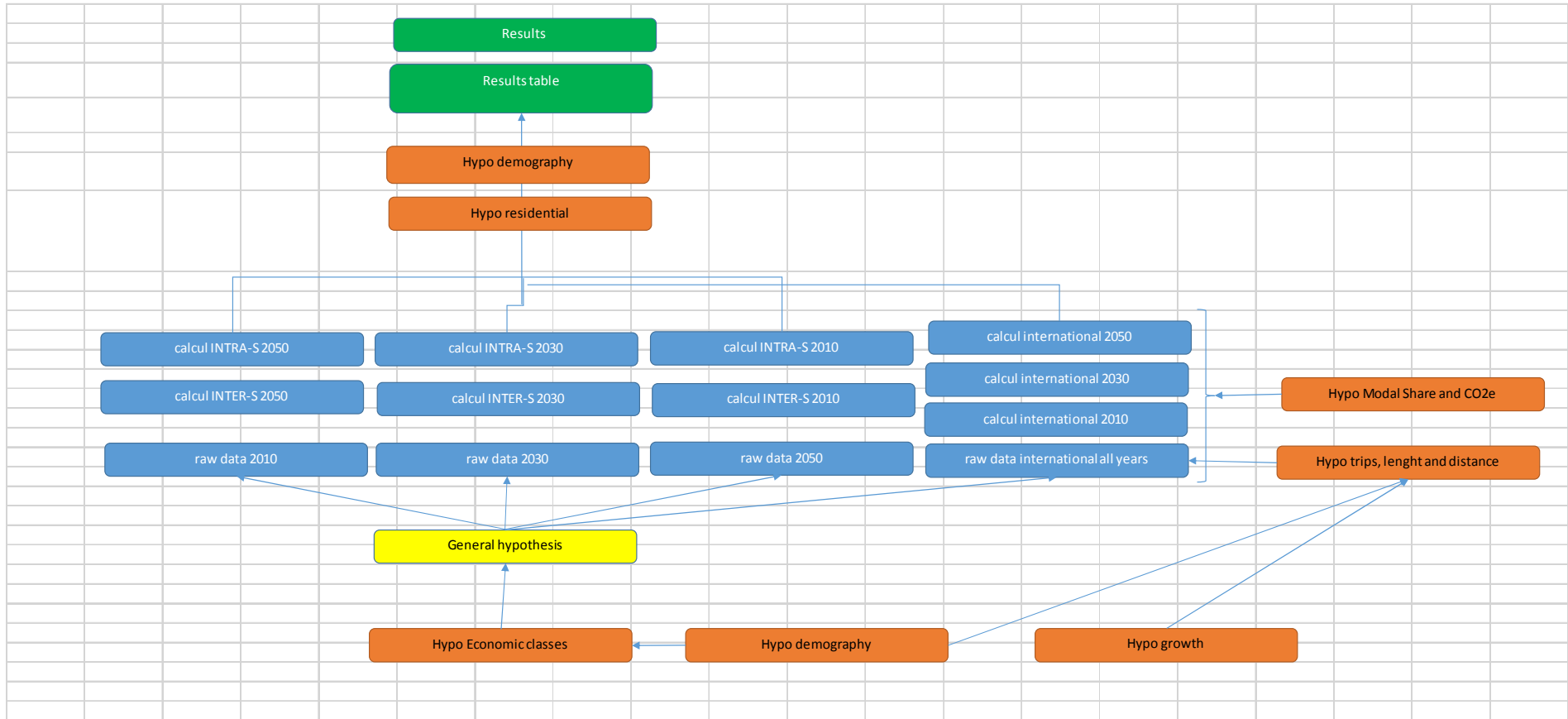
- Modal share (auto, bus, plane), by distance class (<200, 200-500, 500-1000, > 1000)
- Modal share for some selected international destinations (neighboring countries, rest of South America...)

Emission factors

- CO2 emissions of plane (short and long distance)
- Uplift "RFI" factor for non CO2 emissions
- Detour coefficient
- Energy gains in plane per year
- GHG emissions of train
- Energy gains in plane per year
- GHG emissions of car and coach per fuel (Gasolina, Etanol, GNV, Diesel, Biodiesel)
- Substitution of Gasolina to Etanol
- Substitution of Diesel to Biodiesel



Figure 18 : Model structure



The tourism case study and the ECOPA project

Our work is inserted in a larger research called ECOPA. This research involves several teams both in France and in Brazil and several research blocks dealing with the general economy of both countries as well as several in-depth studies, including ours, on tourism.

ECOPA aims at examining how flexible the link between income per capita and consumption patterns is; and at drawing implications of these findings for future emissions scenarios. To do so, ECOPA maps and compares consumption patterns, and their evolution, in France, an “old” industrialized economy, and Brazil, a rapidly emerging economy. In both countries, a combination of econometric analysis of consumption data, household surveys and in-depth studies of representative goods and services is used to (i) map consumption patterns across income groups, and (ii) explore the determinants of their changes over time. Strong emphasis is put on obtaining consistent monetary and physical flows. This is necessary to analyze the energy and emissions implications of consumption patterns, but this constitutes a significant theoretical and empirical stumbling block. Finally, on the basis of the retrospective analysis, scenarios of how household consumption patterns in the two countries might evolve are built and their implications for energy and GHG emissions are computed.

Comparing Brazil and France is relevant. Aggregate GDP in the two countries have followed a quasi-identical path since 1950 with Brazil now slightly ahead at 2.29 T\$ (PPP) in 2011 against 2.22 T\$ for France (IMF, 2012). Though capita GDP remains three times lower in Brazil than in France, as population in Brazil is three times higher than in France (35,156\$ PPP against 11,769\$ PPP), high income inequality means that some groups in Brazil live with revenues similar to those of the highest income brackets in France. In addition, Brazil has a large middle class whose revenue is growing rapidly. Brazil and France are also two large, diversified economies. The major difference is geography: being 17 times larger than France, average population density in Brazil is much lower than in France, with implications for the location, transportation, and access to services, notably energy.

The scientific value-added of ECOPA is threefold. First, ECOPA will produce consistent monetary and physical datasets; both for household consumption, and for intermediary consumption (input-output matrix). To do so, monetary data on consumption will be reconciled with various physical flow data stemming from sectorial surveys (e.g., households housing survey, households transportation survey, etc.). This is a major improvement to existing literature as aggregate consumption so far is mostly studied through monetary data only. Yet physical flows are necessary to compute energy and emissions. However, analysis of aggregate consumption data is likely to be insufficient by itself to meet the project objectives. This is both an empirical and a theoretical issue. Empirically, data scarcity, in Brazil but also in France, will hamper the project’s ability break down consumption data at a sufficiently fine resolution. In addition, even with unlimited data availability (a situation we are clearly not in), econometric analysis can only highlight trends, and point to correlation and causation. Given the complexity of household decisions, interpreting these trends, and highlighting key drivers of changes in consumption patterns, requires additional knowledge. This is why ECOPA combines econometric analysis of comprehensive consumption data with in-depth qualitative studies: both detailed household surveys to understand overall consumption decisions, and detailed studies of consumption patterns for specific goods and services, one “luxury” (tourism) and one “basic” (electricity for building).

The second value-added of ECOPA is thus to combine comprehensive, data-intensive analysis of consumption patterns with in-depth case studies. A major challenge for the project is for these three tracks to yield an integrated result. This is addressed in two ways. First, the organization and management of the project is organized to maximize exchanges and synergies. But the most important point to ensure integration is the construction of forward-looking scenarios where quantitative trends and qualitative observations can be merged into a set of plausible visions of the future. In other words, consistent with CIRED long-standing research tradition, scenario-

building is conceived as the place where the dialogue between economics and social sciences can be most fruitful. This approach is also quite coherent with that the team working on tourism has applied to its previous works on scenarios for tourism in France. The challenge the research project faces is how sectorial results obtained for example in tourism will be able to feed the wider national work.

The third value-added of ECOPA is precisely related to scenarios. Questioning the assumption of convergence of development patterns and lifestyles is extremely important. The energy scenarios have so far been based on the convergence of development patterns and lifestyles. Questioning this strong assumption requires a better understanding of the internal dynamics of regions or countries, the identification of similarities and differences in consumption patterns which constitute strong drivers of development paths. This is a key issue for both the reliability of energy and environmental prospective model and for the efficiency of public policies required to guide mutations towards sustainable development pathways.

The reduction of greenhouse gas emission of consumption patterns depends both on the improvement of energy efficiency (a well-known issue) and on the change of lifestyles in themselves (floor space per capita, level of mobility, diet, etc...). The relative potential of these two types of actions must be assessed. The definition of the population's "needs" varies according to the levels of development, living standards, cultural norms, etc... The potentials of change in consumption patterns are also constrained by the urban environment and rural infrastructure (housing, transportation), good distribution networks, social norms, cultural preferences, advertising and media, etc. Similarly, social inequalities shape lifestyles. The GHG footprint of lifestyles related to the income level has been little addressed so far. Consumption is often seen as a mean of integration in a social group. The project explores the drivers of consumption patterns for the various social groups, especially for the most energy-intensive good and services, and provide insights on whether mimetic behaviors with higher social group still dominant. Disentangling these issues in the French and Brazilian context is important.



III. Current emissions of Brazilian tourism



Scope and methods

Taking into account the discussion on scope p. 39 we define the boundaries assessment of current emissions from Brazilian tourism as follows:

- we deal with the emissions of Brazilian residents, i.e. domestic plus outbound international tourism;
- we take into account the emissions of transport from origin to destination and the emissions from accommodation, whereas we exclude those from on-site transport and activities. This is due to the fact that we have no statistics on the subject and that we do not feel able to find reasonable proxies. This is a set of miscellaneous activities which is considered to represent a small part of emissions (4% according to (UNWTO, UNEP et al. 2008), see p. 12);
- the new the Brazilian statistics that are available for domestic tourism deal with the urban population of Brazil (defined as municipios over 200 000 inhabitants (FIPE 2012) p.31), i.e. almost 169M out of 200M). Apparently, the rural population (13% of the total) is considered too poor to access tourism. Within the urban population 48.5 % travelled for tourism purposes at least once in 2012 (see Figure 19);
- the statistics cover personal and professional purposes;
- Brazilian statistics distinguish within tourism, international trips, domestic trips ("viagens domesticas") and frequent trips ("rotineiras") defined as trips taken to the same destination at least 10 times in the year (FIPE 2012)p.31) We consider that the two last categories cover domestic tourism trips plus same-day trips see Figure 21.

Figure 19. Portion of the Brazilian population that travels at least once a year



Source: (FIPE 2012)

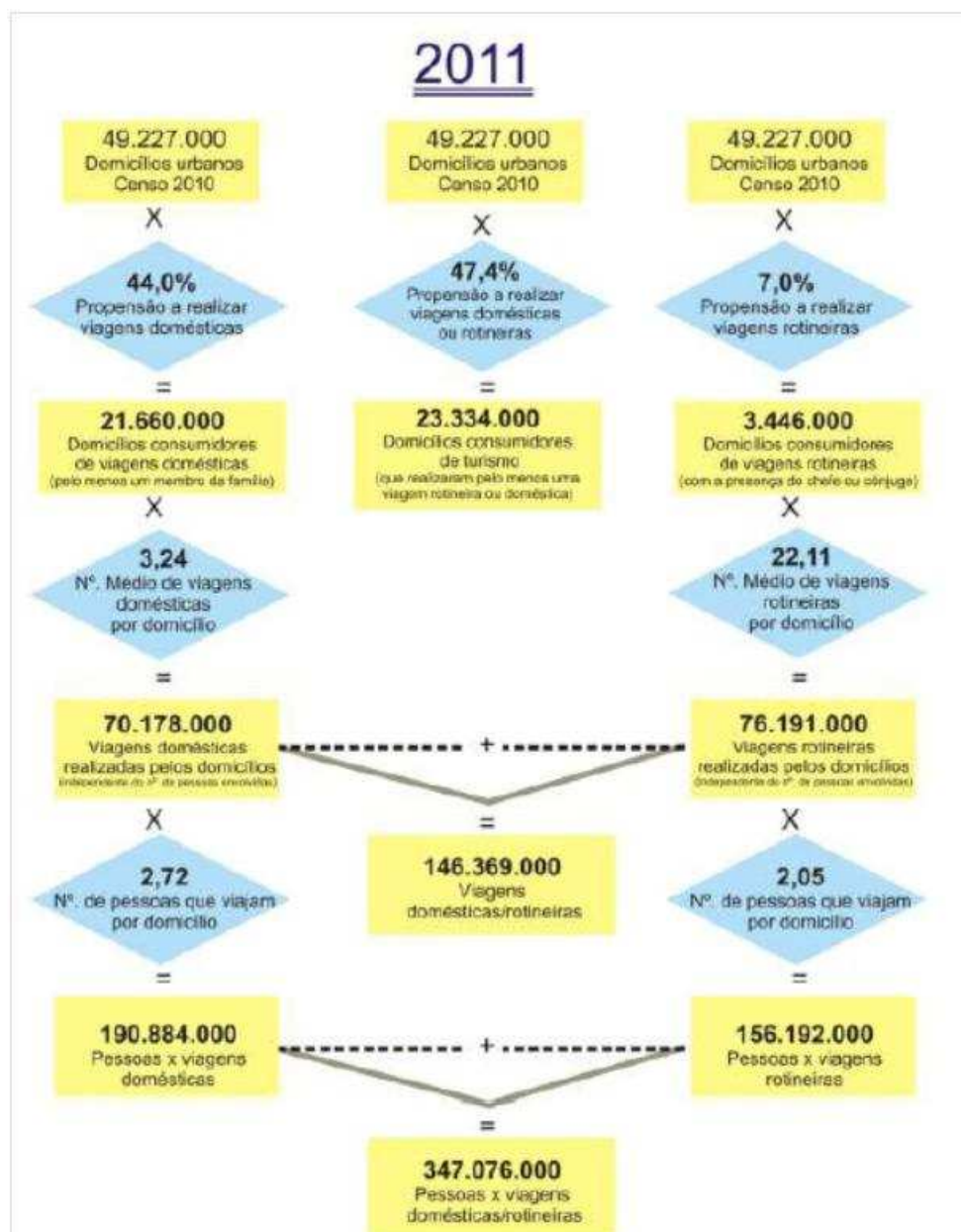


Figure 20. Type of trips for the urban population that travels

Proporção de Domicílios Urbanos com Viajantes: Tipo de Viagem e Total	
Tipo de Viagem	(%)
Doméstica	44,0
Rotineira	7,0
Internacional	4,3
Total: Realizou pelo menos 1 desses tipos de viagem	48,5

Source: (FIPE 2012)

Figure 21. Calculation of domestic trips according to FIPE



Source: (FIPE 2012)



Emissions of domestic tourism

Data sources and hypotheses

Number of trips

Recent statistics give the number of domestic trips in 2011 as shown in Figure 21. They describe the flows from state to state as well as internal to each state and concern both tourist trips and same-days trips (see explanations above); for the sake of illustration see Figure 22 for tourist trips ("viagens domesticas").

Figure 22. Domestic trips, from state to state.

Destino		Origens e Destinos dos Fluxos de Turistas das V. Domésticas, por UF (em %)																				Total									
		Destino																													
Origem	Destino	Sul			Sudeste				Nordeste							Norte					Centro-Oeste										
		PR	RS	SC	ES	MG	RJ	SP	AL	BA	CE	MA	PB	PE	PI	RN	SE	AC	AM	AP	PA	RO	RR	TO	DF	GO	MS	MT			
Origem	Sul	PR	2.5	0.2	1.1	0.0	14%	0.2	0.9	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	5.9	
		RS	0.3	4.7	1.2	0.0	0.1	0.2	0.4	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.4
		SC	0.7	0.6	2.5	0.0	0.1	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Sudeste	ES	0.0	0.0	0.0	0.6	0.2	0.3	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.6
		MG	0.1	0.1	0.1	0.5	2.8	0.9	1.5	0.0	0.6	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.3	0.7	0.0	0.0	8.0	
		RJ	0.2	0.2	0.2	0.5	1.0	4.1	1.0	0.1	0.5	0.2	0.1	0.1	0.2	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	8.6
	Nordeste	SP	1.4	0.4	0.7	0.1	1.7	1.2	12.4	0.2	0.9	0.4	0.1	0.2	0.5	0.1	0.3	0.1	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.3	0.5	0.5	0.2	22.5	
		AL	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.4	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.1	
		BA	0.0	0.0	0.0	0.1	0.1	0.2	0.3	0.1	4.0	0.1	0.0	0.0	0.2	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	5.6	
		CE	0.0	0.0	0.0	0.0	0.0	0.2	0.2	0.0	0.0	2.9	0.1	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	3.9
		MA	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.1	0.3	1.6	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.3	0.0	0.0	0.1	0.1	0.1	0.0	0.0	3.2	
		PB	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.1	0.1	0.0	1.1	0.3	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1
		PE	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.3	0.4	0.2	0.0	0.3	2.8	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8
		PI	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	0.3	0.2	0.0	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	2.1
		RN	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.2	0.0	0.2	0.1	0.0	1.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	2.3
	SE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	
	Norte	AC	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
		AM	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5
		AP	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
		PA	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	1.0	0.0	0.0	0.1	0.0	0.2	0.0	0.0	0.0	0.0	2.0
		RO	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.6	
	Centro-Oeste	RR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.4	
		TO	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.0	0.2	0.0	0.0	0.0	0.7	
		DF	0.0	0.0	0.0	0.0	0.2	0.2	0.2	0.0	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	2.1	
	Total	GO	0.1	0.0	0.1	0.0	0.3	0.1	0.3	0.1	0.3	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.4	2.4	0.1	0.2	4.9	
		MS	0.1	0.0	0.1	0.0	0.0	0.1	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.1	1.4	
		MT	0.1	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.6	1.5		
Total		5.7	6.5	6.3	1.9	6.9	8.3	19.4	1.5	7.8	5.5	2.4	2.1	4.8	2.0	2.8	1.0	0.3	1.2	0.1	2.1	0.4	0.3	0.8	1.9	4.9	1.5	1.5	100.0		

source: (FIPE 2012)

Distances

A matrix of distances corresponding to the flows described above has been built as follows.

From one state to another, the distance between capital cities has been documented in two ways

- the distance by road is taken from Google maps
- the distances by plane are direct flight distances from Google Earth. This underestimates the length of the flight: additional distances linked to landing and takeoff, flights do not necessarily follow a straight line, possibility of stopovers etc.. We took this into account by introducing a detour coefficient into the emission coefficients (see p. 55)

Regarding tourism travel inside a given state, to our knowledge no data exist, given that the origin and destinations are not known. Therefore an educated guess has been necessary, taking into account the opinions of specialists from both the tourism and transport sectors. The average figure which has been retained is 300kms one way.



Distances: France as a point of comparison.

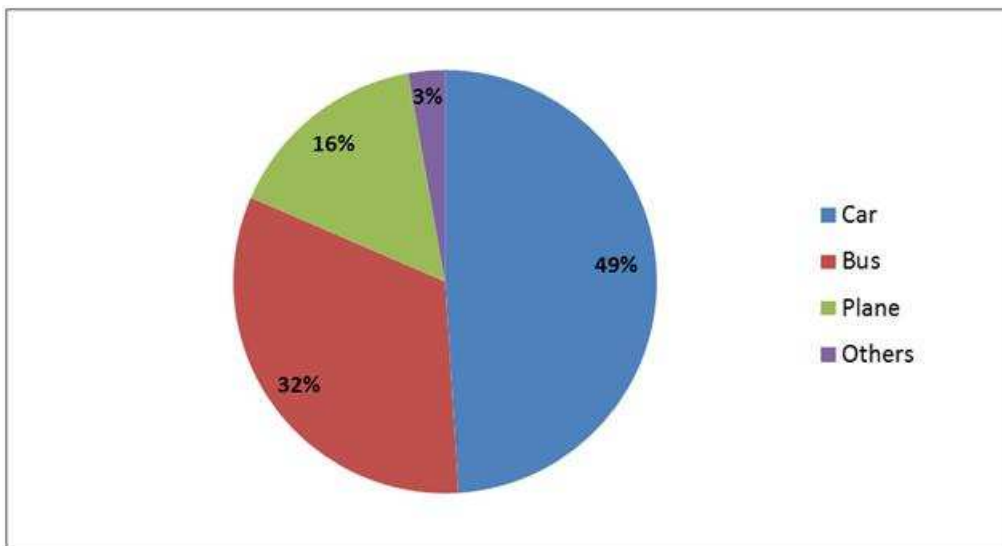
According to data in 2012, the French took 153 million domestic trips, accounting for 127 billion of km (Place 2013), which leads to an average for a return trip of 830 km, i.e. slightly more than 400 km for a one-way trip with a night spent outside the home. For leisure day trips the average distance one-way is just over 200 km (only those over 100 km from home are taken into account in those statistics).

The area of metropolitan France is 543,000 km². This is to be compared to an average area for Brazilian states of 315,000 km² which comes down to 230,000 km² if one considers only the states of Central Brazil (Goias, Minas Gerais, Espirito Santo, Rio Grande do sul, São Paulo, Parana, Santa Catharina, Rio de Janeiro)

Modal Shares

The modal shares for Brazilian domestic tourism are given by (FIPE 2012).

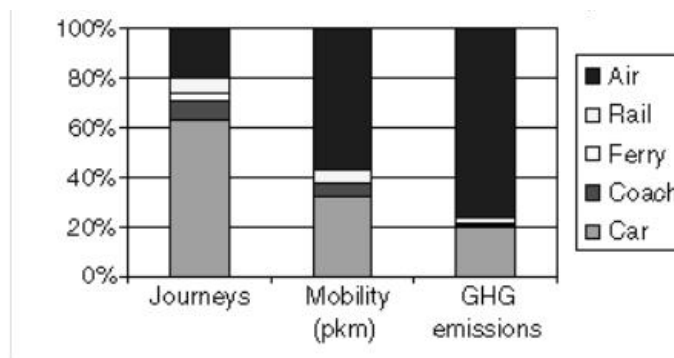
Figure 23. Modal shares (number of trips)



Source: (FIPE 2012)

This can be compared to the first column of the following diagram (Figure 24) for the European Union which additionally shows how much proportions change if passenger kilometers or emissions are considered. The most notable difference is the relative importance of bus in Brazil.

Figure 24. EU 25 outbound tourism 2000 modal split



Source: (Peeters, Szimba et al. 2007)



Modal shares of trips change with distances, but to our knowledge, no data are available for tourism. We just had to proceed through educated guesses, discussed with transport specialists and compared with international data.

Figure 25. Share of trips according to distance (one way)

Distance (km)	auto	bus	plane	Total
inner state <200	65,0%	35,0%	0,0%	100,0%
200 - 500	45,0%	40,0%	15,0%	100,0%
500-1000	40,0%	35,0%	25,0%	100,0%
>1000	35,0%	30,0%	35,0%	100,0%

This split of the modal shares according to distances is coherent with the global modal shares shown above.

France : modal shares according to distances

The modal shares for tourism according to distances (for both domestic and international tourism) are given by the table below (p.km).

one-way distance	Car	Train	Plane
100 to 250	87%	13%	
250 to 500	72.7%	24.9%	2.4%
500 to 900	57.7%	29.5%	12.8%
Over 900	11.5%	3.7%	84.8%

Source: (Place 2013) p.3

It must be noted that in France the train which is a collective ground transport currently adapted to long distances plays an equivalent role to that of long-distance buses in Brazil. This being said, the figures for France and Brazil do not appear contradictory, except for the last distance class (over 900 or 1000 km). This can possibly be explained by the fact that the Brazilian statistics concern domestic tourism whereas the French ones include international tourism, thus including a greater part of very long-distance trips which call for the plane.

Load Factors

Load factors are a crucial input to determine the emissions per passenger kilometer.

Regarding cars, in the absence of specific data concerning tourism in Brazil, a load factor of 2.5 passenger per vehicle has been retained. This is somewhat higher than the factor of 2 that has been used in past studies for Europe (Peeters, van Egmond et al. 2004) and which has been also applied in the UNWTO report (UNWTO, UNEP et al. 2008). We believe this can be justified by the fact that Brazil is an emerging economy, in which the number of cars per inhabitant is by far inferior to what is seen in older developed countries. Thus the load of cars in Brazil should be higher. The same argument applies to buses, with a chosen rate of occupancy of 90% compared to 75% in the European study.



Regarding planes the rate of occupancy is supposed not to be specific.

Generally, the load factors for the means of transport used in tourism combine data from surveys on passenger transport and a good deal of expert judgment, notably to take into account the specificity of tourism travel for which the load factor, in particular regarding cars, is superior to other travel purposes (Ceron and Dubois 2006). We believe the reliability of the figures taken from Brazil is not worse than the corresponding ones used in other contexts.

Emission coefficients

Terrestrial transport

The emission factors are directly related to the type of fuel (or the fuel mix) used. The specificity of Brazil lie is in the widespread use of biofuels for cars.

