Tourism sensitivity to climate change mitigation policies: lessons from recent surveys

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Abstract

Tourism increasingly contributes to global greenhouse gas emissions, in particular through air transport, which already accounts for 40% of its share in CO_2. Projections show a strong growth of impacts, with more than a doubling by 2035. At the same time the Davos declaration, adopted in 2007 under the auspices of UNWTO, UNEP and WMO, requires tourism to reduce its emissions. This mitigation of air transport emissions will unavoidably affect tourism: caps, tradable permits, taxes or legislation could reduce the volume and change the pattern of tourism flows. By presenting several case studies (e.g. the Caribbean, the Mediterranean, the Asia Pacific Region, the French overseas territories) this work generally evaluates changes in tourism flows within various climate policy scenarios, to identify the impact of changing transport on the (re-)distribution of tourism flows and tourism's contribution to the region's economy. In some cases more proactive alternative futures have been developed, in which the tourism system becomes less carbon intensive, and therefore can aim for growth. The paper starts with a presentation of the rationale of the relationship between tourism, air transport and climate policies and of the methods and models to assess it, then critically assesses case studies, and finally presents both methodological and policy recommendations and further research needs.

Keywords: tourism, air transport, climate change, scenarios

Introduction

Due to its dependency on air transport, mitigating tourism GHG emissions might become the most important challenge for the sustainability of the sector. Moreover climate change mitigation will be more and more in conflict with other sustainability objectives such as poverty alleviation or biodiversity conservation through tourism. Indeed, tourism increasingly contributes to global greenhouse gas (GHG) emissions. Transport, and in particular air transport, have the largest share in those emissions, with respectively 75% and 40% of the tourism 5% share of global CO_2 emissions estimated for 2005 (UNWTO et al. 2008). In terms of the actual contribution to climate change, measured in radiative forcing, the share of air transport is between 54% and 83% of tourism, depending on assumptions made on non CO2 effects of aviation (Scott et al. 2010). Projections show a strong growth, with more than a doubling by 2035 (UNWTO et al. 2008). In a context where climate policies try to maintain global warming within the limit of a +2°C, this current tourism growth apparently is at odds with global emission reduction targets (Bows et al. 2007, Gössling et al. 2010).

For scientists, producing figures on tourism emissions was not self evident but asked to implement a transversal perspective on emissions. Indeed, GHG emissions have been assessed essentially from a production, sectorial and territorial point of view (e.g. Bastianoni et al. 2004, CGDD 2010, IPCC 1996) (Dubois and Ceron 2011).This method was designed to feed international negotiations (in particular the Kyoto Protocol). It had two main shortcomings. First it did not shed light on the influence of consumption and social practices (Aall et al. 2009, IFEN 2006, Munasinghe et al. 2009, Peters et al. 2006), whereas it has been shown that the behaviour of households influence three quarters of emissions (Edgar et al. 2009, Pasquier 2010). Second it does not allow taking into account international aspects, i.e. the emissions from international shipping and aviation (European Commission 2001, United Nations 2003) which are particularly important regarding tourism, and the emissions imbedded in trade (Edgar et al. 2009, Helm et al. 2007, Lenglart et al. 2010, Munksgaard et al. 2001). Within IPCC, in spite of the willingness to take into account the mitigation potential of socio-economic systems besides pure economic sectors such as energy, agriculture and transport (IPCC 2001), this position was not really taken into account in the fourth assessment report and tourism was only dealt with in the “impacts and adaptation” perspective, within working group II (Wilbanks et al. 2007). The templates of the working group III chapters in the fifth assessment report (IPCC 2009) include features such as consumption patterns, behavioural and lifestyle changes in at least 7 chapters out of 16. Therefore, tourism is now increasingly identified as a driver for emission growth within the scientific community involved in IPCC.

On the stakeholders’ side, following the first research on the topic, UN institutions (and in particular UNWTO) recognized that the emissions from tourism are a problem (UNWTO 2009, UNWTO et al. 2007). Yet these emissions were not seen as incompatible with a sustainable growth of tourism, which is viewed as indispensable in particular to alleviate poverty in LDCs (UNWTO 2004). It also became clear that emissions from origin/destination transport form the major part of emissions, with 75% globally, and more for remote destinations (UNWTO et al. 2008) and consequently that good practice at the destination, on which goodwill stakeholders usually dwell, are simply not sufficient to create environmentally sustainable tourism development. Logically, after a phase of denial (Gössling et al. 2005a), tourism stakeholders gradually admit they are concerned. Similarly to the vision of UNWTO, the issue is not seen as a need to modify the growth prospects of the industry (BALPA ND, IATA 2009). In the most recent forward thinking papers issued by some aviation stakeholders, it is recognized that the industry will have to go further than what the progress in management and technology will yield (UNWTO 2009). Much (and probably excessive) hope is put into carbon neutral fuels from biomass (Hileman et al. 2009) and, as this will not be enough, buying emission rights from other sectors is the adjustment variable that should allow carbon neutral growth beyond 2020 (IATA 2009).

This growing but still imperfect level of awareness and knowledge from the industry and destinations led to a growing demand of research on the impact of future policies on the tourism system. This research can be purely academic, or commissioned by policy-makers. The use of long term policy scenarios, based on methods of future studies, helps imagining consistent visions of the tourism and transport system, far beyond the current market and institutional context. They can either assess the impact of ambitious climate policies (e.g. a high carbon price, emission trading with tight emission caps) or prepare some more creative visions of a "low carbon" tourism allowing for global growth.