Figure 26. Blend of fuels for cars (2011)

	Gasolina A	Etanol Anidro	Etanol Hidratado	GNV
%	39%	14%	46%	1%
		60%		

Source : (Ministério do Meio Ambiente, Secretaria de Mudanças Climáticas e Qualidade Ambiental et al. 2011)

Figure 27. Blend of fuels for buses (2011)

	Diesel	Biodiesel
%	94%	6%

Source : (Ministério do Meio Ambiente, Secretaria de Mudanças Climáticas e Qualidade Ambiental et al. 2011)

To start with, we have, specifically for Brazil, the emissions of engines according to the types of fuel (Figure 28). As can be seen from the table below, the emissions from biofuels are in the same order of magnitude as those from conventional sources.

Figure 28. Emission factors

TIPO	FATOR DE EMISSÃO		
Fonte Móvel	kg CO ₂ /L	CH ₄ kg CO ₂ e/L	N ₂ O kg CO ₂ e/L
Óleo Diesel	2,681	0,0003612**	0,000022**
Biodiesel	2,499	-	-
Gasolina	2,327	0,0047**	0,0226**
Etanol	1,469	0,0003841*	-
	CO ₂ kg CO ₂ e /m ³	CH ₄ kg CO ₂ e /L	N ₂ O kg CO ₂ e /L
GNV	1,907	-	-

Fontes: Programa Brasileiro Greenhouse Gas Protocol 2010. *IPCC, 2006. **2009/2010 Guidelines to Defra's GHG Conversion Factors: Methodology Paper for Transport Emission Factors.

Source : (Ministério do Meio Ambiente, Secretaria de Mudanças Climáticas e Qualidade Ambiental et al. 2011)

This does not take into account the renewability of biofuels. From well to wheel, the emissions of ethanol are 436 kg CO₂-e m⁻³ for anhydrous and 417 kg CO₂-e m⁻³ for hydrous (Macedo, Seabra et al. 2008). We thus use the value for anhydrous ethanol for our calculations. Since we



do not have the corresponding emissions for bio diesel, we correct the value given by the first table using the same ratio as for ethanol (0.436/2.327).

So as to have comparable well to wheel figures, we add 10% to the figures in the first table for the other fuels. The results from these modifications are given in Figure 29.

Figure 29 Corrected emissions factors

Year-Model	Category	Type	kg CO2e/L	CH4kgCO2e/L	N2OkgCO2e/L	Load factor	Consumption (km/L)
2011	Vehicle	Gasolina	2,5597	0,0047	0,0226	2,5	9,4
2011	Vehicle	Etanol	0,436	0,0003841		2,5	9,4
2011	Vehicle	GNV	2,0977			2,5	12
2011	Highway bus	Diesel	2,9491	0,0003162	0,00022	42	3,03
2011	Highway bus	Biodiesel	0,742			42	3,03

Aviation

Regarding aviation, the coefficients are drawn from (Dubois and Ceron 2009).

Figure 30. Emission factors for plane.

Plane	Emission/p.km (g equiv CO2)	coeff RFI	coeff Détour	Coefficient final (g equiv CO2)	Coeff (kg)
Short distance	146,7	2	1,05	308	0,308
Long distances	110	2	1,05	231	0,231

Source: (Dubois and Ceron 2009).

They apply to economy class (for business class, the emissions are more than twice as high). So we rather underestimate the impact. We distinguish long haul (over 2000 km one-way) and short or medium haul trips. We multiply by 2 the CO2 emissions to obtain a CO2 equivalent figure, taking into account other greenhouse gases and phenomena which are specific to aviation and vastly increase its climate impact (see (Penner, Lister D.H. et al. 1999; Peeters, Gossling et al. 2006), also p.41). This factor 2 was the figure used by the French environmental agency (Ademe, see (Ceron and Dubois 2006)); it corresponds to a minimalist view of the radiating forcing of aviation. The Mustt study on Europe adopts an equivalence factor ranging from 2 (distances less than 500 km) to 2.7 (distances over 1000 km) (Peeters, van Egmond et al. 2004). We also add a small detour factor to take into account flights including stopovers.

The coefficient above gives a better idea of the importance of the impact of air transport than its CO2 emissions alone. Nevertheless, such results cannot be conveniently compared to the total national emissions, since these are not calculated using the same methodology. CO2 equivalent national calculations take into account other greenhouse gases such as CH4 or NOx, but not contrails or the contribution of aviation to the formation of cirrus. So, for the purpose of comparison, we consider a CO2 only figure also needs to be calculated. Using both figures is the most adequate way of assessing the contribution of tourism transport and climate change, see (UNWTO, UNEP et al. 2008).



Accommodation

Energy use in the different types of accommodation includes heating/cooling, cooking, illumination, cleaning, and, in tropical or arid regions, the desalination of seawater. There are a miscellaneous data sources of emissions of accommodation. They apply to various types of accommodation: "Internationally, more than 80 different accommodation categories can be identified, including hotels, hostels, motels, pensions, bed and breakfast, self-catering accommodation, bungalows, vacation homes, holiday villages, campsites and farms, to give just some examples" (UNWTO, UNEP et al. 2008).

The data also deals with different geographical and climatic contexts, which gives widespread results. This suggests to be very careful when using figures from other studies, the more as they mostly concern developed countries. No specific data on tourist accommodation are available from Brazil. We initially thought we could approach the emissions since hotels and *pousadas* are quite probably the largest sources of emissions from tourist accommodation and we have data regarding the number of bed nights taken in them. We tried to calculate the emissions from cooling which we felt could be used as a proxy. This gave results quite inferior to those that were retained in (UNWTO, UNEP et al. 2008) for developing countries, most of which have, like Brazil, warm temperature conditions.

Finally we decided to use the figures of (UNWTO, UNEP et al. 2008), that is an average of 4 kg CO₂/guest night for domestic tourists in developing countries, and 19 kg CO₂/ guest night for international tourism.

Results for domestic tourism travel

Using our model we obtain the following results for 2010.

Tourism inside States.

Tourism inside states is estimated to generate 6 millions of tons CO₂ equivalent. 82% of these originate from cars and 18% from buses (Figure 31).

Figure 31. CO₂-e by type of fuel and vehicle: intra-state travel (2010).

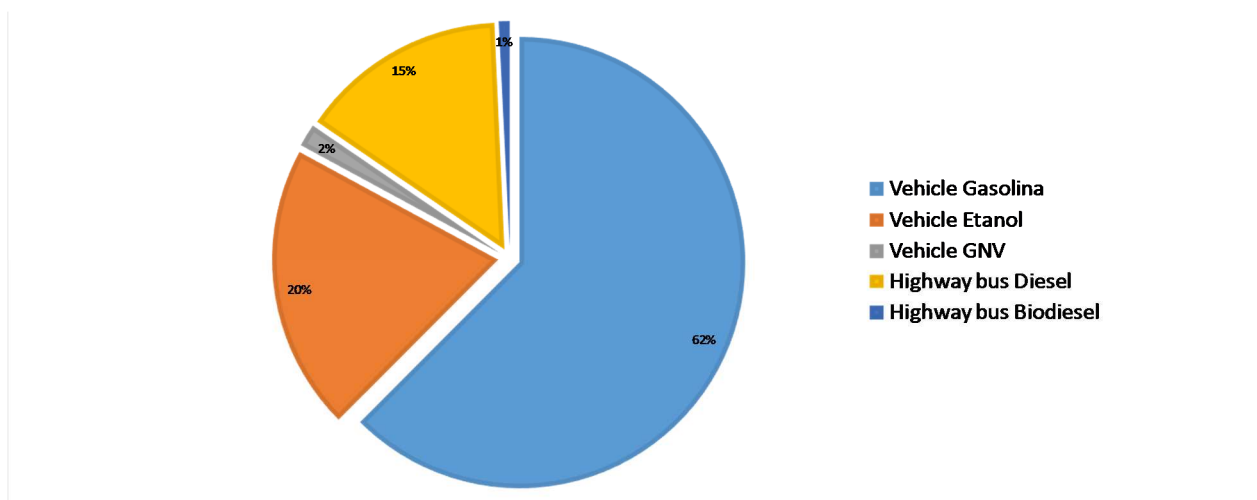
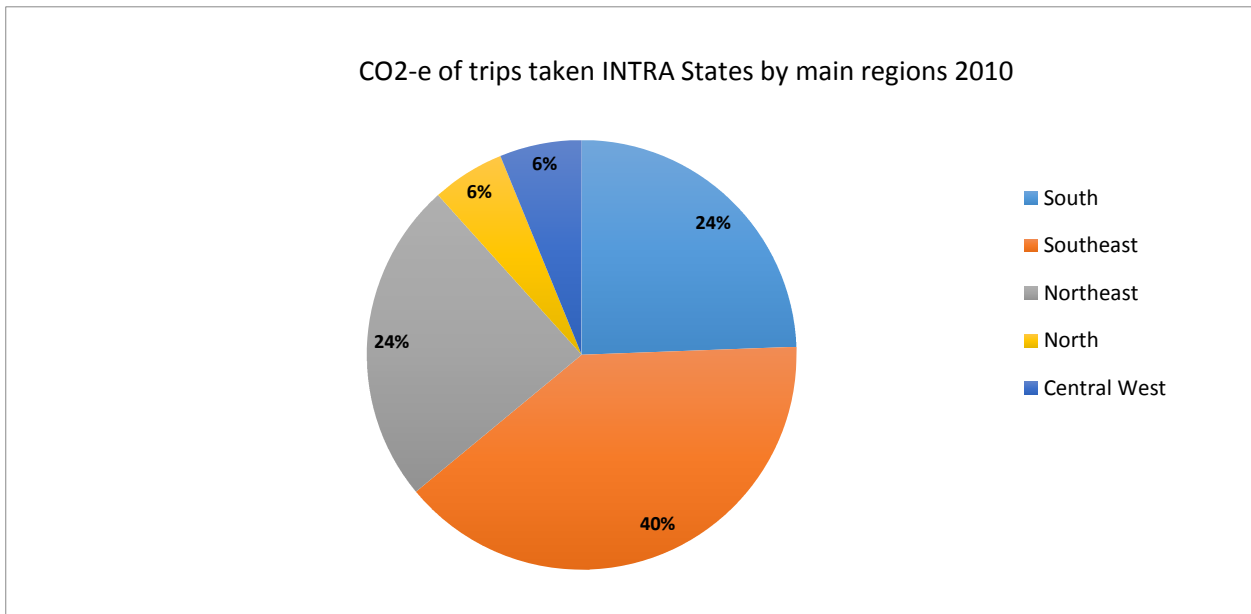


Figure 32 indicates the shares of the different regions showing an overwhelming contribution of Rio de Janeiro, São Paulo and southern states as regards the number of trips taken.

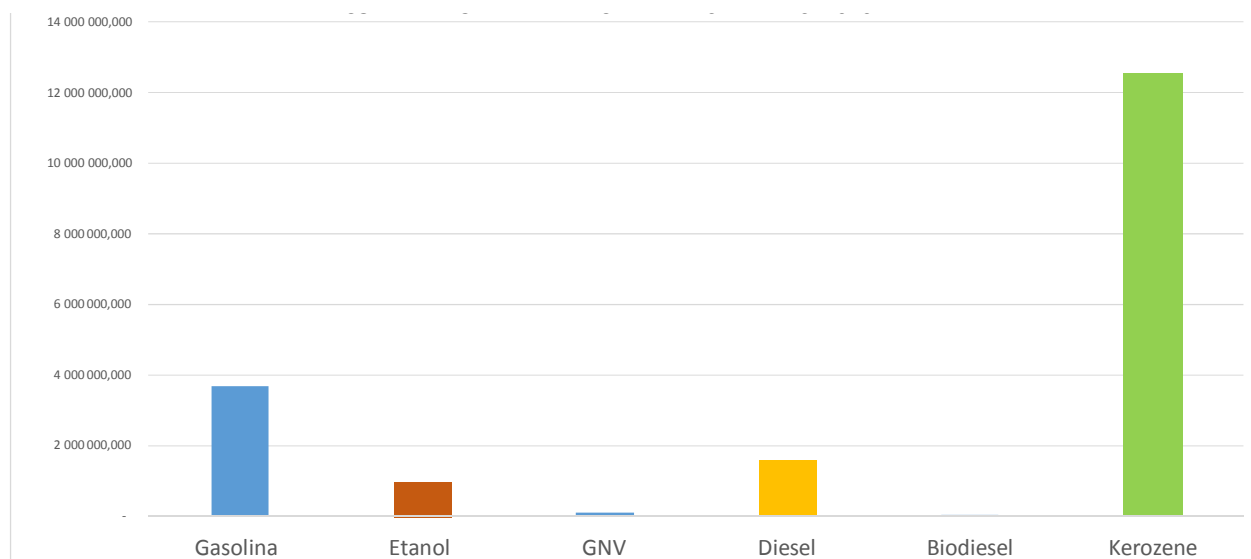
Figure 32. Share of intra-state trips by main region of origin (2010).



Tourism between States

Domestic tourism between Brazilian states is estimated to generate 18,9 millions of tons CO2 equivalent. The contribution of each mode of transport and fuel used is shown in Figure 33.

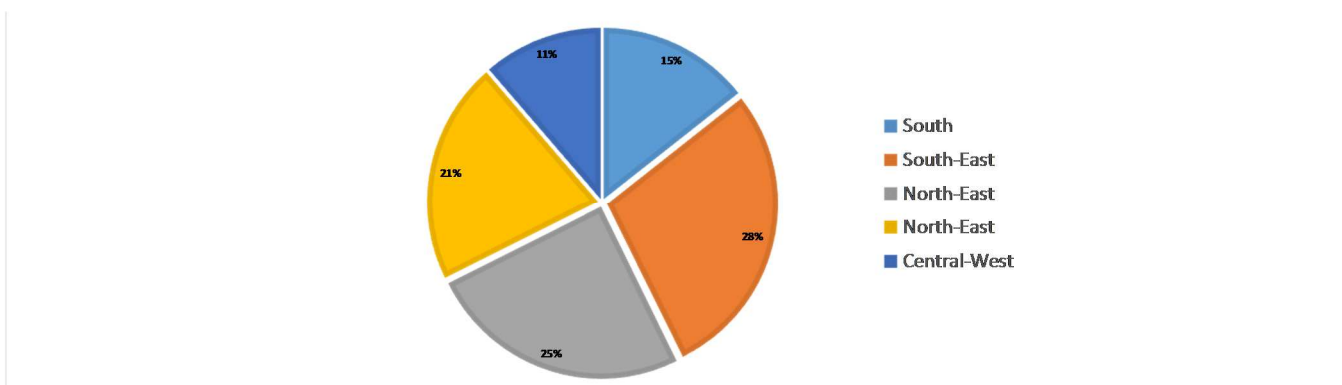
Figure 33. CO2-e by type of fuel: inter-state travel (2010).



The contribution of the different regions is more balanced than for intra state travel; peripheral regions gain in importance owing precisely to their distance to "central" Brazil.



Figure 34. Share of emissions by main region of origin. Inter-state trips (2010).



Emissions of international tourism

Data sources and hypotheses

Number of trips

Regarding the tourism of Brazilians abroad, it is difficult to find coherent and detailed data from Brazilian official sources like those found for domestic tourism (note that official data on foreigners coming to Brazil are much better). We thus surprisingly had to rely on (Ministère du tourisme du Québec 2011) which uses data from Oxford Economics for Brazil (Tourism Economics, Tourism decision metrics 2010) which we could not directly access.

Figure 35 gives figures for 2006 and 2010. They show a steep progression of Brazilians going abroad: +75% in seven years. More recent statistics show that progression has gone on: 8,119,000 tourists in 2012 (<http://data.worldbank.org/indicator/ST.INT.DPRT>). Figure 35 gives data for 19 countries which sum up to 87% of the trips taken by Brazilians abroad.

Figure 35. Main destinations of Brazilian tourists abroad

	2006	2010
USA	525 271	1 197 870
Argentine	571 736	1 005 230
France	419 494	813 199
Uruguay	228 353	343 927
Espagne	256 746	320 491
Portugal	190 000	299 123
Italie	213 059	258 844
Chili	179 348	249 484
Allemagne	156 196	204 187
Royaume-Uni	112 068	181 354



Paraguay	98 480	143 667
Mexique	31 890	109 013
Chine	47 790	80 506
Colombie	31 757	71 221
Suisse	44 668	68 808
Angola	10 589	67 881
Canada	65 169	65 007
Afrique du Sud	29 888	64 433
Bolivie	35 077	57 946
Israël	15 489	44 530
	3 263 068	5 646 721
Monde	3 734 078	6 517 893
Diff	- 471 010	- 871 172

Source: (Ministère du tourisme du Québec 2011)

Distances

Two types of distances are considered: distances by plane and by road.

By plane, we use the distances between capital cities as far as this seems reasonable. This leads to a few adjustments:

- São Paulo is taken as a proxy for all Brazil rather than Brasilia
- for the USA, we use a weighed ratio between Miami, New York and Los Angeles.

For neighbouring Latin American countries, road distances are calculated with the same origin and destination as above, using Google maps.

Figure 36. Distances by country of destination.

Country of destination	distance by plane (direct) :	distance for terrestrial travel
USA	8041	
Argentine	1694	2388
France	9944	
Uruguay	1560	1929
Espagne	8375	
Portugal	7940	
Italie	9466	
Chili	2585	3442



Allemagne	10293	
Royaume-Uni	9470	
Paraguay	1134	1339
Mexique	4615	
Chine	17571	
Colombie	4316	
Suisse	10233	
Angola	6535	
Canada	6560	
Afrique du Sud	6965	
Bolivie	2000	2083
Israël	6970	
Canada	8150	

Source: Google maps

Modal Shares

Given the difficulties encountered to find data on outbound Brazilian tourists, it is not surprising that there are no Brazilian official sources giving the shares of the modes of transport they use. We assume that for countries that have no common borders with Brazil the share of aviation is 100%. Yet, Brazilian statistics give the modes of transport foreign tourists use coming to Brazil. Our hypothesis is that the Brazilian tourists going to these countries use the means of transport in the same proportions as incoming tourists do. The statistics give four means of transport: air, terrestrial, fluvial and maritime. Fluvial and maritime transport represent a very small proportion that we neglect, except for Argentina.

Within terrestrial transport, the statistics do not distinguish between car and bus. We make the hypothesis that the relative share of each is the same as for domestic trips over 1000 km i.e. car: 35% and bus: 30%.

Figure 37 Modal shares according to destinations

	plane 2010	terrestrial 2010	Fluvial/maritime 2010
USA	100		
Argentine	40,5	55,6	3.3
France	100		
Uruguay	34	66,04	
Espagne	100		
Portugal	100		
Italie	100		
Chili	90,6	9	



Allemagne	100		
Royaume-Uni	100		
Paraguay	20,6	77,62	
Mexique	100		
Chine	100		
Colombie	100		
Suisse	100		
Angola	100		
Canada	100		
Afrique du Sud	100		
Bolivie	40,3	59	
Israël	100		

Out of the total of 92 billion passenger kilometres of international travel, air transport represents 87 billion p.km, terrestrial transport accounts for 4 billion pkm and thus car for 1,963 billion passenger kilometres and bus for 2,304 billion p. km. Thus the modal share is the following (Figure 38).

Figure 38. Modal shares for Brazilian international tourists.

modal shares	p, km	%
plane	87753226737	95,36%
car	1962929593	2,13%
bus	2304308652	2,50%

Load Factors

No additional considerations to "domestic tourism".

Emission coefficients

Two points must be added to what has been developed regarding domestic tourism.

- For aviation, the emissions coefficients applied are those of long haul.
- Regarding accommodation, Brazilian tourists abroad use the same accommodation as other international tourists, so the same emissions coefficient (19 kg CO₂/guest night) is applied to them.

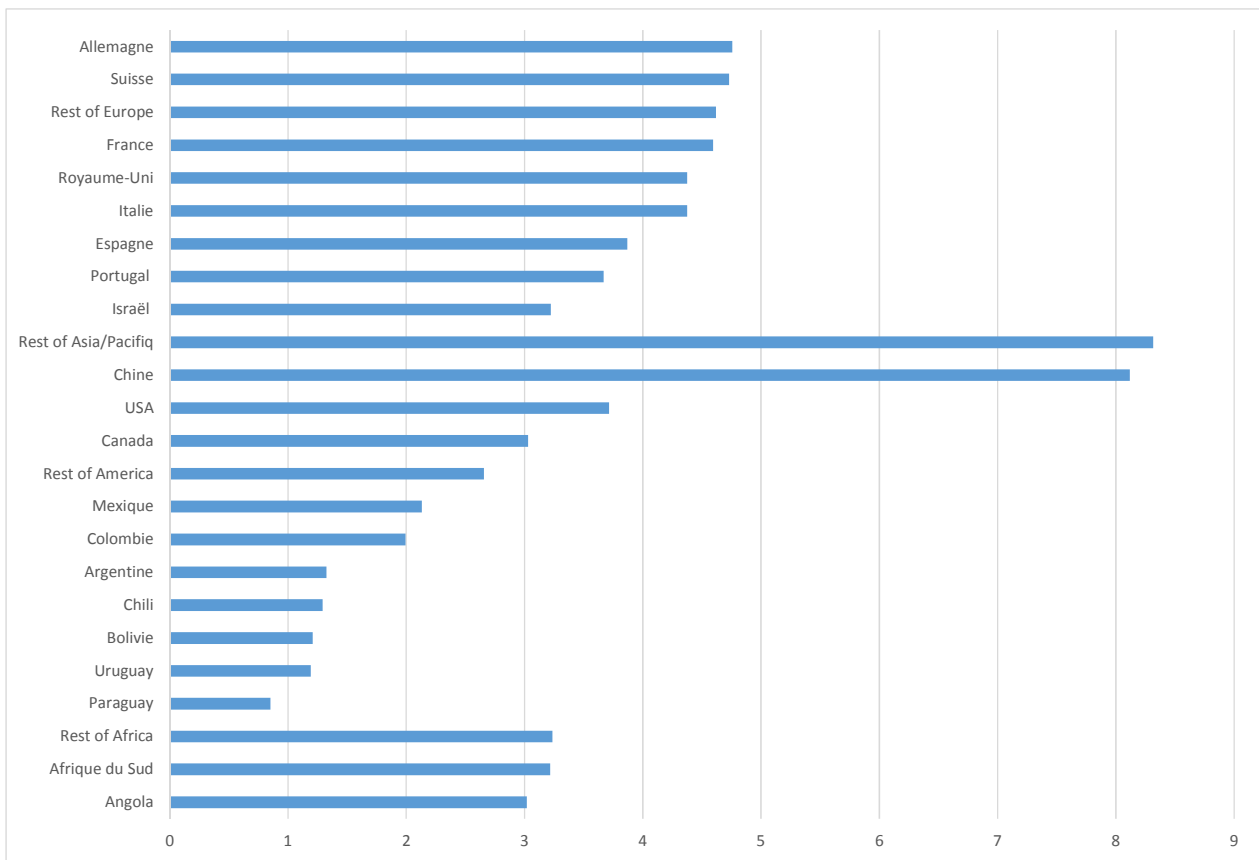
Results

The tourism of Brazilians abroad amounts to 26,5 millions of tons of CO₂ equivalent (including accommodation).



The emissions per trip differ widely as Figure 39 shows:

Figure 39. Emissions per trip according to the destination (2010)

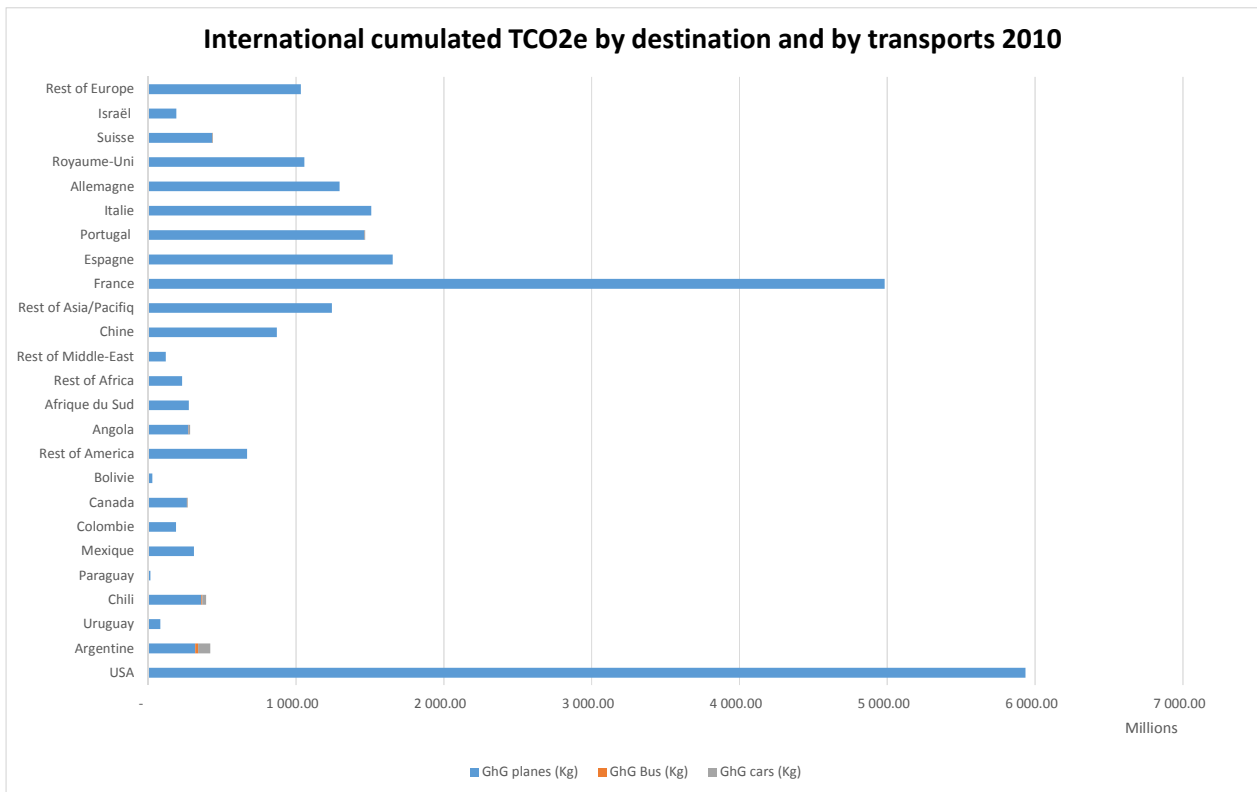


The lowest emissions concern South American neighbouring countries, then the rest of South America, followed by North America for which the emissions are still less than those of a trip to Africa or Europe. The highest emissions are by far those of a trip to Asia.

The following graph shows the total emissions by country of destination and by mode of transport.



Figure 40. Emissions of Brazilian tourists by country of destination and transport mode.

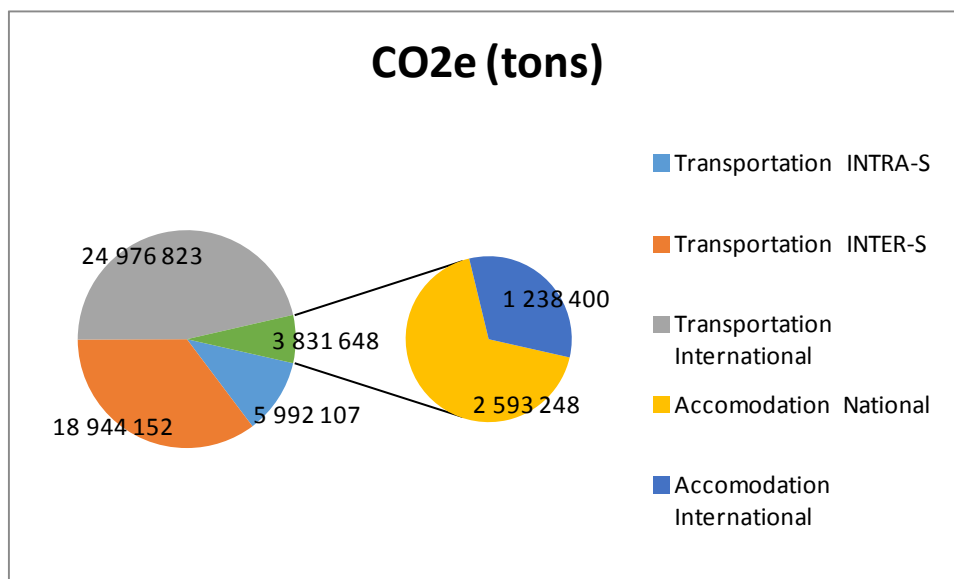


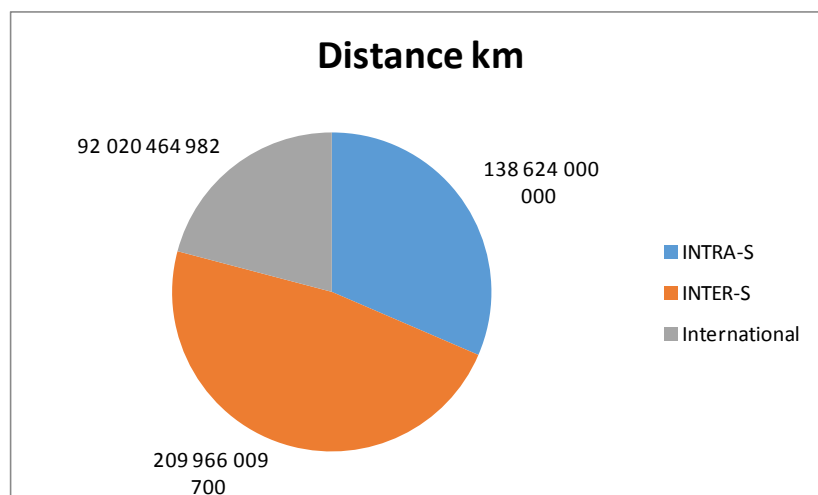
Benchmarks and comparisons

Summary

The CO₂ equivalent emissions (including a radiative forcing index for aviation) from Brazilian tourism sum up to 53,7 MT.

Figure 41 Emissions and passenger.km (2010)





In terms of passenger.kilometres, domestic tourism (340 billion) represents 22 percent of the total of domestic passenger transport (1 546 billion in 2010, source COPPE).

Out of total emissions, international travel (mainly by plane) represents a half. The importance of aviation is confirmed. This also shows that a minority of tourist trips, and thus a minority of travelers, are responsible for the greater part of emissions.

Alternative metrics can be used to facilitate benchmarking and comparisons:

- the first is to take into account CO2 emissions only, excluding both other greenhouse gases and the use of a radiative forcing index for aviation,
- the second is to include all greenhouse gases but not the radiative forcing index.

These three types of results are compared with the total emissions of Brazil and with the emissions that have been calculated for tourism in the UNWTO study (Figure 42).

Figure 42. Emissions of Brazilian tourism (2010) according to three metrics.

		MT	CO2 only			CO2-e			Including specific effects for aviation		
			total	tourism	%	total	tourism ⁶	%	total	Tourism	%
Brazil	1	Brazil 2010 (LUCF excluded)		31,25		1034	32.974	3.2%		53,744	5.2%
	2	Anthropogenic emissions 2005	490 ⁷		6.4%						
	3	LUCF				1404					
	4	Brazil 2010 (LUCF included)				2438		1.35%			
World	5	World 2005								4.4% to 14.3%	
	6	Anthropogenic	26400	1302	4.9						

⁶ CO2+CH4+NOx

⁷ defined as emissions from energy agriculture, industrial processes and waste, source Coppe.



		nic emissions ⁸								
	7	World LUCF incl 2005	32300	1302	4%					

Basis for comparison

The comparison between Brazil and the world average or for individual countries across the three metrics (CO₂, CO₂ equivalent, radiative forcing) are rather tricky, the more as the dates of the assessments can differ by half a decade.

For Brazil they relate to 2010 and for the world to 2005 (Figure 42, lines 5,6,7). Figure 43 allows to appreciate what such difference in dates imply, since the structure of Brazilian emissions seems to evolve quickly and should continue doing so (see below the discussion on the results of the business as usual scenario).

Figure 43. Co2-e emissions of Brazil (2005 and 2010)

Mt.CO2e	2005	2010	evol %
Uso do Solo	1329	1404	5,64%
Agricultura	416	509	22,43%
Energia	329	381	15,76%
Processos Ind.	78	89	13,55%
Resíduos	41	56	35,94%
Total	2193	2438	11,19%

Source : Coppe

This table shows a high proportion of emissions from agriculture compared to the emissions from energy. It should be stressed that in the Brazilian case, this is partly due to the fact that, whereas other countries use overwhelmingly fossil fuels for passenger transport, Brazil uses a significant proportion of fuel from biomass, so that the related emissions are accounted for by the agricultural sector.

We do not have directly for Brazil in 2010 the emissions for CO₂ only. CO₂-e amounts are available for 2005 from the National communication to the UNFCCC (Figure 42, line 1). Since the emissions from agriculture are essentially composed of non-CO₂ gases, Brazilian CO₂ emissions (excluding LUCF) amount to 379 MT and CO₂ equivalent emissions to 863 MT in 2005. Consequently, CO₂ only represents 44 percent of CO₂ equivalent. If that ratio is applied to the emissions we have for a CO₂ equivalent in 2010, this means that CO₂ emissions in 2010 amount to 1034 x 44% = 455 MT. Note that subtracting from the total (2438, line 4, see also Figure 43) the share of land use and of agriculture would lead to 525 Mt, which seems to make sense if one remembers the non-CO₂ emissions of the sectors that are left aside by the subtraction. This leads us to retain the average (490) as a figure to include in Figure 42, line 2.

CO₂ and CO₂-e

Looking at CO₂ only, the emissions of Brazilian tourism appear very high (6.4%) compared to the world average (4.9%), especially as Brazil is an emerging country. As we have pointed above this is an illusion partly due⁹ to the importance of fuel from biomass (which does not result in CO₂ emissions), while other countries use fossil fuels. This is why we think the CO₂ equivalent is a more reasonable metric for comparison: 3.2% in our calculations (line 1). Figure 43 also

⁸ UNWTO 2006 & IPCC AR4, WG1, SPM

⁹ hydroelectricity also contributes to damp down the emissions from energy



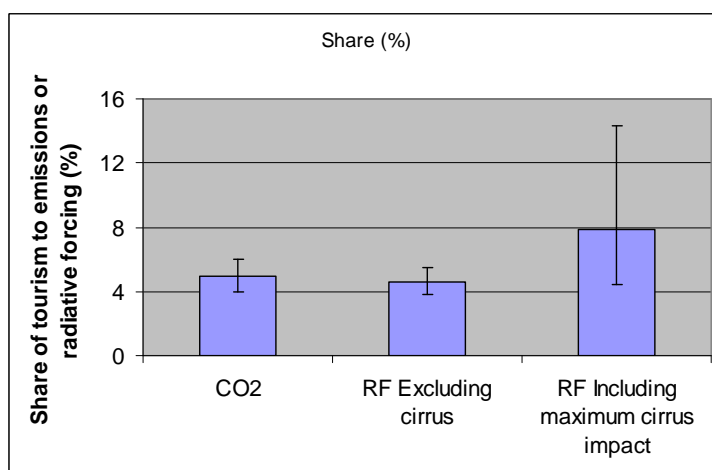
shows that for Brazilian tourism the CO2 equivalent emissions (excluding an uplift factor for aviation) are quite near to CO2 only emissions: they differ by 5%. This means that 3.2% is a decent approximation to compare to the 4.9% benchmark. That is the outstanding result!

So Brazil seems well under the world average, which is not surprising for a still emerging country. It is also quite far from the figures of 8 to 11 % that have been computed for countries such as France for Sweden (see p.12). The question is whether this situation will last.

Radiative forcing

Looking from a radiative forcing perspective seriously changes the results. As it has been already stated, CO2 and CO2 equivalent (including methane and nitrogen oxides) are far from reflecting the contribution of aviation to climate change (see p. 41). Taking into account the specific aspects of aviation translated into an uplift factor of 2 leads to an increase of the impact of 64 percent. According to Coppe, fugitive emissions represent 2% of anthropogenic emissions (LUCF excluded) in 2010. Thus this type of calculation leads to a figure of 5.2 % (line1), i.e. two points more than the calculation in terms of CO2 equivalent. This result can be compared to the world assessment made by UNWTO, (see Figure 44). Including the maximum contribution of cirrus results in a share of tourism in radiative forcing between 4.4% and 14.3% (line5) (UNWTO, UNEP et al. 2008).

Figure 44 Share of tourism in world emissions or radiative forcing (World).



source:(UNWTO, UNEP et al. 2008)

LUCF

The last point to be made concerns LUCF. In 2010 LUCF represents 58% of the total of Brazilian emissions. These emissions stem from an increasing use of land for agriculture which includes the productions of biofuels. Transport which accounts for the larger part of emissions from domestic tourism (93.5%) has thus a share of responsibility in those emissions. Considering LUCF leads to 4% of world emissions for tourism and to 1.35% in Brazil, which is logical owing to the high share of LUCF in Brazilian emissions and reflects the strong specificity of the structure of Brazilian emissions.

Conclusion

The emissions of Brazilian tourism depend on the metrics used, which is no novelty since it has been shown in previous assessments both at world level and for other geographic areas.



The second point is that it is tricky to compare their importance to the emissions that have been assessed in other geographic contexts, owing to the particular structure of Brazilian emissions; i.e. the importance of LUCF and the role of biofuels. LUCF emissions in the Brazilian case replace some emissions from fossil sources in other countries, since biofuels are used as a substitute for fossil fuels, notably in transport. They also exceed that contribution: burning a forest does not generate any useful energy. Usually, the benchmarks used to assess the importance of tourism in the total emissions of other countries do not include any contribution from LUCF, which is a reasonable choice since LUCF are of much lesser importance in those countries.

If the CO₂ only emissions from Brazilian tourism (2010) are compared to the CO₂ only anthropogenic emissions of Brazil in 2005, this results in a contribution of tourism to national emissions higher than the world average. Yet, owing to the emissions "hidden" in LUCF and the rapid change in Brazilian emissions this comparison can be considered as frail.

The results in terms of CO₂ equivalent for 2010 give another, possibly more reliable, assessment: 3.2%, which is lower than the world average (calculated in terms of CO₂ only...). The percentage of CO₂ equivalent emissions fall down considerably when LUCF emissions are included: 1.35% in 2010 (the world average in 2005 is then 4%).

Overall, our assessment gives a picture coherent with what can be expected from an emerging economy. Nevertheless, such results can be expected to evolve rapidly for quite a number of reasons:

- the growth of wealth, implying an increase in the access to tourism,
- the also fast evolution of the volume and of the structure of Brazilian greenhouse gas emissions

The rest of our work will explore these possible evolutions.



IV. The future emissions of Brazilian tourism



Scope and methods

Departing from a conventional approach

Quite an usual method to assess future tourism is to correlate the development of tourism to GDP or income: this is the case with the UNWTO projections to 2030 (UNWTO 2013). The ECOPA project challenge is whether we can do better and take into account the inequalities in income distribution and various other factors specific to Brazilian tourism.

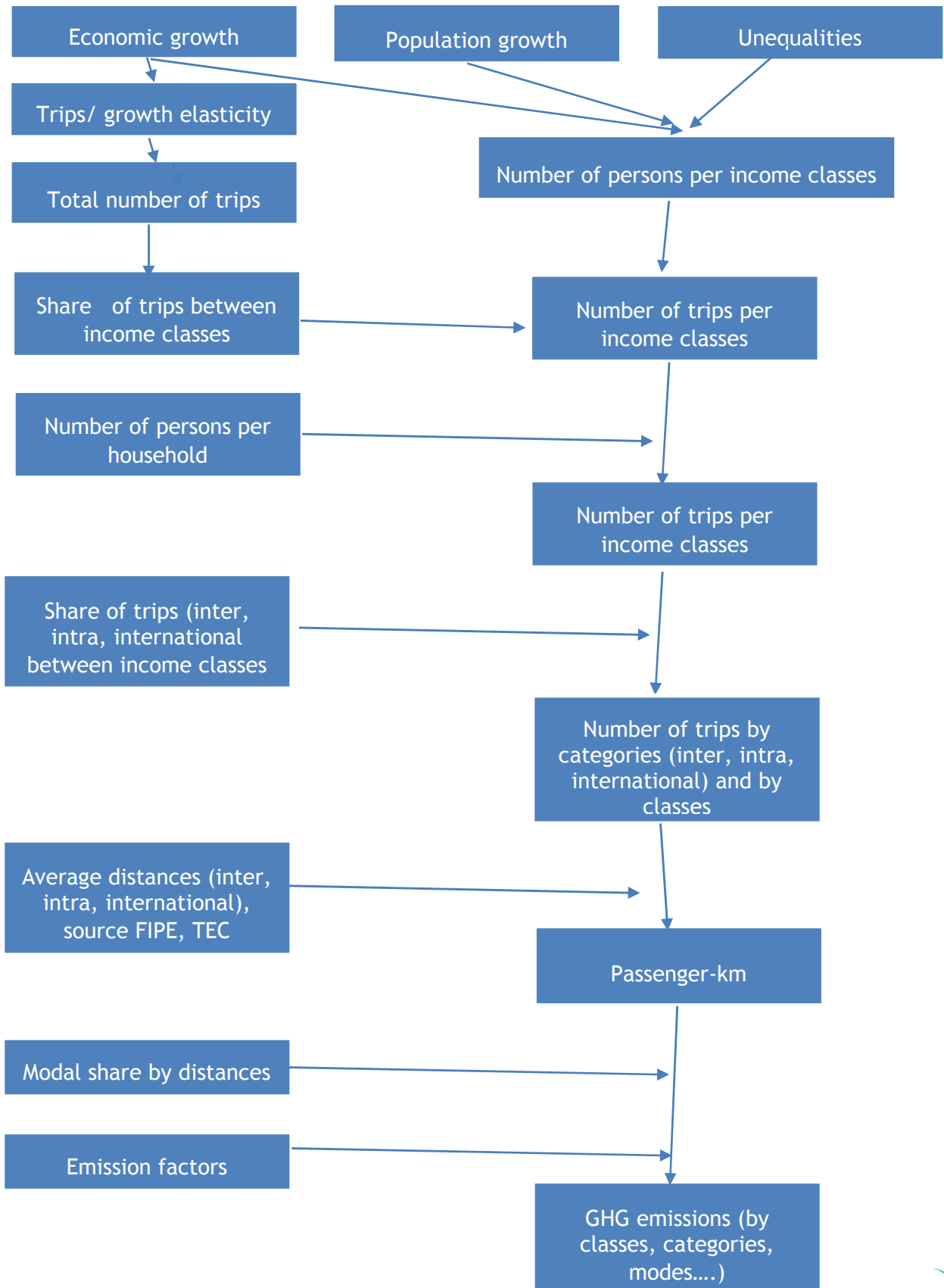
Our benchmark scenario takes as a starting point the current state of the tourism of the Brazilian population and its emissions that have been calculated previously. It makes various hypotheses on the variables that will shape Brazilian tourism in 2030 and 2050. These variables are the following (see p. 43).

- GDP
- population
- departure rates
- length of stay
- modal share
- destinations and thus distances
- emission factors
- ...

The hypotheses take into account what visions exist on the future of Brazilian tourism, the literature on the driving forces, and consider the choices that have been made in other scenarios of tourism futures (particularly our previous work for France (Dubois and Ceron 2005)). Naturally, we do not paste on the Brazilian case the hypotheses made for other contexts, we just use them as benchmarks to elaborate specific ones for Brazil.

The benchmark scenario refrains from simply projecting trends into the future. Exponential types of projections will lead by themselves to unsustainable futures which are not realistic ones. Moreover, in the future, some trends can become contradictory one with another (Dubois and Ceron 2007). Though this scenario is not connected to general equilibrium considerations, it endeavors to remain coherent with national expectations. We try to draw, with this benchmark scenario, possible futures of Brazilian tourism, which does not exclude at all that they will be unsustainable. This also means that we are extremely cautious regarding silver bullets or technological fixes that are periodically put forward and said to solve the problems (e.g. hydrogen for vehicles). If one looks back at the scenarios built a decade ago or more, dealing in particular with transportation, it is easy to see that we are already completely off the track from most of the decisive innovations that were relied on (e.g. the penetration of fuel cells in vehicles) e.g.(ENERDATA 2004). This does not mean that there will be no major technological breakthroughs in the coming decades, but we reasonably cannot foresee what and when (remember that in the 70s no one foresaw the importance microcomputers took in society 20 years later). We just pretend that the uncertainties are too great to build the core of the scenarios around such hypotheses.

Reference scenario

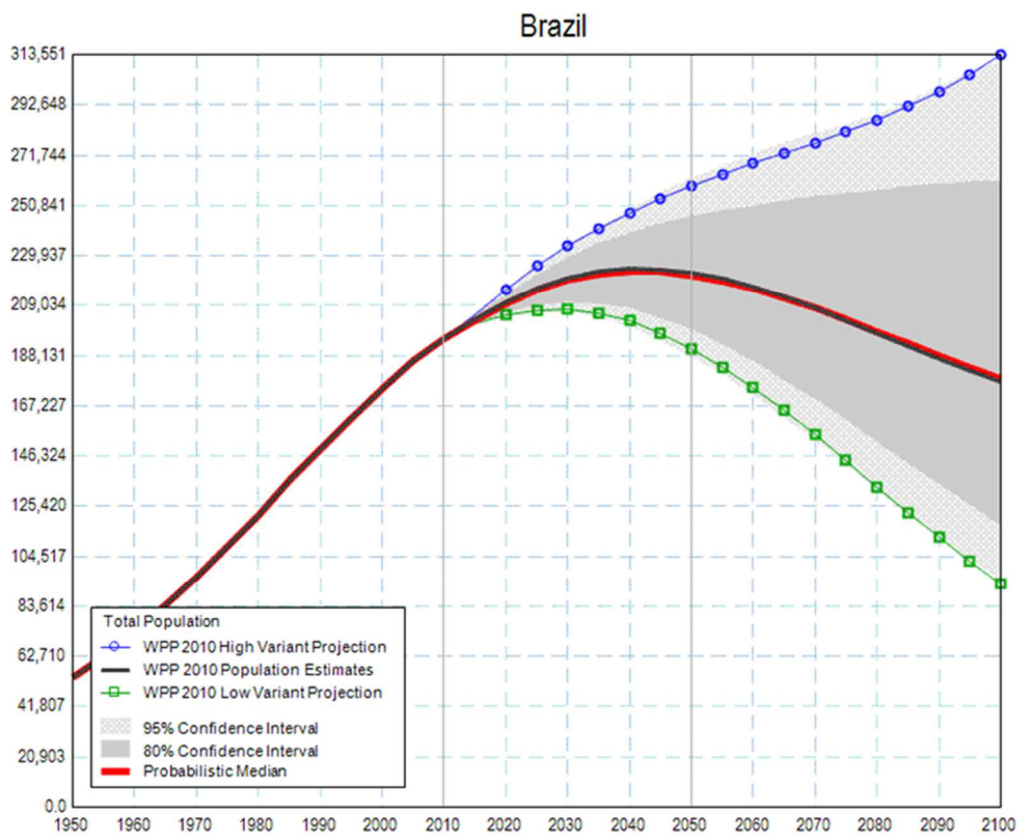


Variables and hypotheses

Population perspectives

Brazil is considered to be on the way to a demographic transition, reaching a maximum of population in 2040, with a slow decrease afterwards. We take into account the average projections as given by Figure 45, using figures of 219.7 millions for 2030 and 221.6 million for 2050. It can be noted that in 2030 the difference between the high and low variants approximates 10 million inhabitants and in 2050 exceeds 60 million (see sensitivity tests below).

Figure 45. Projections of the Brazilian population



United Nations Population Division. Chart created: 27/11/2012

Source: http://esa.un.org/unpd/ppp/Figures-Output/Population/PPP_Total-Population.htm

Number of persons by household

The number of persons per household is another important demographic factor, in particular for car mobility. It tends to diminish with time. A study by (Ernst and Young 2011) gives for 2007 an average of 3.1 people per household and predict a figure of 2.4 for 2030. We derive our figures from this trend: note that the average household size for France was 3.1 in 1968 and 2.25 in 2011 (http://www.insee.fr/fr/themes/tableau.asp?reg_id=0&ref_id=AMFd1)

Figure 46. Projected number of persons per household

Persons per household	
2010	3,1
2030	2,5
2050	2,25



Proportion of urban population

The proportion of urban population in Brazil is still projected to grow in the following decades and to attain 88% in 2030 and 91% in 2050 (United Nations 2012).

GDP growth

OECD projections gives a 4.4% growth rate for 2012-2017, 3.9% for 2018-2030 and 2.5% for 2031-2050 (Source : OECD economic Outlook 91 long-term database (http://stats.oecd.org/Index.aspx?DataSetCode=EO91_LTB)). It seems to us that more limited growth rates are more in line with what can be reasonably expected. As Piketty states "we have no example in history of any country with a GDP per inhabitant growth superior to 1.5% on the long run... The idea according to which growth should attain at least 3 or 4% per year is still imbedded in our minds. This is an illusion both on historical and logical grounds" (Piketty 2013)p.158). The recent growth rates in Brazil tend to support this perspective: 2.7% in 2011, 0.9% in 2012, 2.3% in 2013, 1.5% in 2014 (forecast) (<http://data.worldbank.org/country/brazil>).

Therefore, for the reference scenario, we assume a GDP growth of 3% for 2010 to 2030 and 2% for 2030 to 2050.

Income distribution

The statistics used in Brazil for tourism studies distinguish three income classes representing highly unequal shares of the total population in 2010: between 0 and 4 minimum salaries, from 4 to 15 and 15+ minimum salaries.

Moreover these statistics only consider urban population which amounts to 87% of the total population; this seems justified by the extreme poverty of the rural population which almost does not allow it to travel; thus taking into account only the urban population is considered as a fair approximation (FIPE 2012).

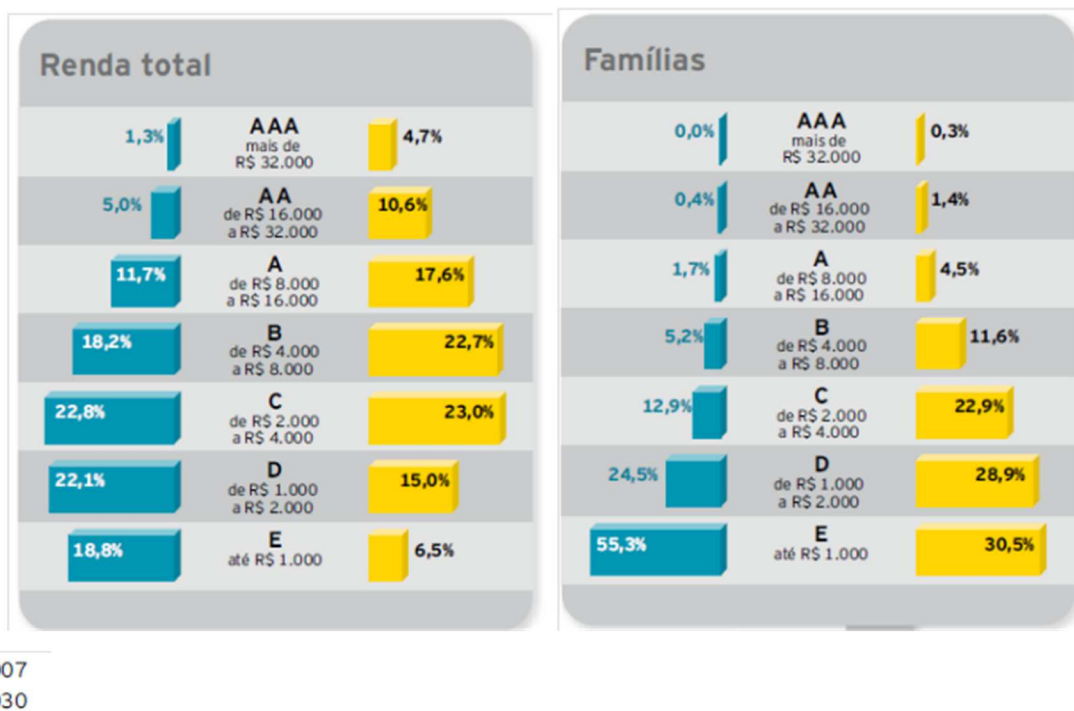
Quite obviously the share of these income classes in the total population is going to change in the future decades. A study by Ernst &Young gives projections to 2030 (Ernst and Young 2011); see



Figure 47.



Figure 47. Future share of income classes in total national income (left) and population (right).



Source : (Ernst and Young 2011)

Since the two partitions do not coincide, we translate this projection into the categories used for tourism and project them further to 2050. More precisely, for different assumptions of economic growth, we recalculate the share of social classes (being defined with threshold of minimum salaries, in real of 2010). Mechanically, if the economy grows, the share of people earning less than 4 minimum salary of 2010 will decrease in the future. The share of social classes cannot be considered as equal in coming decades, even if the overall situation of inequality does not change.

The results are presented in Figure 48. This new share of income classes only reflect the consequences of hypotheses of economic growth as exposed above. In alternative scenarios (see from p.91), we will adjust these projections with additional hypotheses of inequality and social welfare.

Figure 48. Share of income classes in the population in 2010 (Tourism statistics partition).

		2010	2030	2050
Lowest	0 to 4 minimum salary	58,63%	42,00%	26,17%
Middle	4 to 15 minimum salary	33,04%	40,00%	46,96%
Upper	more than 15 minimum salary	8,43%	18,00%	27,57%

Source:(FIPE 2012).



Share of trips between income classes according to departure rates for each class

We have an idea on the share of income classes in the Brazilian population and its evolution (see above). Yet, no Brazilian statistics indicate how this translates into travel shares.

Domestic trips

We have the total number of trips for 2010 (FIPE 2012). The same source gives, for each income class, the distribution of trips according to their frequency. See Figure 49.

Figure 49. Number of domestic trips per household (2010).

Número de Viagens Domésticas no Domicílio, por Renda (em %)				
Número de Viagens	Classe de Renda Mensal Familiar			Total
	De 0 a 4 SM	De 4 a 15 SM	Acima de 15 SM	
1	56,9	40,3	31,9	48,1
2 ou 3	29,2	33,5	34,7	31,4
4 a 6	10,8	17,7	19,8	14,3
7 a 10	2,1	5,9	9,6	4,3
11 ou mais	1,0	2,6	4,0	1,9
Total	100,0	100,0	100,0	100,0
Média	2,60			

Source: (FIPE 2012).

This allows to approximate for each income class the average number of trips per household. Since we also know the share of each income class in the total number of households, we can determine the share of each income class in the total of domestic trips (see Figure 50).

Figure 50. Share of each income class in the total of domestic trips.

2010	%
Lowest	32%
Middle	50%
Upper	18%

For the future, the distribution of trips is supposed to follow the distribution of income classes (Figure 51), assuming that for the same categories of revenues (in real of 2010), households will have the same travel behavior, i.e. a household earning 4 times the minimum salary of 2010, but in 2030 will behave the same than a similar household in 2010.

Figure 51. Future share of each income class in the total of domestic trips.

	2030	2050
Lowest	16%	10%
Middle	54%	56%
Upper	30%	34%



This just means that the number of people with low income decrease, they essentially shift to the middle income class, whereas a quite significant number of people of the middle income class access to upper income. As a result the middle income class increases somewhat.

International trips

We do not have any statistics either, regarding the distribution of the Brazilian's international trips according to income. Yet, statistics on the distribution of income for foreign passengers arriving to Heathrow airport can be found (see Figure 52).

Figure 52. Income of UK and foreign passengers at Heathrow airport in 2011.

Income	UK Passengers				Foreign Passengers				ALL	
	Business		Leisure		Business		Leisure		Business	Leisure
	International %	Domestic %	International %	Domestic %	International %	Domestic %	International %	Domestic %	Total %	Total %
Under £5,750	0.3	0.1	5.7	3.6	1.1	0.0	3.0	0.0	0.6	4.5
£5,750-£8,624	1.4	0.4	3.5	2.6	1.0	0.0	1.6	0.0	1.2	2.7
£8,625-£11,499	0.5	0.4	2.5	1.3	0.9	0.0	2.0	0.0	0.6	2.2
£11,500-£14,374	0.2	0.1	3.0	4.6	1.1	0.0	2.2	3.2	0.5	2.7
£14,375-£17,249	1.0	1.2	3.2	2.0	1.2	0.0	3.5	0.0	1.1	3.3
£17,250-£22,999	1.8	3.5	4.6	2.1	2.5	7.4	4.2	0.0	2.3	4.4
£23,000-£28,749	3.9	7.4	7.7	7.4	4.9	4.7	6.1	1.1	4.6	7.0
£28,750-£34,499	9.4	7.8	9.9	9.0	6.6	13.0	9.4	3.6	8.1	9.6
£34,500-£40,249	12.0	10.8	9.8	10.2	9.2	7.0	8.9	13.3	10.8	9.5
£40,250-£45,999	9.4	11.8	10.2	7.4	9.0	29.8	11.4	3.7	9.5	10.6
£46,000-£57,499	13.3	14.8	8.3	13.5	11.9	7.4	10.9	10.8	12.8	9.5
£57,500-£80,499	17.6	15.6	13.1	15.1	18.5	12.2	11.6	33.9	17.8	12.6
£80,500-£114,999	13.3	9.7	8.6	9.5	13.1	5.1	10.3	6.1	12.9	9.3
£115,000-£172,999	7.6	9.5	6.1	8.1	10.6	9.8	9.2	11.7	9.0	7.4
£173,000-£229,999	2.2	1.4	1.4	1.2	2.7	0.0	2.3	12.7	2.3	1.8
Over £230,000	5.9	5.4	2.3	2.5	5.8	3.5	3.4	0.0	5.8	2.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Total terminating passengers (000s)	7,300	1,308	17,549	704	6,417	88	12,460	115	15,113	30,828
Mean income	£78,595	£75,185	£56,016	£61,751	£81,494	£64,287	£66,774	£85,834	£79,395	£60,542

Note: Excludes interviews where passengers have not answered all relevant core questions

* Business passengers are asked for their personal income and leisure passengers are asked for their household income.

Source: (Regulatory Policy Group 2011).

We assume that international tourists from Brazil present, regarding this feature, the same characteristics as the average of international tourists. So we translate the data for Heathrow into the three categories we use in the model (

Figure 53).

Figure 53. Income proxy for Brazilian tourists abroad.

	2010	2030	2050
Lowest	3,80%	1,40%	0,60%
Middle	19,00%	12,00%	9,60%
Upper	77,40%	86,50%	89,80%

Modal share

We have no indications on the possible evolution of modal shares for Brazil to 2030 and 2050, neither for tourism nor for other mobility purposes. In the business as usual scenario we cannot accept to keep current modal shares, the more as we know they are evolving rapidly, mainly with the steep progress of air travel and its substitution to long distance bus travel.



Besides, the business as usual scenario is built around the background idea of some convergence with developed countries. So we use as a source of inspiration and as a benchmark, the assessment of the modal shares made for Europe (25 countries) in year 2000 and its projection to 2020 (Peeters, van Egmond et al. 2004).

Figure 54. Modal shares for EU 25 in year 2000 and projections to 2020.

EU 25	Car	Coach	Ferry	Rail	Air
2000	54%	7%	2%	5%	32%
2020	50%	6%	2%	6%	36%

Source: (Peeters, van Egmond et al. 2004; Peeters, Szimba et al. 2007)¹⁰

The justifications of this choice are:

- some similarity in the scale of both geographic entities
- the fact that the EU (25) includes, particularly in its eastern parts a certain number of economies in transition, which were in 2000 quite far from presenting the tourism and transport patterns of Western Europe.

Basically, the idea is to use the European situation in 2000 (Figure 55) as a benchmark for Brazil in 2030, and the projection for Europe in 2020 (Figure 56) for Brazil in 2050. For Europe the report gives figures regarding:

- domestic tourism (i.e. for each European country) which can be used as source of inspiration for Brazilian intra state or short distance travel;
- international tourism within Europe which can be used for Brazilian inter state or long-distance travel.

Note that this European source gives no indication of the modal shares of intercontinental travel.

Figure 55. Modal share EU 25, in 2000.

	Car	Coach	Ferry	Rail	Air
domestic	69%	17%	3%	11%	0%
international	36%	5%	1%	4%	53%

Figure 56. Modal share EU 25, in 2020.

	Car	Coach	Ferry	Rail	Air
domestic	75%	9%	3%	6%	6%
international	32%	4%	1%	5%	58%

Naturally we cannot directly apply the European values to Brazil and have to include some modifications:

- the European figures distinguish coach, ferry and rail which are forms of collective transport. In Europe there is an important rail network which does not exist in Brazil. Besides, in the economies in transition of Eastern Europe, transport by coach still had in 2000 an importance which never existed in Western Europe. Collective transport is

¹⁰ N.B. Neither the report itself nor the paper published give the figures for 2020, they only contain graphs without precise numbers. The figures in the table are drawn from Excel files transmitted by Paul Peeters.



essentially taken up in Brazil by long-distance buses. The sum of coach, ferry and rail is thus taken as a benchmark for long-distance travel by bus in Brazil.

- The European figures do not give modal shares according to distance classes as we use them in our model, but according to a partition between domestic and international tourism (within Europe). We assume a direct correspondence between the modal shares for domestic travel (in Europe) and intra state travel in Brazil. We adopt the same option for international travel (Europe) and long-distance domestic travel in Brazil (over 1000 kilometres). Regarding the two intermediate distance classes, we somewhat inflect the European figures:
 - o for the 200-500 kilometres distance class, we include in 2030 a small share of air travel (5%), and in 2050, some 15 %
 - o for the 500-1000 kilometres distance class, we use modal shares intermediate between the distance classes above and below.
 - o For intra state (< 200km) in 2050 we consider plane= 0, whereas for the 200-500km class we apply the same as EU domestic 2020

All this results in Figure 57 and Figure 58.

Figure 57. Modal share 2030.

Distance (km)	auto	bus	plane	Total
inner state <200	69,0%	31,0%	0,0%	100,0%
200 - 500	59,0%	26,0%	15,0%	100,0%
500-1000	50,0%	18,0%	32,0%	100,0%
>1000	37,0%	10,0%	53,0%	100,0%

Figure 58. Modal share 2050.

Distance (km)	auto	bus	plane	Total
inner state <200	75,0%	25,0%	0,0%	100,0%
200 - 500	66,0%	19,0%	15,0%	100,0%
500-1000	60,0%	15,0%	25,0%	100,0%
>1000	32,0%	8,0%	60,0%	100,0%

Emission factors

Two dimensions are to be taken in consideration: the improvement of the efficiency (less fuel per passenger.km) and the substitution of fuels from biomass to fossil fuels.

The improvement of energy efficiency

Cars and coaches

Conventional passenger vehicles could see their energy efficiency improved by almost 50% to 2050 (IPCC 2014). We have no specific forecasts for Brazil - e.g (De Gouvello 2010) is not explicit on this issue - we use an improvement ratio of 2% till 2030 and 1% after

Aviation



The energy efficiency of commercial aviation has grown by over 60 percent during the last 40 years (Lee, Fahey et al. 2009). Yet the potential for improvement appears to dwindle along time (Peeters, Middel et al. 2005; Scott, Peeters et al. 2010).

Various scenarios are envisaged for the future. The IPCC fourth assessment report examined several cases to 2030 including (Lee, Fahey et al. 2009):

- "an overall fleet fuel-efficiency improvement of 1.3% yr⁻¹ to 2010, 1% yr⁻¹ to 2020 and 0.5% yr⁻¹ thereafter based upon Greene (1992) - this was assumed to be a reference case;
- an advanced technology case brought about by regulatory pressures that yielded a further 0.5% yr⁻¹ fuel efficiency from 2005 on...;
- a case similar to the previous one but yielding a further 1% fuel efficiency per year from 2005 on".

Such an exercise does not go as far as 2050. For this time scale it is possible to refer to the special report on aviation published by the IPCC in 2000 (Penner, Lister D.H. et al. 1999) which estimated that improvements in design and of planes and engines could yield around a 40-50 % energy efficiency improvement. Adding other improvements (e.g. improved management of the traffic and procedures) could lead to about 60 percent by 2050 which means a yearly improvement of about 1%. This is the figure we shall retain for our business as usual scenario; this can be considered as rather optimistic (Peeters, Middel et al. 2005).

Fuel substitution

The use of ethanol in terrestrial transport is an important Brazilian specificity. It can be expected to increase in the future and predictions regarding ethanol for cars and bio diesel for coaches can be found for 2030 (De Gouvello 2010). We prolong these trends to 2050 (see Figure 59 and Figure 60).

Figure 59: Share of fuels for cars

Cars			
Share %	Gasolina	Etanol	GNV
2010	39	60	1
2030	34	65	1
2050	29	70	1

Figure 60: Share of fuels for coaches

Coaches		
Share %	diesel	biodiesel
2010	94	6
2030	84	16
2050	79	21

Accommodation

The hypotheses regarding the future emissions from accommodation are rather arbitrary.

On the one hand, the residential sector is considered as quite inefficient in its energy use and its mitigation potential is huge compared to sectors where efforts have been made over a long period (e.g. industry). On the other hand, for tourism there is an overall trend towards more comfortable (even luxurious) sheltering: larger rooms, more comfortable heating or cooling,



more land or water use. The question whether the latter will offset the former (in terms of emissions per overnight stays) remains open.

Facing this dilemma, one option is to consider that the emissions factors will remain as they are. We would tend to think that the future should differ in developed and in emerging countries. In developed countries, tourist accommodation is likely not to be spared by the strong mitigation pressure on the residential sector and its greenhouse gas efficiency might improve at the same pace (remember there is also a long-term trend in main homes towards more space, more comfort etc).

In an emerging tropical country such as Brazil, the pressure regarding mitigation efforts in the residential sector is likely to be weaker and the quest for an improvement in comfort (notably cooling) quite strong.

For these reasons we opt for constant emissions factors regarding domestic tourism of Brazilians and for an efficiency improving at the rate of 1% for their international tourism, largely directed towards developed countries.

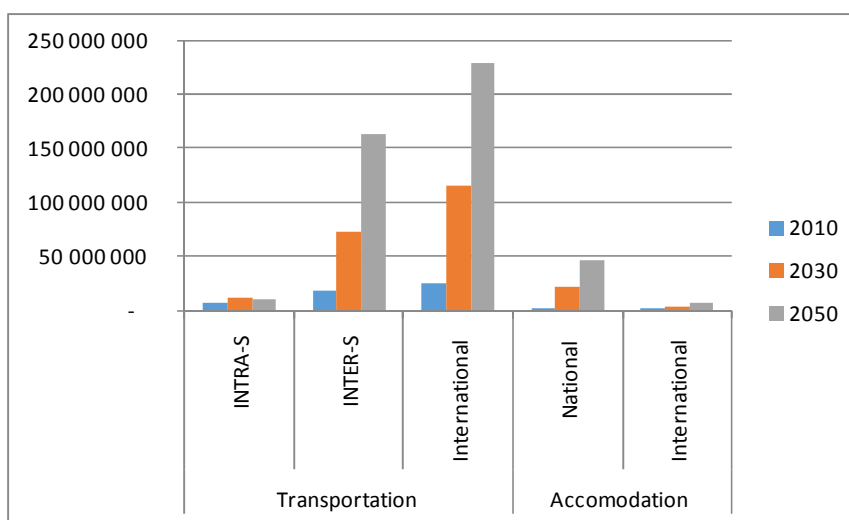
Results

The increase of emissions

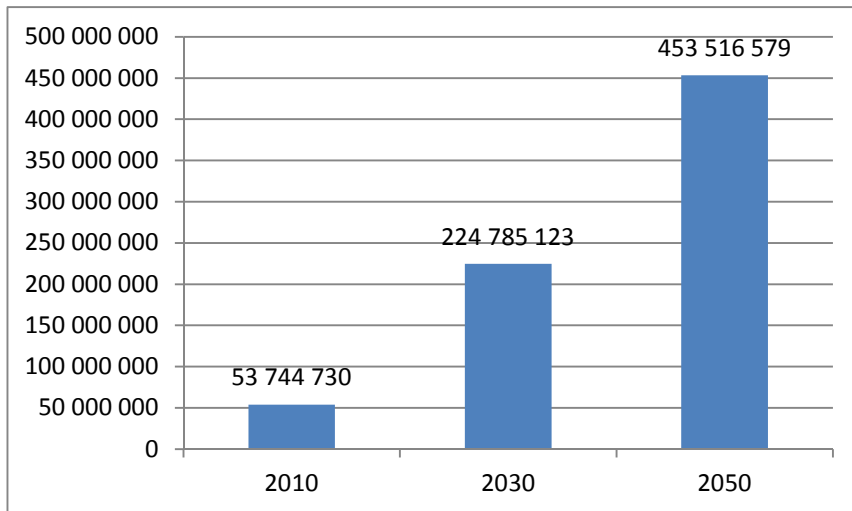
Figure 61 gives the results of the business as usual scenarios for 2030 and 2050.

Figure 61. Results of the Business as usual scenario

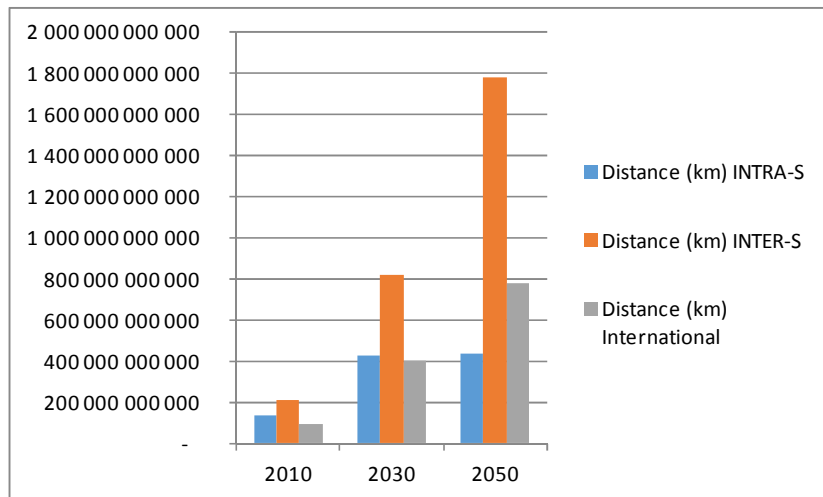
a) GHG emissions (tons)



b) Total GHG emissions (tons)



c) Passenger.km



It shows that the emissions leap from 55Mt in 2010 to 224Mt in 2030 and 453MT t in 2050. This means a multiplication by 4 and 8.2 relative to the baseline year. The major contribution to emissions is made by inter-state and international travel. The impact of intra-state travel and of accommodation is much lower. It can also be noted that, whereas international travel is the first emitter, it only covers distances equivalent to intra-state travel in 2030 or less than half the mileage of inter-state travel in 2050.

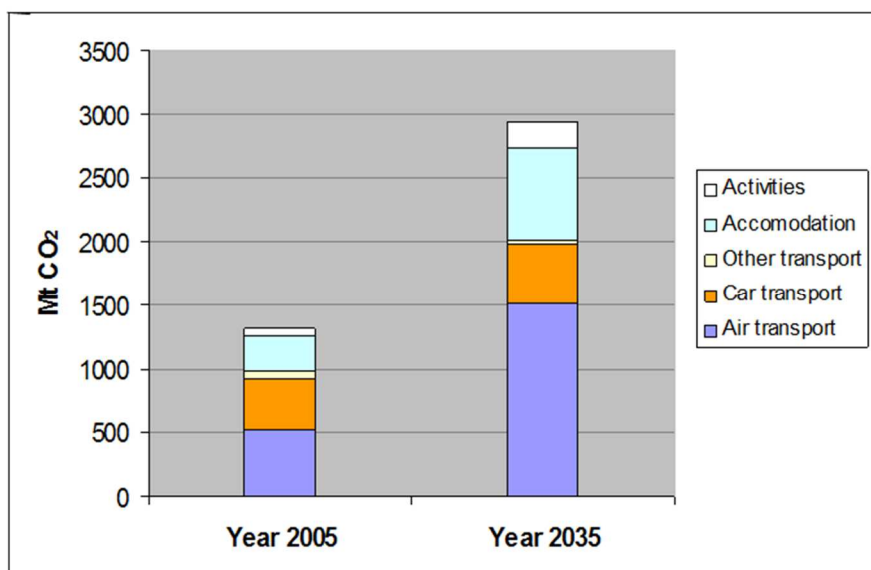
Benchmarks for future emissions

International benchmarks

The UNWTO study gives CO₂ projections for global tourism emissions from 2005 to 2035, that is through a lap of 30 years, to be compared to the 2 laps of 20 years we use in our work. The UNWTO study predicts emissions to grow globally by 152% over 30 years. A projection over 30 years in our study would give far higher figures: adding the increase over the first 20 years to half of the increase over the next 20 years would lead to an increase by more than a factor 5 (169 + 114 = 283, and 283/55= 5.15).



Figure 62. UNWTO scenario of world tourism emissions to 2035.



Source: (UNWTO, UNEP et al. 2008)

We can also compare the results to those of our business as usual scenario for French tourism which showed a multiplication by 2 (+ 106%) in 2050 relatively to year 2000 (Ceron and Dubois 2006).

In terms of emissions per capita, the emissions from Brazil in 2010 are 0.28 t CO₂-e per capita (55Mt / 195 M inhabitants). The UNWTO correspondent figure is for 2005, 0.2 t of CO₂ per capita (1302 Mt / 6.514 billion inhabitants) which includes accommodation and activities, but no uplift factor for aviation (40% of the total emissions). Introducing an uplift factor of 2 as we did in the calculations from Brazil leads to 0.28 tons of CO₂ equivalent per capita, which situates Brazil in the world average.

The emissions per capita we calculated previously for French tourism in 2007 (Dubois and Ceron 2009) were 0.603 t per capita for origin to destination for travel only (38Mt for 63 M inhabitants). If we add the world average percentage for accommodation and activities (i.e. 25%) this comes up to 0.75 t per capita.

In 2030 the Brazilian emissions per capita would reach 1ton (225 Mt divided by 219.7 million inhabitants) and in 2050 2.04 t per inhabitant (453.5 divided by 221.6). At these horizons Brazil would be well over the predicted world average i.e. 0.331t/cap in 2035 (2900Mt/8.743 billion inhabitants). For 2050, our business as usual scenario for France led to 1.3 ton per capita for origin to destination travel only, which uplifted by 25% for accommodation and activities comes up to 1.62 ton per capita, which is significantly under the estimation from Brazil in 2050.

Brazilian benchmarks

So as to compare the business as usual scenario of emissions from tourism to the total of Brazilian emissions, we rely on the business as usual scenario built by COPPE (2014 unpublished), indicating 1 539 Mt for 2030 (compared to 2 351M t in 2005). This means that the national business as usual scenario expects a quite significant decrease of emissions, even though it is built on growth prospects (3.7% per year) superior to ours (3%).

Currently (2010), the tourism of Brazilians represents 1.35% of national emissions, based on the perimeter which is retained by COPPE's assessment (i.e. including land use, see p.63). Considering the UNWTO perimeter it comes up to 3.2%. **Our business as usual scenario for 2030, excluding radiative forcing leads to roughly 150 M t CO₂ equivalent which represents 10% of the total national BAU emissions.** This is, already in 2030, the same order of magnitude



as any currently “highly developed” country. The perimeter of the National BAU includes land use, which means that if considering the UNWTO perimeter, the percentage would be higher. It would probably not double since much of the effort Brazil will do to reduce its emissions will concern land use. Naturally this comparison calls for some caveats. The two business as usual scenarios are not exactly built with the same hypotheses (GDP growth etc). As it will be seen in this sensitivity tests below, GDP is the major variable influencing the results. Yet these results in terms of order of magnitude are significant enough, the more as the emissions from tourism are projected to double between 2030 and 2050 - in a context where the national emissions are expected to continue to diminish.

We have already pointed out that previous research showed tourism to be a crucial problem from the future of greenhouse gas emissions, both at the world scale and for various developed countries. The calculations for an emerging country such as Brazil show even more problematic prospects where, besides the filling of the development gap with the old world, national specificities such as geography and the structure of emissions (land use) play a decisive role.

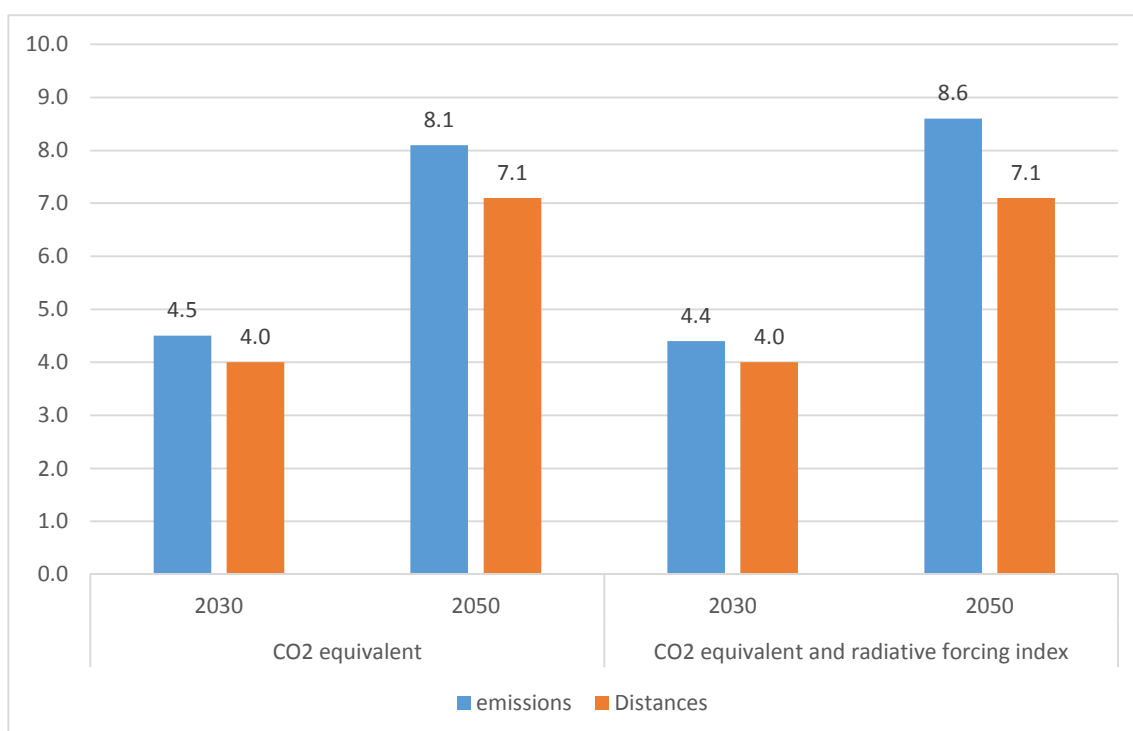
The greenhouse gas intensity of Brazilian tourism in the future

The business as usual scenario shows the greenhouse gas intensity of Brazilian tourism increases in the future. This can be shown both regarding transport and accommodation.

Distances and emissions

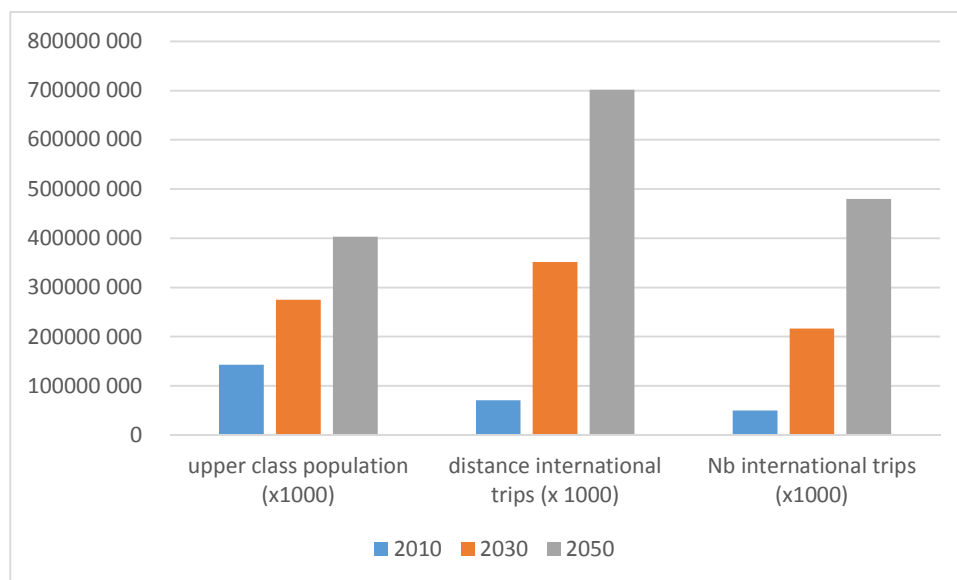
Figure 63 shows the multiplying coefficient for emissions and distances to 2030 and 2050 using two metrics: with and without the radiating forcing index. Emissions grow faster than distances, even more when introducing a radiative forcing index.

Figure 63. The increase in emissions and distances in the BAU scenario (multiplying factors)



This is not the consequence of an evolution of the average distance per trip. In 2010 the average distance (over all trips) is 1275 km, which is comparable to the average distance of tourist trips by the French (1381 km in 2012 for a return trip with a minimal distance from home over 100 km (Commissariat général au développement durable 2013). The average distance of an international return trip does not change significantly from 2010 to 2050: it remains around 15,000 km; but what does change is the number of individuals of the upper-class (multiplied by almost 4 between 2010 and 2050) and the distance each of them travels for international trips (multiplied by nearly 3 between 2010 and 2050).

Figure 64 : Evolution of upper class population mobility



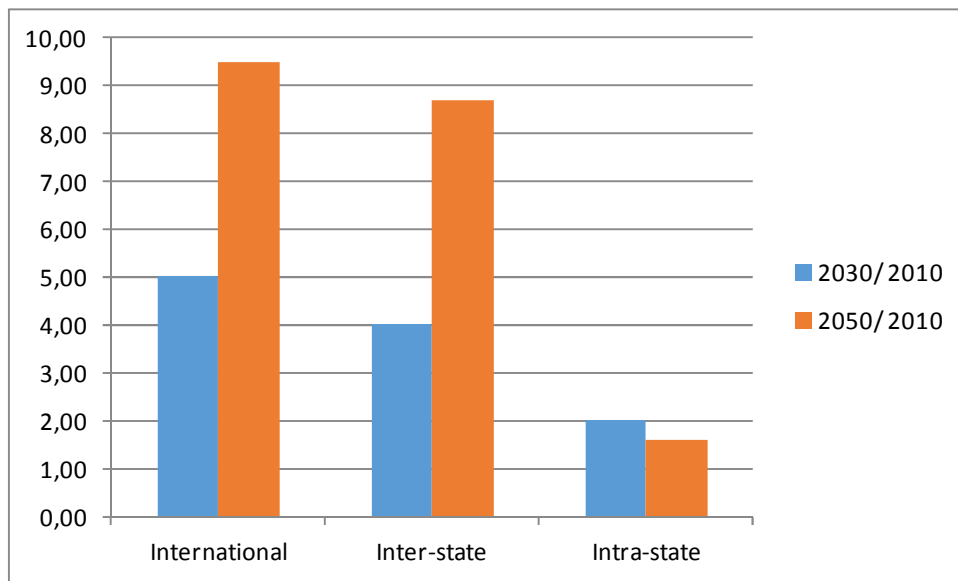
Geographical, institutional and cultural factors certainly have some responsibility in this drift of the greenhouse gas intensity of the tourism of Brazilians. Brazil is one country with one language, which means that, 2000 km away from home, Brazilian tourists will not be confronted with a different language, administrative constraints or social codes which could discourage some tourists. The distances major passenger transport flows encounter (e.g. Rio de Janeiro to Salvador, São Paulo to Recife etc) can be superior to comparable ones in Europe (e.g. London to Paris, Berlin to Brussels etc), see p.26. Nevertheless, it does not seem indispensable to quantify the influence of these factors to recognize that they are outweighed by socio economic drivers, notably the growth of social classes with enough disposable income to access tourism.

The issue of destinations

The growth of emissions is essentially due to long-distance trips. The table below shows that the divide is not between international and domestic, but between intra-state trips on the one hand and inter-state and international trips on the other. There is not much difference in the multiplying factors of international and inter-state trips. In other terms, owing to the size of Brazil, long-distance trips domestic trips are by themselves a problem for the future of emissions.



Figure 65. Comparative increase in emissions.



Economic classes

The number of individuals in the three classes (lower, middle, upper) varies along time: the lower class diminishes to the benefit of the middle-class, and the middle class to the benefit of the upper. In 2050 the middle-class represents almost half of the population, the lower and the upper-class around 25% each. The total number of trips follows the GDP and is distributed between the classes according to their relative importance at a given date (see p.72). The evolution of the emissions according to classes is given in



Figure 67.

Figure 66. Evolution of economic classes to 2030 and 2050 (nb of people)

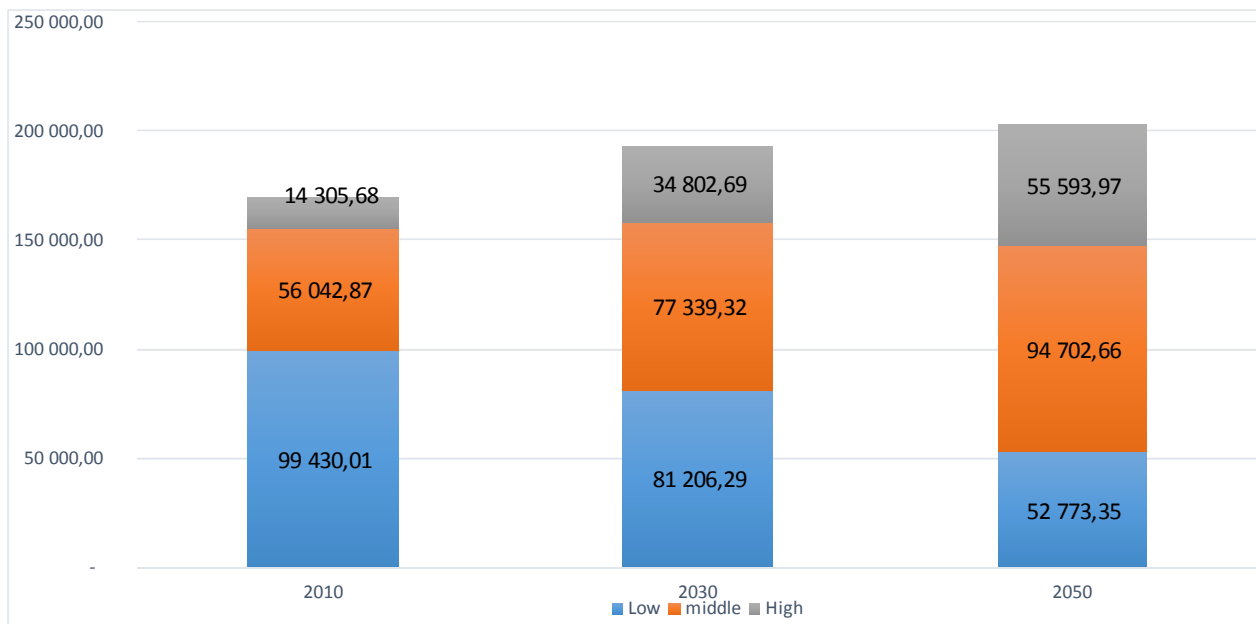
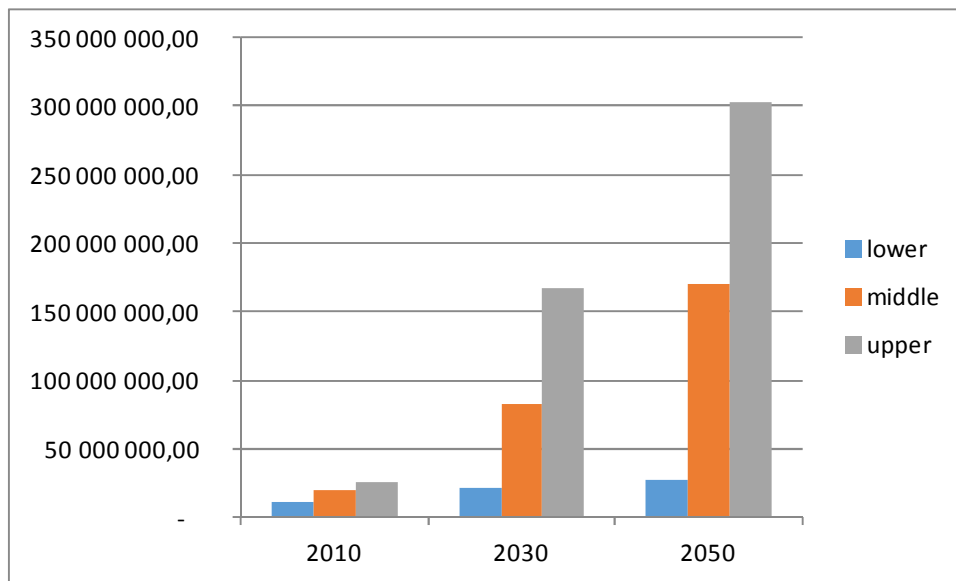
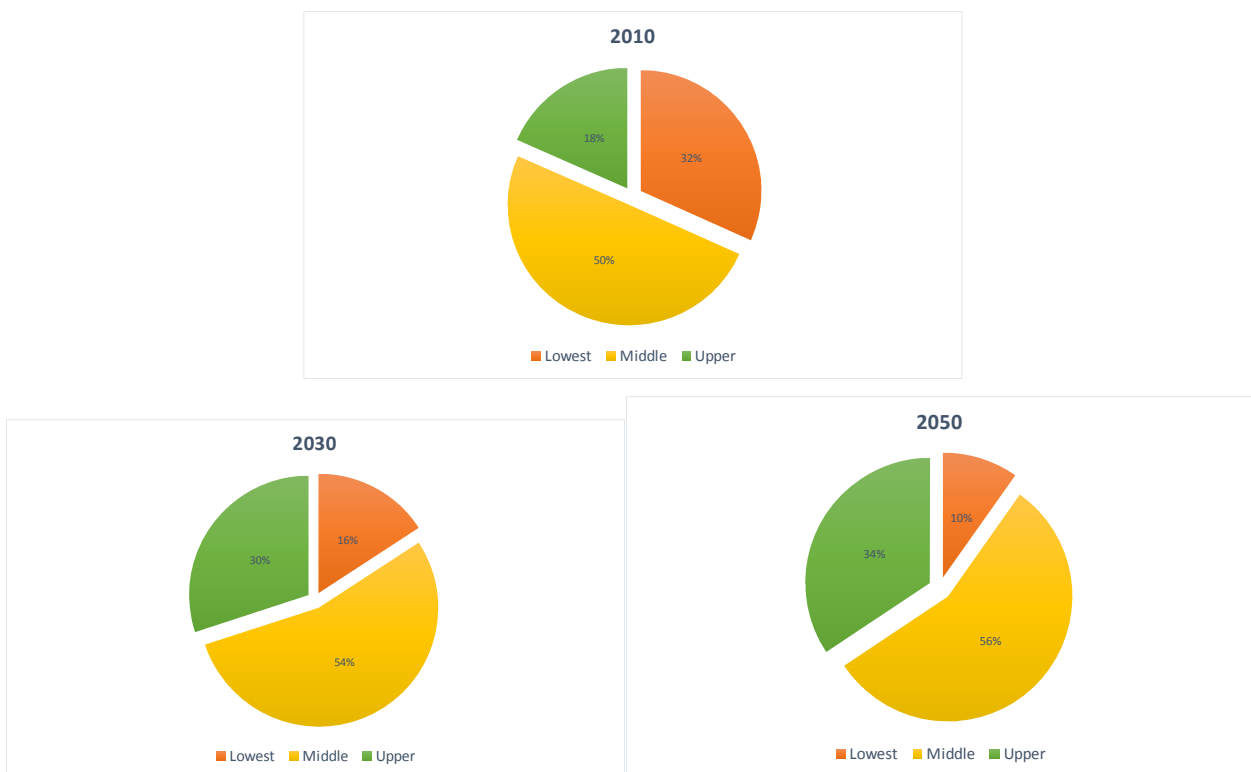


Figure 67 Evolution of Emissions (MT CO2-e).



Domestic and international tourism can be distinguished.

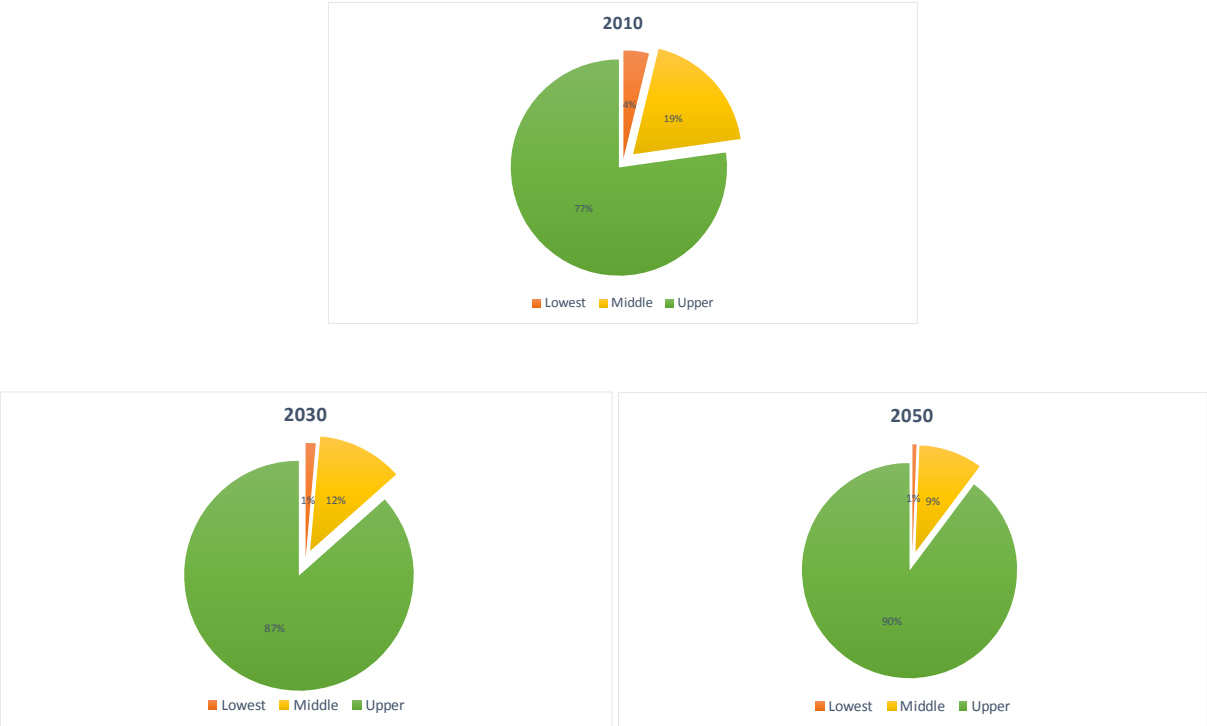
Figure 68 Share of economic classes in domestic trips.



Keeping in mind the evolution of the population of each class (see above), it appears that the share of the lower class in the number of trips is bound to diminish. It can be noticed that the share of the lower class in trips diminishes faster than its share in the population: respectively -50% and -18.3% from 2010 to 2030, or -37.5% and -35.1% from 2030 to 2050. This is due to the fact that the lower class is depleted to the benefit of a middle-class that travels much more intensively.



Figure 69. Share of economic classes in international trips.



Greenhouse gas emissions according to fuels

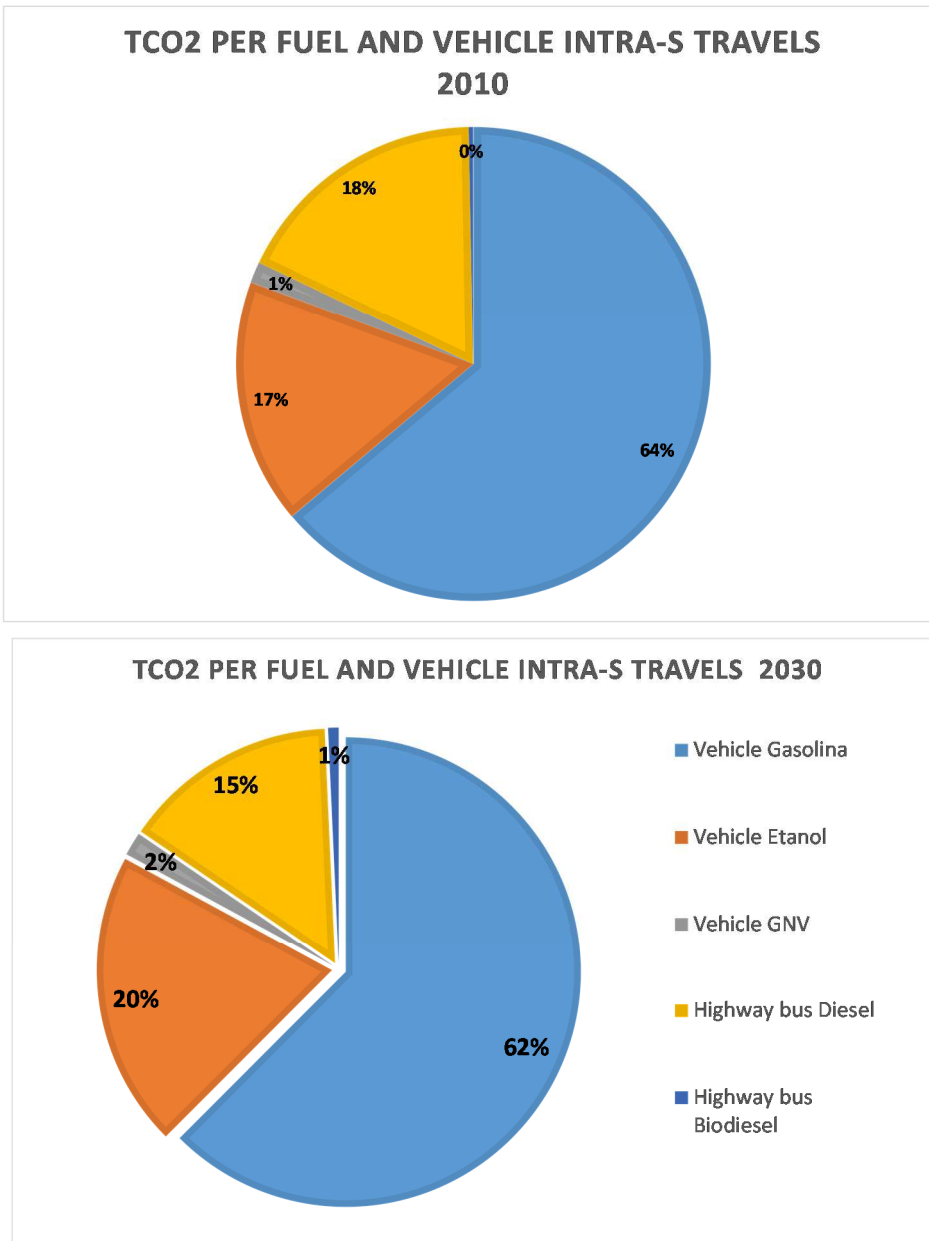
The contribution of each type of fuel to emissions from travel is given by the following figures: for intra-state travel (Figure 70), inter-state travel (

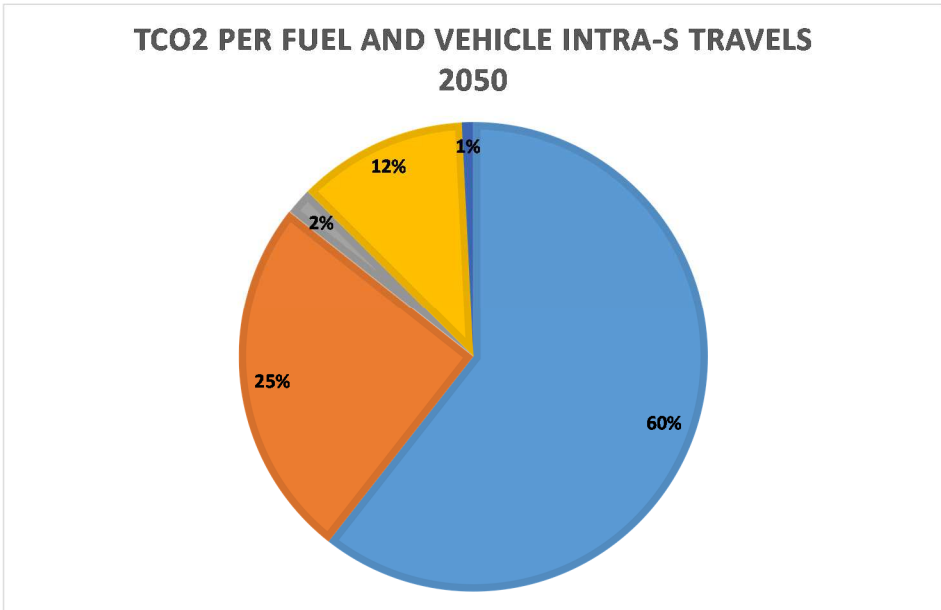
For inter-state mobility, the share of the emissions from kerosene tend to increase with time whereas the relative share of the other fuels remains rather constant.

Figure 71) and international tourism.

The evolution of intra-state mobility shows an increase in the share of biofuels.

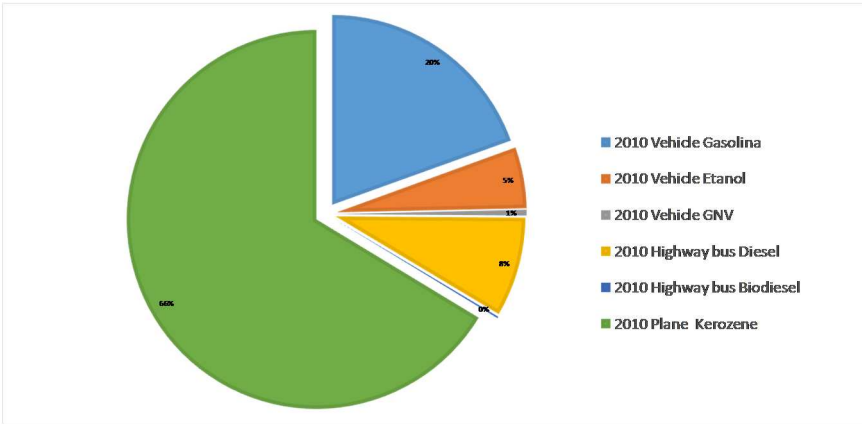
Figure 70. Emissions according to fuels and vehicles for 2010, 2030, 2050. Intra-state travel.

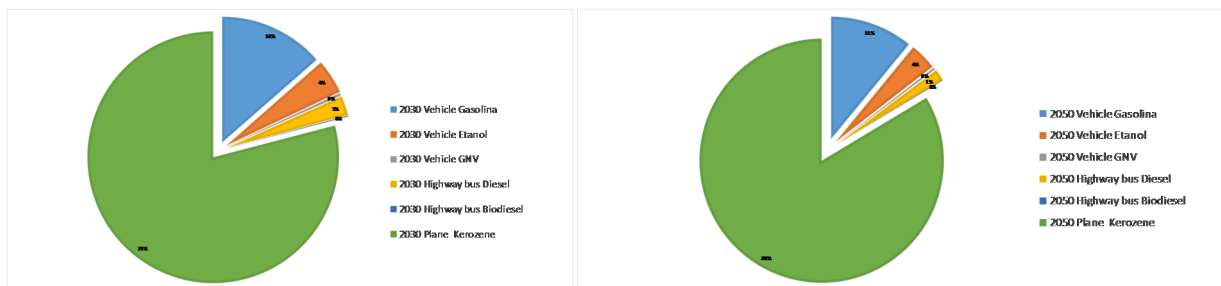




For inter-state mobility, the share of the emissions from kerosene tend to increase with time whereas the relative share of the other fuels remains rather constant.

Figure 71. Emissions according to fuels and vehicles for 2010, 2030, 2050. Inter-state travel.





Regarding international emissions, emissions from kerosene dwarf all the rest and this situation does not significantly change along time.

Factors for change / sensitivity tests

Before building alternative scenarios explaining how some fair contribution of tourism to Brazil’s mitigation objectives could be reached, we go through an intermediate step. We draw alternative hypotheses for the variables we deem relevant. For each variable this can be one or more alternative hypotheses to the one retained for the business as usual scenario; this can also be none. The hypotheses can express two extreme states for a given variable (e.g. a maximum and a minimum outcome for population). Yet, future states of a variable do not necessarily represent extremes: there can be just one alternative hypothesis or more than two. **This is why the alternatives will be referred to as A, B...** In further steps, these hypothesis will be used as “building blocks” for the construction of scenarios.

GDP

We make an optimistic assumption, i.e. the projected growth as seen by the OECD: 3.9% to 2030 and 2.5% after (see p.72) (Hypothesis B).

We also make a pessimistic assumption were Brazil would rapidly behave as what is foreseen by Piketty (Piketty 2013) for old industrialized countries (see p.72), i.e. 1.5% to 2030 and 1.2% after (Hypothesis A).

Finally we retain as an intermediate hypothesis between the first two i.e. the one already made for the business as usual scenario: 3% to 2030 and 2% after (Hypothesis C).

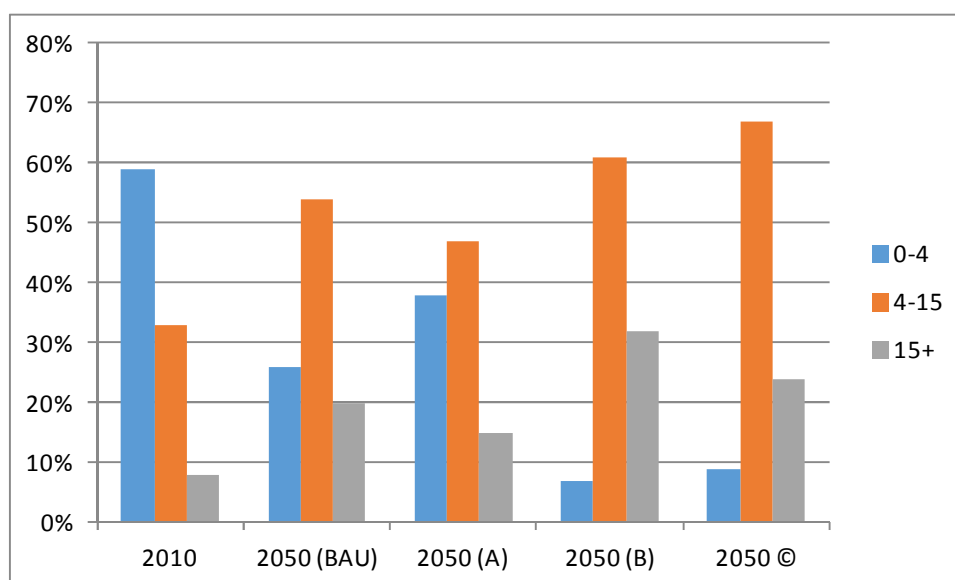
We take into account in our calculations the fact that the growth of wealth mechanically implies the shift of the richer people of one class (e.g. low) to the next (e.g. middle) whose behaviour they adopt. This shift is described in Figure 72.

Figure 72. Evolution of the share of economic classes according to growth hypotheses.



	2010	2050 (BAU)	2050 (A)	2050 (B)	2050 ©
0-4	59%	26%	38%	7%	9%
4-15	33%	54%	47%	61%	67%
15+	8%	20%	15%	32%	24%

0-4 minimum salary of 2010 : lower class; 4-15 minimum salary : middle class; 15+ minimum salary : upper class



Income distribution

Brazil is one of the most inegalitarian countries in the world. Its Gini index was 57.19 in 2012 (<http://search.worldbank.org/data?qterm=income+distribution&language=&format=>). The most equalitarian countries have an index around 36 (e.g. Denmark in 2010).

We may one alternative hypothesis which is to suppose that in 2050 Brazil would have the same income distribution as Denmark in 2010 (Figure 73) (Hypothesis A). The outcome of such an hypothesis varies according to the three growth rates hypotheses that have been made above.

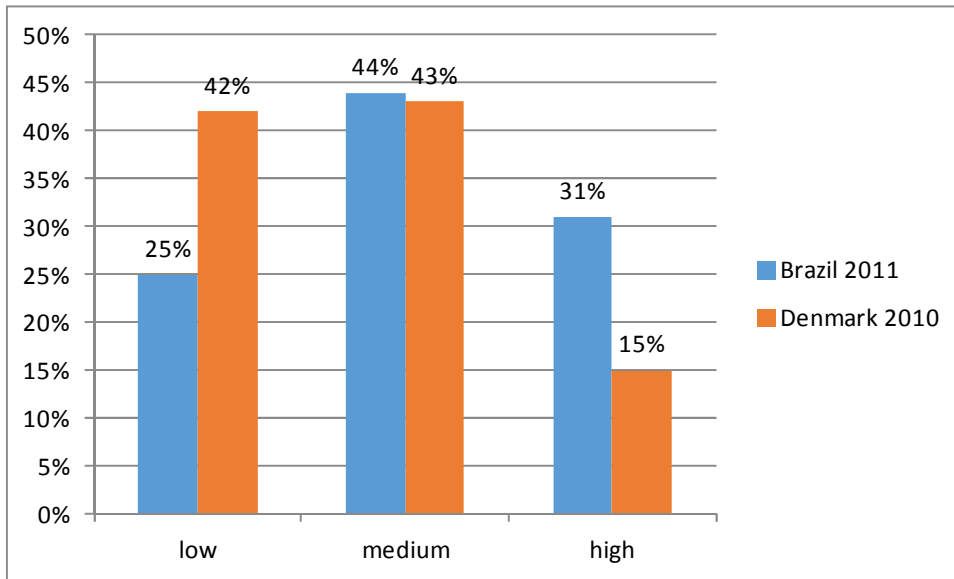
No other alternative is studied since we have some difficulties to imagine for Brazil a more inegalitarian income distribution than it is now.

Figure 73. Comparative structure of income in Brazil and Denmark based on the partition used for tourism statistics in Brazil.

% of income	Brazil 2011	Denmark 2010
low	25%	42%
medium	44%	43%
high	31%	15%

NB: the lower class (i.e. 60% of the population in Brazil) represents 25% of income, the same proportion of the population represents 42% of income in Denmark....



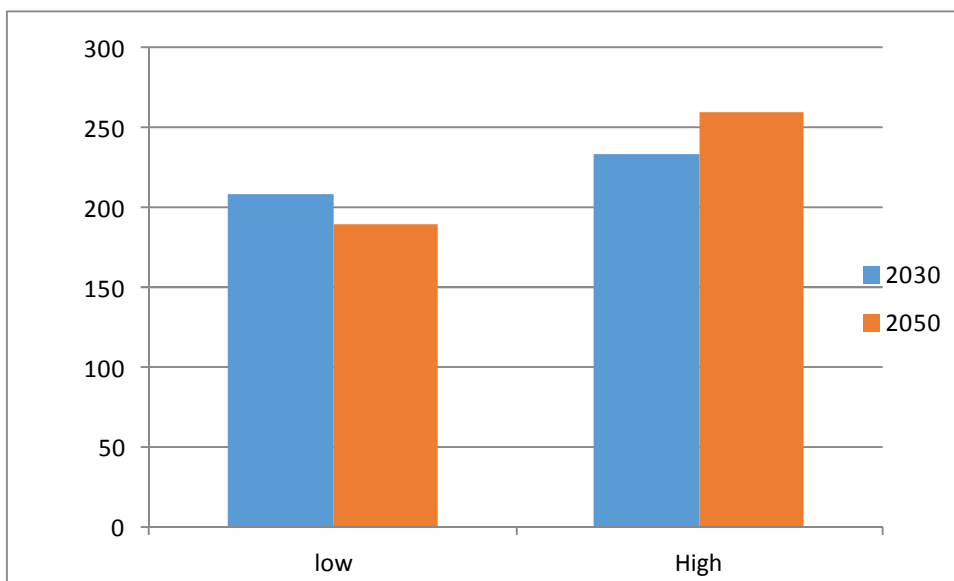


Demography

For the projection of population we use the low and high variants of the population projection by the UN Population Division (see Figure 45). This leads to the following values.

Figure 74. High and low variants of the Brazilian population (2030,2050)

Million	2030	2050
Low	208	190
High	233	260



Households

The figures which have been retained for the reference scenario represent a low prediction of household size: all countries with small households currently still exceed two persons per



household. The sole reasonable alternative we can consider as relevant would be an almost constant number of persons per household that would be linked with economic stagnation.

Figure 75. Number of persons per household.

2010	3,1
2030	3,0
2050	2,9

Proportion of urban population

We make no further hypothesis diverging from BAU.

Accommodation

CO2 efficiency of accommodation

In the business as usual scenario we made the hypothesis that the greenhouse gas efficiency of domestic accommodation would not improve whereas that of international accommodation would improve at the rate of 1% per year. We can make two alternative hypotheses: in the first one neither the efficiency of the domestic nor of the international accommodation improve, and in the second one, both improve at the rate of 1% per year.

Length of stay

In the business as usual scenario, the length of stay remains constant along time. In the sensitivity tests we make two alternative hypotheses.

- The first would be a lengthening of stays, i.e. for international trips: 10 days in 2030, 15 days in 2050 and for domestic trips: 5 days in 2030, 6 days in 2050.
- The second would be a shortening of stays i.e. for international trips: 7 days in 2030 and 5 days in 2050, for domestic trips: 3 days both in 2030 and 2050.

In the way we built the model, length of stay strongly impacts the number of trips, and therefore the GHG emissions. Indeed, we assume that for a given GDP per capita, the total number of days spent outside home remains constant, i.e. that if the length of stay increases, the number of trips decrease (and conversely).

Modal share

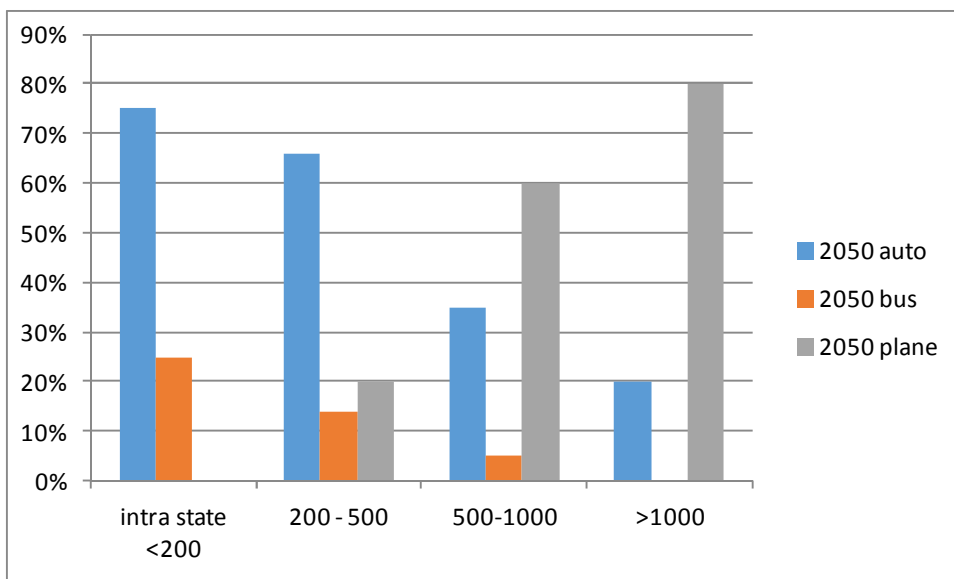
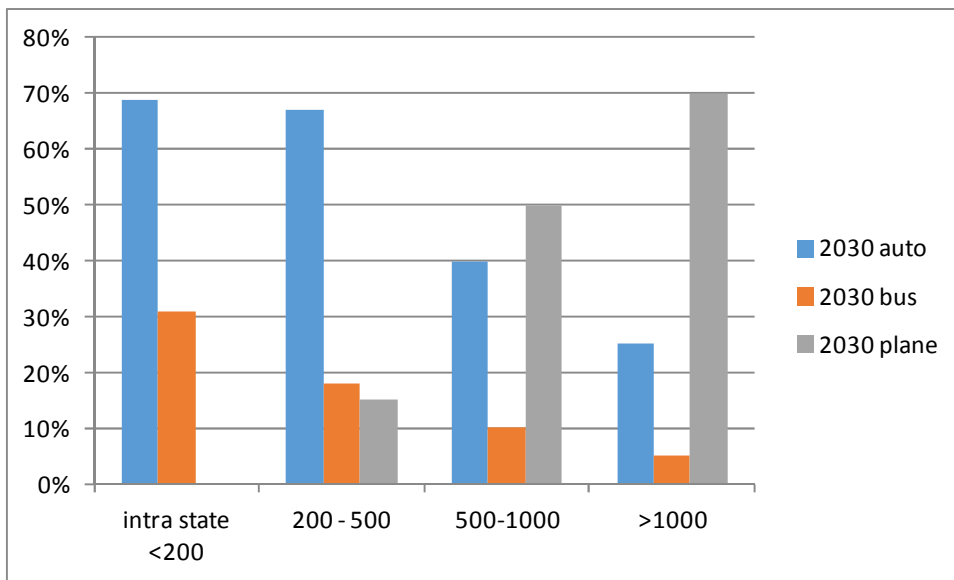
We make two alternative assumptions.

The first one (Hypothesis A) consists in maximizing the share of aviation well over the figures of the business as usual scenario; this leads to the figures in the tables below.



Figure 76. Modal share 2030,2050 - Hypothesis A.

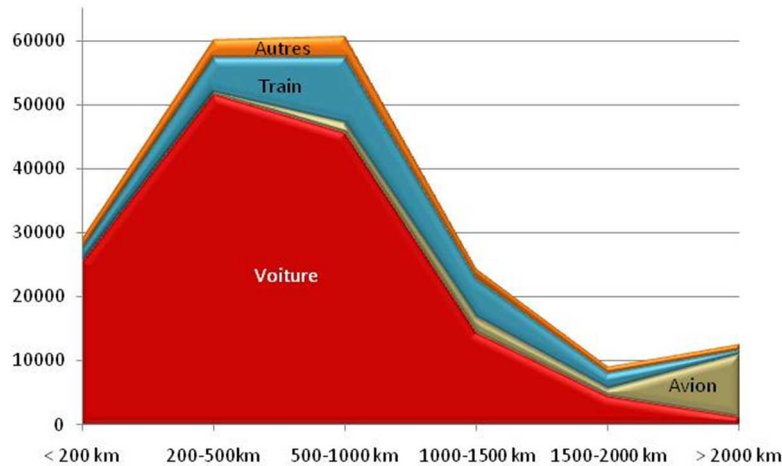
2030				
Distance (km)	auto	bus	plane	Total
intra state <200	69%	31%	0%	100%
200 - 500	67%	18%	15%	100%
500-1000	40%	10%	50%	100%
>1000	25%	5%	70%	100%
2050				
Distance (km)	auto	bus	plane	Total
intra state <200	75%	25%	0%	100%
200 - 500	66%	14%	20%	100%
500-1000	35%	5%	60%	100%
>1000	20%	0%	80%	100%



The share of aviation depicted here does not seem absurd when compared to our previous work for France.

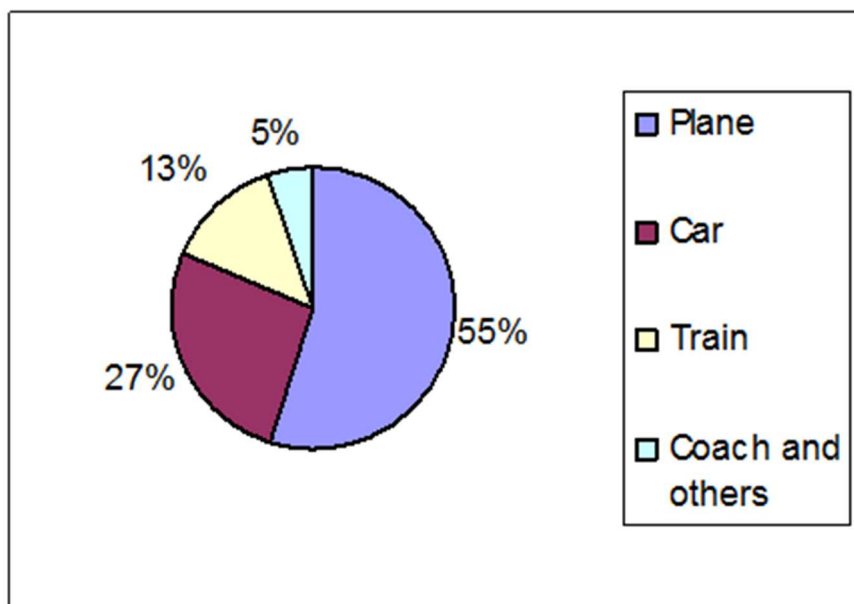
For distances over 1000 km one-way (2000 km return) aviation already represents in France more than 80% of trips (see Figure 77).

Figure 77. Modal share for tourist trips of French tourists according to distance (return trips). 2007.



In the business as usual scenario we built for 2050 (Ceron and Dubois 2006), aviation represented 55% of passenger kilometres (an average over all distance classes, see Figure 78).

Figure 78. Modal share in a French business as usual scenario (2050).



Source: (Ceron and Dubois 2006)



The hypotheses for aviation are completed by a sharp downfall of the share of bus, whereas, car transport resists well notably on short and moderate distances. Besides, these evolutions are reflected in the figures we use for the share of terrestrial versus air transport and bus versus car for trips to neighbouring countries in South America .

Figure 79. Evolution of the relative share of car and bus in international trips by ground transport (Hypothesis A)

	2010	2030	2050
Bus	54	20	0
Cars	46	80	100

The second hypothesis (B) innovates by introducing some travel by train. In Brazil there is hardly any passenger transport by rail and both the population and the government do not seem interested in developing it. A recent attempt to build a high-speed link between Rio de Janeiro and São Paulo was abandoned. It remains that the bulk of passenger transport concerns distances where the train is an interesting mode of transport, the more as in Brazil it would be fuelled by hydroelectricity which is carbon neutral.

The World Bank scenarios for Brazilian transport in 2030 (De Gouvello 2010) include a low carbon scenario where the train takes the share of 3% of passenger transport in 2030. We take this as a basis for our own scenario in 2030; we distribute a larger part of these 3% on short and medium distances whereas we consider that they do not inflect the shares over 1000 km one-way. Practically all this shift of passengers is taken from aviation whereas the share of cars remains practically constant. This is yet not enough to compensate at this time scale the loss of the share of buses. Nevertheless collective terrestrial transport takes a larger part than in the business as usual scenario.

2050 is quite a different time horizon. Should Brazil decide in the near future to invest massively in passenger rail transport, the results would come after 2030. If we consider such a hypothesis, we face the choice of the level of the modal share to take for 2050. In France which is not an exception in Western Europe, the modal share of trains is 9%. Japan with a share of 27% can be seen as currently the world record. For 2050, in our sustainable development scenario for French tourism, we came to a share of 36% which the Japanese case shows not to be completely absurd. This however can be seen as far too much from Brazil, owing to its starting point and perhaps to the investment which would be necessary¹¹ etc. We thus take a share of 20% for medium on short distances, and 10% for long distances where the competition with plane will be less favorable. Since trains will be powered by hydro electricity (almost carbon neutral) we consider the emissions coefficient as next to 0 (see the figures for high speed trains in France (Dubois and Ceron 2009).

Within this hypothesis we still consider the modal share of buses will continue to diminish up to 2050; but from 2030 on, the train does more than compensate this loss. Yet, the net effect is rather moderate though significant. Compared to the business as usual, the car loses shares for the two shorter distance classes and resists on long distances. The plane also loses modal share, more significantly for short distances than for long distances (see

¹¹ nevertheless if we consider the investment in road infrastructure, notably in megacities, setting up a rail infrastructure does not seem completely out of reach.



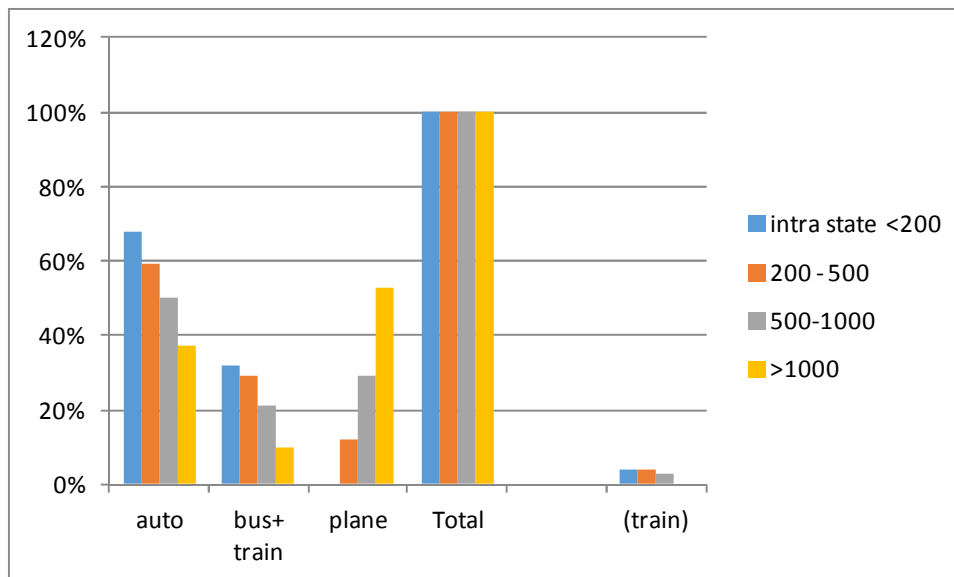
Figure 80 & Figure 81).



Figure 80. Modal share 2030,2050 ; Hypothesis B.

2030						
Distance (km)	auto	bus+ train	plane	Total		(train)
intra state <200	68%	32%	0%	100%		4%
200 - 500	59%	29%	12%	100%		4%
500-1000	50%	21%	29%	100%		3%
>1000	37%	10%	53%	100%		0%
2050						
Distance (km)	auto	bus+train	plane	Total		(train)
intra state <200	60%	40%	0%	100%		20%
200 - 500	55%	40%	5%	100%		20%
500-1000	49%	36%	25%	110%		20%
>1000	32%	20%	48%	100%		10%

2030...



2050...

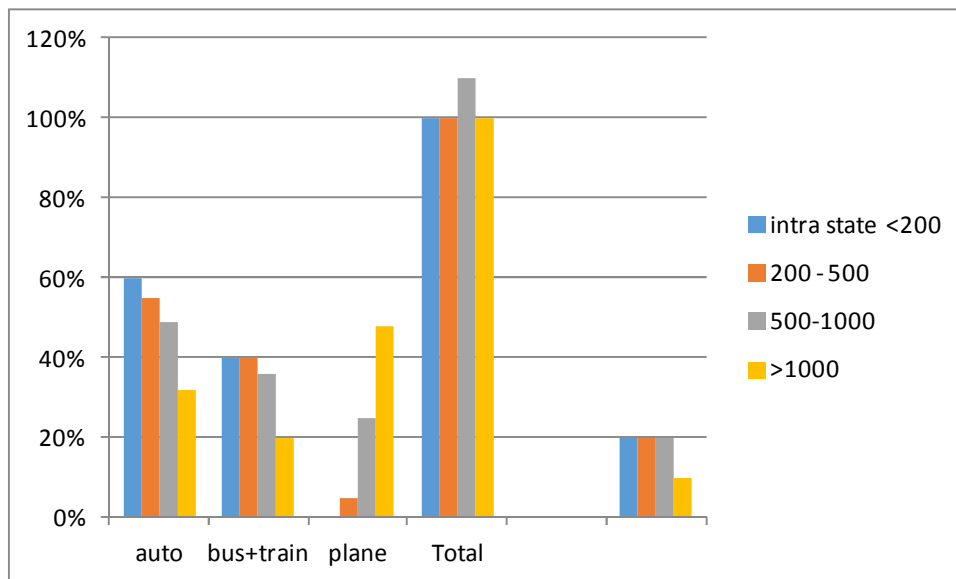


Figure 81. Evolution of the relative share of car and bus in international trips.

	2010	2030	2050
Bus	54	30	10
Cars	46	70	80

Emission factors

Ethanol in the blend of fuels

The rate to which ethanol is being used in Brazil has changed over the years, depending on the regulations, the price of gasoline etc.

Ethanol and flex fuel in Brazil

“Brazil already has a long tradition of substituting gasoline with ethanol. In 1975, Brazil initiated a major bio-ethanol substitution program; it culminated in the 1980s, with more than 85 percent of all new cars produced each year running exclusively on ethanol. By the early 1990s, higher sugar prices and lower oil prices meant that ethanol production was no longer cost-effective. The country faced a supply shortage, forcing customers to revert to gasoline-run cars. However, in 2003, the Brazilian car industry launched the first flex-fuel vehicle, equipped with an engine that can use any mixture of gasoline and ethanol. This innovation represented the flexibility the market needed for mitigating supply and price risks for customers. Since then, the number of flex-fuel vehicles has grown rapidly and now totals more than 8 million; in June 2009, 89 percent of all new vehicles produced in Brazil were flex-fuel”

Source: (De Gouvello 2010)

This leads us to make the alternative hypotheses.

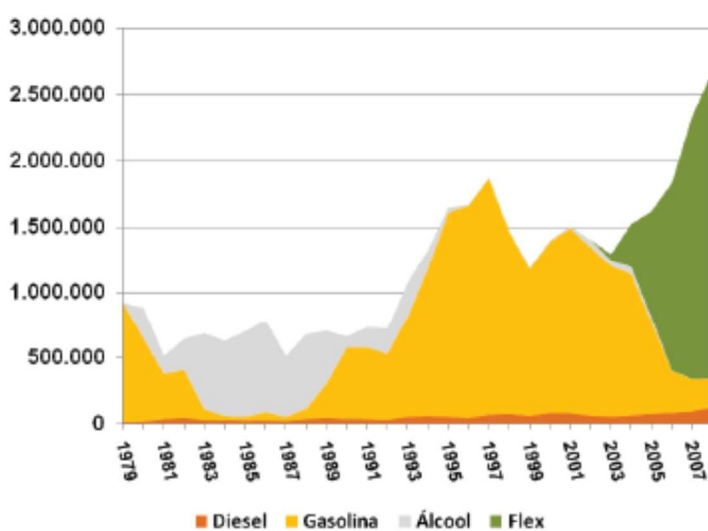
The first (Hypothesis A) would be a tendency toward cheaper oil which would lead to reverse the trend towards a larger use of ethanol: the large proportion of flex cars (see above) shows



that this possibility is not excluded. The percentage of ethanol would then be 55% in 2030 and 50% in 2050 (compared to 65% and 70% in the business as usual scenario). The proportion of bio diesel in buses would not change.

The second (Hypothesis B) would be a generalisation of ethanol in cars, with a proportion of 70% in 2030 and 100% in 2050. The proportion of bio diesel used in buses would increase by 10% in 2030 over business as usual (i.e. 26%) and 20% in 2050.

Figure 82. Evolution of individual vehicles sales by engine type; 1979-2007 (showing number of cars sold per year).



Source: ANFAVEA.

Source: (De Gouvello 2010)

Terrestrial modal split for international travel

We take into account the decline of buses which would lead to increase (Hypothesis A) the proportion of cars in the part of terrestrial travel that would be left to reach neighbouring countries: 70% of car travel in 2030, 90% in 2050. The proportion of terrestrial travel versus air travel would remain the same: 10%.

Emission factors for air transport

Owing to the role that aviation plays in the total emissions, the future of emissions coefficients appear critical. In the business as usual scenario we have considered a rather optimistic prediction providing aviation remains fuelled by kerosene.

At the time horizons we are considering, the only revolution in coefficients could come from the introduction of biofuels. “Airlines are experimenting with replacing kerosene with biofuels, which offer direct greenhouse gas emission reductions of 30-90%.” (IPCC 2013). For the Brazilian case we adopt a savings ratio which is the same as for shifting from gasoline to ethanol (i.e. $0.436/2.56=83\%$). Brazil is certainly one of the countries where biofuels could be the most easily introduced; this is coherent with the hypothesis made for terrestrial transport... We consider a hypothesis where in 2050, or Brazilian companies (supposedly 50% of the traffic) would use biofuels to leave Brazil but kerosene to return, which means that biofuels would be 25% of the total. For 2030 will make an assumption of 5%. Domestic flights would totally depend on biofuels in 2050 (20% in 2030).



Regarding non-CO2 emissions and radiative forcing, we assume we will have to add the new emissions due to biofuels and the warming potential specific to aviation which does not change with the use of biofuels : this means we add the equivalent of initial CO2 emissions since we are not aware of any reason why biofuels emitting at high altitude would not have the same effect as conventional fuels. This means that for instance for 2050/long-distance (see below) we add 110 to 18.7 =128.7

Figure 83 : Emission factors under biofuel substitution assumptions (CO2 and radiative forcing effects included)

Coefficients	2030	2050
International (long)	215.44	197.18
Domestic (average)	229	146

The detailed calculation is in Annex.

Emission factors for terrestrial vehicles

We formulate two alternative hypotheses.

The first one (Hypothesis A) takes into account the acknowledgement that in the IPCC fifth assessment report, there are still 50% of gains to be made on the energy efficiency of vehicles, which corresponds to a yearly progress of 1.7% over 40 years. In this case we also assume that there will be no rebound effect.

The second one considers a high rebound effect (e.g. larger cars due to savings in fuel consumption gains by energy efficiency), which the same source says to be particularly important in developing countries, e.g. up to 60% which translates into a yearly progress of 0.6%.

Load factors for terrestrial transport

Whereas we consider that the load factor for cars will not change (2.5), it seems coherent to associate the regression in the use of buses with a diminishing load factor (30 instead of 42).



Results

Figure 84 gives for the various hypotheses that are made on selected variables the deviation from the business as usual scenario.

The variable with the greatest impact on emissions is clearly the **rate of growth** of the economy, giving outcomes ranging from -25% to + 36% in 2050 for the three hypotheses (low, medium and high) we retained. The major distance is between the high-growth hypothesis on the one side and the low and medium growth hypotheses on the other.

It must also be noted that these outcomes are highly modified¹² by the hypothesis of a **more equalitarian income distribution** (see also Figure 85). An equalitarian distribution lowers the emissions in all cases : the highest gain resulting from an equalitarian society is for the high-growth scenario (36.4 - 11 = 25.4%), and the lowest for the low growth scenario (31.5 - 25.7 = 5.8%). The importance of the impact of the equalitarian distribution of income on the high-growth scenario must be stressed: if high-growth (which is highly desired by politicians...) occurs (i.e. 0.9% over business as usual to 2030 and 0.5% after), the most efficient way of mitigating the increase of emissions is a more equalitarian society. Nevertheless, the absolute value of emissions remains quite a problematic.

In absolute value is the most important decrease in emissions relative to business as usual is obtained by the equalitarian low growth scenario; let us remind that in a long term perspective, growth rates ranging from 1.2% to 1.5% can be considered as usual and do not reflect an immobile society.

The importance of the deviation from business as usual related to the modification of **length of stays** (longer stays and less trips...) is of the same order of magnitude as for the two factors above, i.e. from -30% to +30%. This factor is quite naturally identified as crucial in previous work (e.g.(UNWTO, UNEP et al. 2008)), the novelty here is that its importance is more clearly weighed against other factors. The overall trend along the past decades in developed economies is a shortening of length of stays. Mitigating emissions clearly implies that this trend should be reversed (Ceron and Dubois 2005). This calls for policies framing the role of leisure in society and the place of tourism in leisure time, which will be probably more effective than policies limited to the field of merchant tourism (i.e. acting on the "tourism industry").

A fourth factor of significant importance is the hypothetical introduction of **biofuels** in aviation, which would in our mind be specific to Brazil. The hypothesis we made (p.101) has some influence on the emissions in 2030 (-10%) and a quite significant one in 2050 (-19 %). In terms of energy efficiency and fuel substitution, it is by far the hypothesis that leads to the most important reduction of emissions.

More surprisingly, modal shifts, given the assumptions one can reasonably do for the future, impact less significantly future emissions (less than +/- 10%in 2050), notwithstanding the fact that some rather strong deviations from the business as usual scenario have been considered regarding modal share. The first one (a sharp increase in the share of aviation, impacting essentially domestic travel...) would result in +11% above business as usual. The second one characterised by an introduction of train would diminish emissions by 7% in 2050. Overall, the impact of modal share appears rather moderate compared to the first four variables. This results is rather disappointing compared to what has been demonstrated for France in previous work (Ceron and Dubois 2006), but it can be explained by the foreseeable decline of bus on the one hand, and by the fact that the train cannot be developed fast enough to reach a potential that can be compared to that of European countries or Japan.

12 note that the changes implied by the two variables do not add up: e.g. The impact of low growth alone is 25.7% and combined with an equalitarian distribution of income reaches -31.5% C

Figure 84. Sensitivity tests.

		Hypothesis A	Delta A 2030	Delta A2050
GDP	Rate of GDP growth	1,5% to 2030, 1,2% 2030-2050	-19,7%	-25,7%
	Income distribution + GDP	Income distribution equal to that of Denmark 2011, First combined with growth A	-28,1%	-31,5%
Demography	population	208 M in 2030,190 M in 2050	-4,1%	-6,0%
	Households	3 to 2030, 2,9 after	-4,4%	-1,2%
	Urban proportion	no alternative hypothesis		
Accommodation	Length of stay	International: 10 days in 2030, 15 days in 2050 . Domestic: 5 days in 2030, 6 days in 2050	-32,5%	-30,5%
	Accommodation CO2 efficiency domestic and international	improvement: 0% per year	0,4%	0,8%
Modal share and CO2	modal share	see separate figures	6,2%	10,8%
	Ethanol in the blend of fuel	Inversed tendency : 55% in 2030 50% in 2050 Buses no move	1,9%	1,7%
	Emission factor plane	domestic flights: biofuels in 2030, 20%, in 2050 100%. International flights: biofuels in 2030, 5%, in 2050, 25%	-10,0%	-19,8%
	Emission factors terrestrial vehicles	energy efficiency 1,7 % per year	0,9%	-0,5%
	Load factors buses	30	0,3%	0,1%
	Load factors cars	no change		
		Hypothesis B	Delta B 2030	Delta B2050
GDP	Rate of GDP growth	3,9% to 2030, 2,5% 2030 to 2050	40,5%	36,4%
	Income distribution + GDP	Income distribution equal to that of Denmark 2011, Combined with growth B	1,6%	11,0%
Demography	population	233M in 2030, 260M in 2050	4,7%	6,7%
	Households			
	Urban proportion			
Accommodation	Length of stay	International: 7 days in 2030 5 days in 2050, Domestic: 3 days in 2030 and 2050	30,2%	29,1%
	Accommodation CO2 efficiency domestic and international	Improvement: 1% per year	-1,7%	-3,3%
Modal share and CO2	modal share	See separate figures	-1,3%	-6,9%
	Ethanol in the blend of fuel	70% in 2030 :26 and 41% 100% in 2050 Buses : + 10% biodiesel in 2030 and + 20% in 2050	-1,1%	-1,7%
	Emission factor plane			
	Emission factors terrestrial vehicles	Energy efficiency 0,56% / year	4,7%	4,3%
	Load factors buses			
	Load factors cars			
		Hyp C	Delta C 2030	Delta C 2050
GDP	Rate of GDP growth	3% to 2030, 2% after	0	0
	Income distribution + GDP	Income distribution equal to that of Denmark 2011,combined with growth C	-11,0%	-7,9%



Figure 85. Emissions resulting from the combination of various rates of growth with distribution of income in 2050.

Emissions compared to BAU	low growth	high-growth	medium growth
Combined with equalitarian distribution.	-31.5%	+11%	-7.9%
Combined with inegalitarian distribution. i.e. BAU	-25.7%	+36.4%	0%

It thus appears that three out of the four variables (taking into account bio fuels in aviation below...) that impact the most the future of emissions are exogenous to the world of tourism and out of reach of its "sectoral" policies.

The sharp increases of emissions linked with high growth rates (which currently are highly desired by an overwhelming part of society...) are also shown; yet we know that desiring high growth rates is not enough to obtain them. As we have already pointed out (p.72), the rates of growth expected by the OECD and governments reveal more wishful thinking than they relate to historical experience .

The category of income inequality is also exogenous to tourism; and undoubtedly it is a major factor shaping societies. Correlations of equality can be shown with the indicators of well-being and everyday life (health, crime, education, etc.) <http://fr.slideshare.net/equalitytrust>. The historical evolution of income inequality suggests that it might be more easily handled by policies than growth, at least in the sense that growth is confronted to the planet's limits and to the international economic context. Both tools and circumstances leading to a more equalitarian society have been identified for a long time (Ricardo was a pioneer...) and traced along history (Piketty 2013). Enforcing them is source of conflict, as the social groups who benefit from the inequalities also largely detain power and are not willing to hand it over. This changes nothing to the fact that the sensitivity tests show that a more equal society would have a major impact on the mitigation of emissions from tourism.

Alternative scenarios

The choice of variables and the sensitivity tests above allow us to combine variables so as to build alternative scenarios to business as usual. Our main interest is in scenarios that result in emissions reductions. The process we developed also allows us to assess how far over business as usual the increase in emissions could go.

The reduction of emissions associated to the various scenarios can be compared to the goals that are envisaged for the whole of Brazilian emissions so as to see whether tourism can be expected to contribute at a fair level.

Should the contribution of scenarios fall short, this would imply considering further discussions or additional alternatives, i.e.

- one option would be to grant tourism are more favourable treatment than the average of activities. On what grounds could this be justified?



- the other option is to cap the growth of tourism. In that case what substitutions in the field of leisure time can be envisaged so as to maintain the level of welfare?

The combination of hypotheses for the different variables in each scenario must tell a coherent story: e.g. A constant size of households seems coherent with low growth, not with high growth; so in this last case we shall keep the hypothesis of a decrease as in the business as usual scenario.

Methodological issues: which variables to combine?

The high weight of growth hypotheses has been pointed above. Consequently we build one reduction scenario for each growth hypothesis. Since the aim is a reduction of emissions and the high impact of an equalitarian distribution of income has been show, we add this choice to each of the previous ones.

The “low growth” scenario

The low growth scenario is in a first step an assessment of how far the reduction of emissions can go. This is why, within it, we combine hypotheses leading to high reduction of emissions for the remaining variables: e.g. a small increase in the population and a small decrease in household size compared to the business as usual scenario; the length of stay increases, the higher progress in the energy efficiency of accommodation is considered. Regarding transport, modal share choices favorable to collective transport and unfavorable to aviation are retained, as well as the most optimistic hypotheses for energy efficiency and the penetration of biofuels (including from aviation).

Figure 86. Low growth scenario: the combination of hypotheses.

			HYP A	HYP B	HYP C
1	GDP	Rate of GDP growth			
2		Income distribution			
3	Demography	population			
4		Households			
5	Accomodation	Length of stay			
6		Accomodation CO2 efficiency domestic and international			
7	Modal share and CO2	modal share			
8		Ethanol in the blend of fuel			
9		Emission factor plane			
10		Emission factors terrestrial vehicles			
11		Load factors buses			

The “high growth” scenario.

The GDP and income distribution hypotheses are here associated with:

- a low projection for population, since a fast demographic transition is felt to be coherent with a general progress of wealth and its more equal distribution;
- a diminishing size of households as in the business as usual scenario, for the same type of reason as above;
- a length of stay that would diminish as it has done in countries which developed earlier;
- a low progress in energy efficiency of accommodation, related to an increase in luxury;
- an increase in the modal share of aviation, in a context where cheap oil would hamper the use of ethanol;



- finally, the load factor of buses would decrease along with the crisis of this mode of transport.

Figure 87. High growth scenario: the combination of hypotheses.

			HYP A	HYP B	HYP C
1	GDP	Rate of GDP growth			
2		Income distribution			
3	Demography	population			
4		Households			
5	Accommodation	Length of stay			
6		Accommodation CO2 efficiency domestic and international			
7	Modal share and CO2	modal share			
8		Ethanol in the blend of fuel			
9		Emission factor plane			
10		Emission factors terrestrial vehicles			
11		Load factors buses			

The “medium growth” scenario.

The GDP growth hypothesis is the same as in the business as usual scenario. The income distribution hypothesis are associated with the same demographic growth hypotheses as in the previous scenario. Conversely the length of stay is supposed to increase and the most favourable choices for a reduction of emissions in accommodation and transport are retained as in the low growth scenario.

Figure 88. Medium growth scenario: the combination of hypotheses.

			HYP A	HYP B	HYP C
1	GDP	Rate of GDP growth			
2		Income distribution			
3	Demography	population			
4		Households			
5	Accommodation	Length of stay			
6		Accommodation CO2 efficiency domestic and international			
7	Modal share and CO2	modal share			
8		Ethanol in the blend of fuel			
9		Emission factor plane			
10		Emission factors terrestrial vehicles			
11		Load factors buses			



The “worst case” scenario.

This last scenario aims of assessing some upper limit for emissions.

It associates are high GDP growth with an inegalitarian distribution of income such as in the business as usual scenario. Regarding demography, a high population variant and a diminishing size of households are retained. The length of stay diminishes. The less favourable options for energy intensity and the choice of fuels are also retained.

Figure 89. Worst case scenario: the combination of hypotheses.

			HYP A	HYP B	HYP C
1	GDP	Rate of GDP growth			
2		Income distribution			
3	Demography	population			
4		Households			
5	Accommodation	Length of stay			
6		Accommodation CO2 efficiency domestic and international			
7	Modal share and CO2	modal share			
8		Ethanol in the blend of fuel			
9		Emission factor plane			
10		Emission factors terrestrial vehicles			
11		Load factors buses			

Results

Following the combinations described (Figure 86, Figure 87, Figure 88, Figure 89), we give for the four scenarios in 2030 and 2050 the absolute value of emissions (Figure 90), their deviation from the business as usual scenario (Figure 91) and their increase compared to 2010.

Figure 90. Absolute value of emissions of the four scenarios (tons).

Emissions	2010	2030	2050
BAU	53 744 730	222 958 916	450 979 741
low growth scen	53 744 730	90 620 627	149 092 986
high growth scen	53 744 730	307 911 707	706 643 352
medium growth	53 744 730	111 846 593	191 145 318
worse case scen	53 744 730	397 960 773	889 032 717



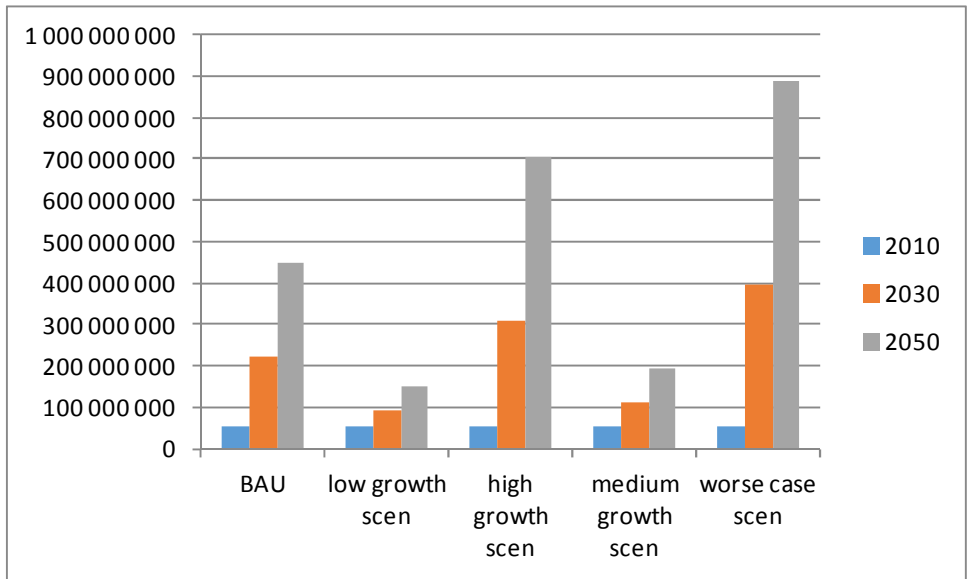
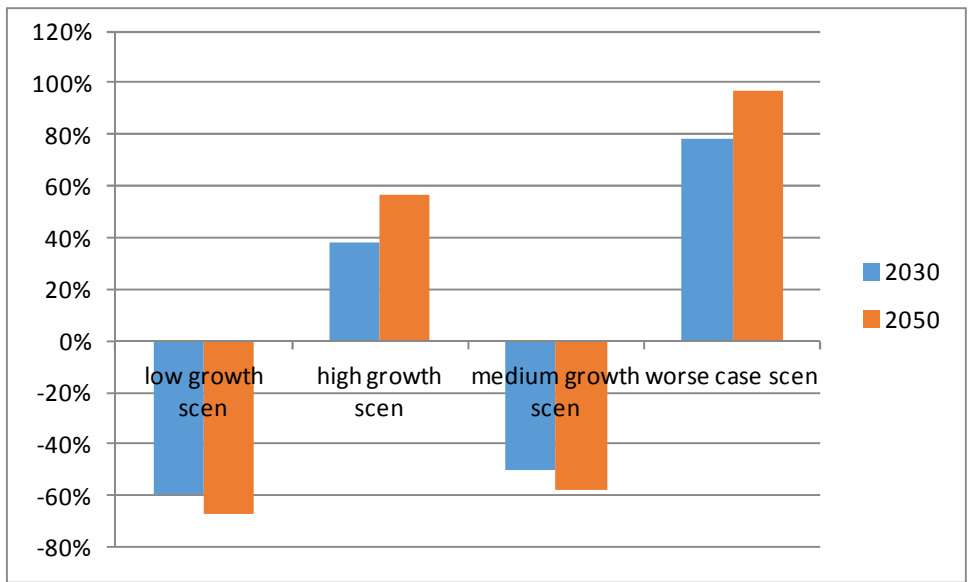


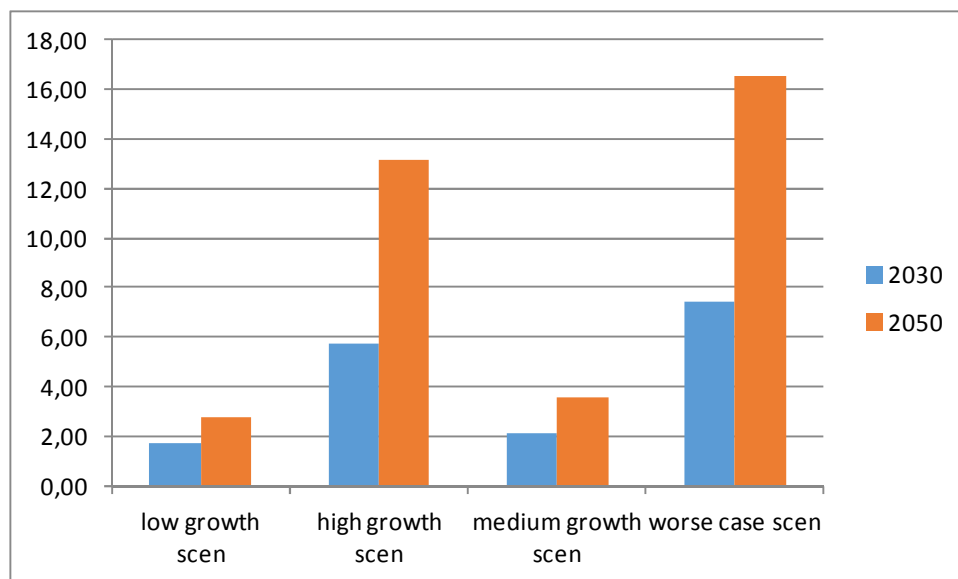
Figure 91. Emissions relative to 2010.and to BAU (%)

	2030	2050	2030	2050
BAU				
low growth scen	1,69	2,77	-59%	-67%
high growth scen	5,73	13,15	38%	57%
medium growth scen	2,08	3,56	-50%	-58%
worse case scen	7,40	16,54	78%	97%

Emissions relative to BAU (%)



Emissions relative to 2010



Comparing the scenarios between them

The increase of emissions in the business as usual scenario must be first recalled: roughly a multiplication by 4 and 8 to 2030 and 2050; this shows how much the emissions from tourism should be a concern!

The worst-case scenario shows that these prospects could be more than doubled (factor of x7.4 and x16.5 !) by an unfavourable combination of hypotheses. Looking at Figure 84 and Figure 89 shows that none of these individual hypotheses are incredible and that the combination one with another is not illogical (though naturally some combinations can be discussed).

Some of the drivers of the worst-case scenario are highly desired by governmental bodies or society as a whole. The rate of growth considered is near to governmental or OECD expectations; the shortening of stays is a constant observation in the development of tourism in other countries... The projection of population is just the high version of UN prospects. The energy and transport choices would be coherent with a context of cheap fossil resources (unconventional sources of oil at a rather low price (bearing in mind that Brazil has some growing proven oil resources) and a weak global concern for climate change mitigation. New sources of oil in North America and Latin America, the endless difficulty to find global agreements on climate change mitigation tend to support such a global prospect.

The progress of GDP is confirmed to be one of the major drivers of the evolution of emissions (-25% to + 36% in 2050). It is also shown that it is not the only one situated in that order of magnitude: the length of stay, income distribution, or the use of biofuels in aviation can also be identified. One important question is whether such variables are connected (“are” or “could be”) or disconnected with GDP. In the first case it can be argued that considering the evolution of GDP can suffice to explore the future (as it is frequently done). We wish to point:

- that some connections, i.e. GDP and income distribution depend on a given historical context and are not founded on logical grounds; growth of GDP in affluent societies is currently associated with a high and increasingly unequal distribution of wealth. There is no logical reason why it should always be so; in fact the reverse situation has been noted in other periods, e.g. postwar years in Europe. So it is shown, even in the high-growth scenario, that an equalitarian distribution of income can largely offset the impact of growth on emissions;
- the other highly impacting variables are even more clearly disconnected from the evolution of GDP. The length of stay is linked to the way a society organizes its use of



leisure time, whatever the level of wealth (providing of course wealth and its distribution allow access to tourism). The length of stay can for example be shaped and constrained by the legislation on holidays (how many days? taken in one period or split into several?) or the schedule of school vacations. The same can be said for the introduction of biofuels which is highly dependent on political will and on the organisation of the energy market.

This being said, it remains that if no action is taken on variables such as length of stay, energy use in accommodation etc, the spontaneous trend will be towards reinforcing the impact of growth on emissions.

Considering the outcome in terms of emissions it is interesting to note that the medium growth and low growth scenarios lead in 2030 and 2050 to decreases in emissions that only differ by 10% with an advantage to the low growth scenario (e.g. in 2030 LG - 59%, MG -50%) . With a version of the low growth scenario including an inegalitarian distribution of income, the difference would be of 5% (e.g. in 2030 LG -55%) the conclusion is that it is possible to imagine a medium growth scenario (3% to 2030, 2% after) leading to emissions not so far from a low growth scenario (1.5% to 2030, 1.2% after). H A very low growth could not change fundamentally the results compared to a medium growth version (though the emissions must be admitted to be slightly lower).

What share of Brazilian national emissions in the future?

As it has already been shown above (p.82), we have a reference scenario from Brazilian emissions in 2030. This scenario is built for a population of 223 million and a growth rate of GDP of 3.87%. Both are rather high compared to our business as usual scenario. This reference scenario was founded on the post-Copenhagen conference pledges made by Brazil, i.e. a reduction of 36 to 39% compared to the current trajectory. The corresponding emissions in 2030 are 1 539 Mt CO2 equivalent. It can be reminded that the business as usual emissions of tourism (excluding radiative forcing) in 2030 would represent 9.7% of this reference scenario. Including radiative forcing this comes up to 15% (see

Figure 93).

The same work from Brazil builds two other scenarios going further than the Copenhagen pledges. The first of them is founded on a US\$20 carbon tax plus some mitigation measures. The second one takes into account US\$100 carbon tax and some tougher mitigation measures. The mitigation measures of both scenarios are much along the same lines as those we apply, yet it would be difficult to draw a precise comparison; notably because the mitigation scenarios imply growth rates quite similar to the Copenhagen pledges, resulting in the multiplication by 2.59 of GDP in 2030, against 2.58 and 2.55 for the mitigation scenarios (source COPPE). Knowing the impact of growth rates on emissions, which has been shown earlier, it would make no sense to compare our scenarios with others using quite different growth perspectives.

Figure 93 synthesizes what will be the share of emissions from tourism in all these cases. Note that excluding the radiative forcing specificity from aviation will diminish these percentages by about one third.



Figure 92. "Copenhagen pledges" and two alternative scenarios for Brazil in 2030.

Scenario	Description
CPG	Reference Scenario – Follow trends from Copenhagen Pledges
MA1-T	Mitigation Scenario 1 – (20 US\$ carbon tax + mitigation measures)
MA2-T	Mitigation Scenario 2 – (100 US\$ carbon tax + mitigation measures)

source: COPPE.

Figure 93. Share of tourism (non CO2 radiative forcing of aviation included) in national emissions (2030) in a "Copenhagen pledge Scenario"

	CPG 2030
BAU	14%
low growth scen	6%
high growth scen	20%
medium growth	7%
worse case scen	26%

It appears that it is possible to maintain the share of tourism in national emissions at a reasonable level, i.e. comparable or somewhat less than the share it currently takes in developed countries. Such an achievement does not necessitate a very slow growth path: 3% to 2030 is compatible. However, letting tourism develop along what we have called a business as usual scenario leads to a share well over that currently assessed in developed countries (over %). This should probably be considered as unacceptable, the more as Brazil has other priorities which need an emissions budget to be dealt with. Thus, some additional policies than those included in the business as usual scenario are indispensable. When enforced as suggested in the medium growth scenario, it is possible to maintain the share of emissions at 9 to 11% in the two mitigation scenarios, in a context which is highly constrained.

The assessment above deals with 2030. We have no scenarios for the global emissions of Brazil in 2050, yet in order to contribute to maintain global climate change within the 2°C guardrail, the emissions of Brazil should continue to diminish. With regards to this perspective, the emissions of the three scenarios are highly problematic since they lead to a multiplication of the emissions in 2030 by 1.65 the low growth scenario, 1.7 for the medium growth scenario and 2.3 for the high-growth scenario. There is of course no written law that the share of sectors or activities within the national emissions should remain the same over the next 40 years. Some will diminish and others increase, because mitigation potentials vary along the sectors and because some activities are more desirable and valued by society than others. Nevertheless the prospects of an increase to 2050 are more difficult to envisage for activities that already represent in 2030 a quite significant share of the national emissions, which is the case for tourism with more or less 10% for the medium growth scenario (according to whether a an uplifting factor for aviation is included not). It can be noted that the situation of mature tourism economies is even worse, since the order of magnitude of their emissions is already the same



as the one expected from Brazil in 2030. With regards to emissions, tourism is a challenging sector all over the world.



Conclusion

What is the current contribution of Brazilian tourism to climate change ?

A world assessment showed tourism to be responsible for 5% of the world emissions of CO₂; besides, the bulk of the increase in tourism flows (national and international) is expected to come from developing countries and more particularly from emerging ones.

The assessment of current emissions from Brazilian tourism strongly depends on the metrics used: 55Mt when including an uplift factor for aviation's radiative forcing, 32 or 34Mt when considering CO₂ only and CO₂ equivalent (including non-CO₂ gases but no uplift factor).

The interpretation of such figures depends on the strong specificity of Brazilian national emissions: i.e. an importance of LUCF well over an average, which makes quite a difference whether LUCF is included or not. Moreover, the national emissions of Brazil evolve at a fast pace and the share of LUCF within them too ; so using 2010 or 2005 as a benchmark also makes a difference. A few figures help framing the debate :

- the world average assessment (CO₂ only) does not include LUCF and estimates tourism to 4.9% of global emissions (4% when LUCF included);
- when LUCF is included (2438Mt in 2010) tourism represents 1.35% of national emissions,, well under the international average (which itself is slightly under 4%);
- in 2010, tourism represented around 3.2% of national emissions (1034Mt) of CO₂ equivalent (LUCF excluded);
- when introducing an uplift factor for aviation in 2010, the percentage of tourism for Brazil would have been around 5%;
- the anthropogenic emissions from Brazil in 2005 were 490Mt (26 400 Mt for the same perimeter worldwide). The share for tourism in Brazil would have been then 6.4% (world average: 4.9%).

Assessing the volume of current emissions is therefore in itself an achievement. The benchmarking of these results is not straightforward. In 2010, the emissions of Brazilian tourism are still under the world average. The share of the emissions of Brazilian tourism in national emissions is still quite inferior compared to that of developed countries. Yet, it starts being significant, especially when the specific impact of aviation is included.

Is Brazilian tourism converging with developed countries ?

Tourism is on the way to becoming a mass phenomenon among the Brazilian population. Massification is at its beginning and we have no long data series that would allow to quantify trends as we have in Western Europe, though we can see that in half a decade already significant changes occurred. The tourism of Brazilians already on a track of rapid expansion, which will drastically change its greenhouse gas emissions.

The first question is to assess where this track spontaneously leads to. To explore this we had to refer :

- to endogenous features of Brazilian tourism, culture and economy;
- to past trends in other countries insofar as the previous analysis shows that in some regards Brazilian tourism tends "to borrow" some features from elsewhere.

On these bases, we built a reference (or business as usual) scenario for 2030 and 2050. This scenario leads to a multiplication of emissions by 4 and 8 at these dates. This factor is much higher than the world average as assessed in the UNWTO business as usual scenario for 2035. This pace is also far superior to the growth in emissions expected in business as usual scenarios built for mature tourism economies: e.g. a multiplication by 2 of the emissions of French tourism



in 2050; which is not in itself surprising (Brazil catches up...). Some consideration needs to be given that the emissions per capita. In the reference scenario, the Brazilian emissions of tourism reach roughly 1t in 2030 and 2t in 2050. This means that by these dates, the emissions per capita of the Brazilian would have done more than catch up with the emissions of the French (1.6 ton in the French business as usual scenario for 2050). Though such a comparison should be taken with great caution, due to the differences in methodologies of the two scenarios, and also to the more or less bold hypotheses they include, it tends to show that convergence is in the air and might occur sooner than some expect.

What are the specificities of Brazil regarding tourism GHG emissions ?

Such results also call for a discussion of the impact of Brazilian specificities in these higher growth trends. Some features push up, other pull down and so it would seem that the former supersede the latter.

The highly inegalitarian current state of Brazilian society is the first characteristic to be considered. Compared to a more equalitarian society, the larger proportion of poor form a greater tank of population for which the situation might change (i.e. new conditions of wealth allowing an access to tourism). This has been concretely seen under the presidency of Lula.

The second point is the Brazilians' attitude towards leisure and their relation to work. Certainly, the Brazilian society is consumer oriented, but it can be less expected to sacrifice free time to more work in order to acquire goods than other societies (in Asia for example) will do. What will be the share of tourism in the uses of free time is an open issue, as well as the profiles of tourism (distant or not, merchant or visiting friends and relatives...).

The third point, is that geography also matters. Some 80% of the Brazilian population lives at less than 200 km from the sea which suggests that a large share of 3S activities can be taken near the home or through day trips, which is not the case in mature tourism economies, apart from the case of Australia or New Zealand. This, associated with a warm climate and lively neighborhoods does not push to frantic long-distance travel. Yet Brazil is a very large and diverse country, worth visiting including by Brazilians. If Brazilians massively decide to visit their own country, this will generate a good deal of trips implying quasi intercontinental distances. Besides, Brazilians are highly interested in visiting the US or Europe and when looking at Brazil's position on the globe, it appears very far from these points of interest. Emissions would follow.

The fourth point lies in the specificity of the energy sources of Brazil. The rich endowment in hydroelectricity currently plays almost no role really regarding tourism (this would change in the long term should rail infrastructures be developed). The key point regarding our subject is the importance of fuel from the biomass which, in the business as usual scenario, should increase and render terrestrial travel rather more greenhouse gas friendly than in most other countries. Yet all travel, specifically on long distances, is not terrestrial and in the reference perspective biofuels are not introduced into aviation.

What are the main factors for change (and for action) ?

This discussion shows that, however founded on Brazilian literature and

international benchmarks, the hypotheses of the reference scenario can be questioned. This also shows, once more, that the future is not written and that alternative hypotheses on the key variables can be made and, combined, can be used to build alternative scenarios.

The first step in that process was to assess the importance of the variables relative one to the other, through sensitivity tests; for each variable we defined 0 to 3 alternatives to the business as usual. The tests show that the variants retained from growth (high, medium, low) have the greatest impact relative to the reference scenario in 2050: -25 to +36%. The distribution of income (an equalitarian hypothesis comparable to the current distribution in Northern Europe) has an impact almost of the same order of magnitude in the case of a high growth scenario. Modifications of the length of stay (lengthening or shortening) have an impact comparable to



the first two: +/-30% in 2050 relative to business as usual. Lastly the introduction of biofuels in aviation has a significant impact in 2050 (-20% relative to business as usual) and half of this impact in 2030. The impact of the hypotheses on the other variables is lower, including the modifications of the modal share (+/-7% in 2050) or the introduction of biofuels in terrestrial transportation etc.

This confirms that growth is a major driving force of the emissions of tourism, which is a point on which the research community agrees. But the sensitivity tests also show that considering the future of emissions as essentially linked to growth, (which a significant part of the literature does...), is highly misleading. First, the impact of the distribution of wealth can be just as important, as well as lifestyle factors which is shown by the importance of the length of stay. Note that the length of stay is just one indicator in the field of tourism lifestyles and that other features of lifestyles are included in various other variables such as modal share etc. Another point is that previous research in the field of tourism emissions have pointed that technology is not a variable powerful enough to curb the emissions of tourism in the future. Even prior to building alternative scenarios, the sensitivity tests confirm this. The impact of variables linked to technology is rather weak compared to those above and the most powerful variable (i.e. the introduction of biofuels into aviation) seems quite specific to Brazil and is more questionable in most other countries. Moreover, note that the variables retained for the sensitivity tests often include a mixed content of technology and lifestyles (e.g. in modal share) and that their impact cannot be exclusively attributed to technology.

Are alternatives thinkable ?

After having gone through the sensitivity tests, we explored how much the combination of alternative hypotheses within reasonable and logical settings can reduce the emissions compared to the business as usual scenario, how do these outcomes compare to current emissions and what share they could represent in the future of national emissions.

We define first three alternative scenarios founded on three different growth perspectives: one reflecting the perspectives retained by governmental and international bodies (“high growth”), another far more pessimistic but in our mind plausible (“low growth”) and founded on some scientific literature, and lastly an intermediate scenario (“medium growth”). All these three scenarios are associated with an equalitarian income distribution, since its effectiveness in diminishing emissions has been proven above. Hypotheses chosen for the other variables more or less differ according to the scenario: they are supposed to be compatible with the growth context of each scenario. In some cases other choices for a given variable could have been made; the scenarios do not cover all the possible futures.

Lastly we have built a worst case scenario which aims at assessing how high emissions could go. It combines high growth with an inegalitarian income distribution and the most unfavorable hypotheses for the other variables. Note that some hypotheses either reflect current trends (e.g. shorter length of stay) or plausible evolutions (e.g. a low price of petrol hampering the development of biofuels).

Figure 94 : Synthesis of scenarios

	Emissions (t)			Emissions relative to 2010		Emissions relative to BAU (%)	
	2010	2030	2050	2030	2050	2030	2050
BAU	53 744 730	222 958 916	450 979 741				
low growth scen	53 744 730	90 620 627	149 092 986	1.69	2.77	-59%	-67%
high growth scen	53 744 730	307 911 707	706 643 352	5.73	13.15	38%	57%
medium growth scen	53 744 730	111 846 593	191 145 318	2.08	3.56	-50%	-58%
worse case scen	53 744 730	397 960 773	889 032 717	7.40	16.54	78%	97%

The increase of emissions in the business as usual scenario comes up to a factor 4 by 2030 and a factor 8 to 2050. The worst-case scenario shows that these prospects could be more than doubled by an unfavourable combination of hypotheses.



It is interesting to note that the medium growth scenario (with an equalitarian income distribution) has an emissions outcome rather near to a version of the low growth scenario which would keep unequalitarian income distribution. This means that a very low growth does not change fundamentally the results compared to a medium growth version, though the emissions must be admitted to be slightly lower.

Will tourism prevent Brazil from meeting its pledges ?

For 2030 the national emissions corresponding to the Copenhagen pledges (i.e. a reduction of emissions from 36 to 39% relative to business as usual: CPG 2030) have been calculated. The emissions of the business as usual scenario for tourism in 2030 excluding radiative forcing represent 9.7% of such emissions (and up to 15% including it). The emissions of the medium growth scenario would represent 7% of the national emissions.

Two other scenarios for the national emissions are also available (MA1-T, MA2-T); they imply different levels of carbon tax and various mitigation measures. The table below gives the percentage of the scenarios of tourism compared to the national outcomes.

Figure 95 : Share of tourism in national emissions, in 2030 for a national scenario along Copenhagen pledges

	CPG 2030
BAU	14%
low growth scen	6%
high growth scen	20%
medium growth	7%
worse case scen	26%

It appears that it is possible to maintain the share of tourism in national emissions at a level comparable or somewhat less than the share it currently takes in developed countries. Such an achievement does not necessitate a very slow growth path: 3% to 2030 (medium growth scenario) is compatible. However, letting tourism develop along a business as usual scenario or a high growth scenario leads to a share well over that currently assessed in developed countries (20 or 30%). This should probably be considered as unacceptable. Thus, some additional policies than those included in the business as usual scenario are indispensable. When enforced as suggested in the medium growth scenario, it is possible to maintain the share of emissions at 9 to 11% in the two mitigation scenarios, in a context which is highly constrained.

No scenarios for the global emissions of Brazil in 2050 are available. Yet in order to contribute to maintain global climate change within the 2°C guardrail, the emissions of Brazil should continue to diminish. With regards to this perspective, the emissions of the three scenarios are highly problematic since they lead to a multiplication of the emissions in 2030 by 1.65 the low growth scenario, 1.7 for the medium growth scenario and 2.3 for the high-growth scenario. There is of course no written law that the share of sectors or activities within the national emissions should remain the same over the next 40 years. Some will diminish and others increase, because mitigation potentials vary along the sectors and because some activities are more desirable and valued by society than others. Nevertheless the prospects of an increase to 2050 are more difficult to envisage for activities that already represent in 2030 a quite significant share of the national emissions, which is the case for tourism with more or less 10% for the medium growth scenario (according to whether a an uplifting factor for aviation is included not). It can be noted that the situation of mature tourism economies is even worse, since the order of magnitude of their emissions is already the same as the one expected from Brazil in 2030. With regards to emissions, tourism is a challenging sector all over the world.



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Annexes

1. Detailed calculation of plane emission factors under alternative assumptions (continued from p. 101).

The modified coefficients for international flights would be:

- 2030/short distance: $146.7 (0.95 + 0.05 \times 0.17) =$
- 2030 /long-distance: $110 (0.95 + 0.05 \times 0.17) = 105.44 (+ 110)$
- 2050/short distance: $146.7 (0.75 + 0.25 \times 0.17) =$
- 2050/long-distance: $110 (0.75 + 0.25 \times 0.17) = 87.18 (+110)$

The modified coefficients for domestic flights would be:

- 2030/short distance: $146.7 (0.80 + 0.20 \times 0.17) = 122.35 (+146.7)$
- 2030 /long-distance: $110 (0.80 + 0.20 \times 0.17) = 91.74 (110)$
- 2050/short distance: $146.7 \times 0.17 = 24.82 (146.7)$
- 2050/long-distance: $110 \times 0.17 = 18.7 (+110)$

The share of international passenger kilometres (only long-distance flights) in the total is:

- in 2030: $1 - (2.86/4.56) = 37.3\%$
- in 2050: $1 - (6.53/8.20) = 20.4\%$

The share of domestic passenger kilometres and is thus :

- in 2030: $100 - 37.3 = 62.7\%$
- in 2050: $100 - 20.4 = 79.6\%$

We have no convenient way for calculating the share of long-distance and short distance Brazilian domestic air travel. We derive the figures we use the general outlook on distances of tourist trips given by (Peeters and Landré 2012). We consider 75% of trips are shorter than 1300 km one-way and represent 40% of passenger kilometers: thus short distance 40%, long-distance 60% of passenger. Will presume this share will remain constant.

The average coefficient applied for domestic travel by plane is thus:

- in 2030: $122.35 \times 0.4 + 91.74 \times 0.6 = 104$
- in 2050: $24.82 \times 0.4 + 18.7 \times 0.6 = 21$
- to this must be added an average uplift factor: $146.7 \times 0.4 + 110 \times 0.6 = 125$

The average long-distance coefficients (international and domestic) are thus:

- for 2030: $(0.373 \times 215.14) + (0.627 \times 0.6 \times 191.74) = 152.38$
- for 2050: $(0.204 \times 197.18) \times (0.796 \times 0.6 \times 128.7) = 101.69$

The short distance coefficients are:

- for 2030: 269.05
- for 2050: 171.52