Section one outlines the methods presented in recently published studies for assessing the relationship between tourism, air transport and climate policies. Section 2 critically assesses case studies (world, a sample of developing countries, the Caribbean, Asia Pacific, French Overseas Territories, the Mediterranean) and Section 3 finally discusses policy options and presents methodological recommendations.

1. Methodological options

Reported studies found in the literature use varying methods to assess the relationship between tourism, air transport and climate policies, according to several parameters.

- The objectives can be either to show the potential risks for tourism associated to climate policies, or more proactively to explore alternative options, reducing the carbon intensity of tourism. This influences methods towards a comparison to a baseline with a forecasting perspective in the former case (Mayor et al. 2010, Tol 2007, Veryard 2009b), or towards the development of contrasted scenarios, often with a backcasting perspective in the latter (Ceron et al. 2009, Dubois et al. 2011, Peeters et al. 2010).

- The modelling approaches differ widely, depending on the project objective, but also on the research team background. It can have a predominant qualitative scope, quantitative one or endeavours to combine both (Ceron and Dubois 2007).The sample of case studies presented in this paper always include a substantial task of quantification/modelling of the future tourism demand. Some models are based on a central parameter, like price/demand elasticity, other on a combination of parameters (prices, elasticity, absolute volumes of trips, etc.). There are considerable discrepancies in the value given to these parameters, sometimes without clear justification. In particular one must question the use of constant elasticities to assess the impacts of mitigation policies on demand. Though elasticities are certainly a good way to get a first order impact of measures, they are statistical artefacts and their validity is low when large price shocks are assumed (see for a wider discussion e.g. Brons et al. 2002, Seetaram 2010). Another problem most case studies face is to choose a single value from the large range of values published for elasticities. For example air transport elasticities range from -3.2 to +0.3 (Brons et al. 2002). The main problem is that elasticities do not describe a 'physical' property of systems, but just the outcome of statistical properties of a database (of tourism arrivals in relation to generally prices, transport travel times and tourist's income). This however can never catch second order systemic changes in the tourism system. An example: very strong mitigation policies may affect tourism to a not too remote islands (like Corsica, Ireland, the Isle of Man) in two ways : a strong reduction of air transport and a strong increase of arrivals by ferry in combination with car, bus and/or rail (the so-called slow travel concept). Such a change will immediately cause a reduction of the supply (frequency) of flights, thus reducing the quality (travel time, choice of arrival time) of air travel, further diminishing its share. On a longer term the ferry companies will see their demand increase, invest in a higher frequency and better supply and thus attract even more passengers and will finally induce more lines to be opened and new harbours to be built. Such dynamic changes in the infrastructure and supply can never be captured by single constant price elasticities as is applied in most studies. What many studies do provide is sensitivity to the assumed elasticity, at least covering the impacts of uncertainty in the value of elasticities.

- The main methodological issue we would like to insist on is the boundaries choice of the studies, which proved to impact drastically the results. This covers the geographical scope (worldwide, regional, national); the focus on international tourism only or on both international and domestic markets; the inclusion of ground transport modes or not. Indeed, focusing on a too narrow field might hinder the possibility to consider substitutions between markets and transport modes, and therefore opportunities that might arise from climate policies. Indeed, a major problem we found in many studies (e.g. just looking at the international market in Tol 2007, Uyarra et al. 2005, Veryard 2009a or ignoring opportunities of different organisation of a large event to save transport as in Department of Environmental Affairs and Tourism 2009) is that the researchers ignored the impact of the choice of system boundaries on the conclusions. Generally the impacts of climate policies are evaluated for international tourism arrivals only, sometimes even further restricted to arrivals by air. This inevitably has serious implications for the results. If you evaluate an emissions tax on aviation and just looks at air transport arrivals for a destination than you will always find a loss of arrivals and a reduction of the contribution of these arrivals to the destination's GDP. However, such a tax will have a much more complicated impact as it will affect the whole tourism economy of the destination in both negative and positive ways. For example in case of an emission tax on air transport only and evaluating the impacts on whole countries as e.g. in (Veryard 2009b):
    - air transport arrivals will reduce (reduction of both emissions and GDP)
    - air transport departures (outbound tourism) will reduce (reduction of emissions, but increase of GDP as people will spend their money not anymore in other places);
    - domestic tourism will increase (relatively small increase of emissions and increase of GDP generated by the country's tourism industry);
    - short haul non-air tourist arrivals from neighbouring countries will increase (relatively small increase of emissions, increase of GDP);
    - short haul non-air arrivals to neighbouring countries will increase (relatively small increase of emissions, decrease of GDP).

  As in most countries, domestic tourism and short haul tourism between neighbouring countries are up to two orders of magnitudes larger then international arrivals at medium to long haul aviation arrivals. Thus, the impacts of the often ignored parts of the economy can be much larger and even be reversed compared to the impacts found by just investigating air tourist international arrivals. We will insert some critical methodological notes to all case studies mainly regarding the issue of ignoring large parts of the tourism system.

2. Case studies

2.1. Global

Tol (2007) uses an existing model - the Hamburg tourism model (Hamilton 2005) - to estimate the impact of a carbon tax on demand and emissions. Three values are considered: \$10, \$100, \$1000 /ton CO_2. A \$1000 tax would reduce demand by 0.8% and emissions by 0.9%.
The results are sensitive to the choice of price/demand elasticity which is not well known: the option for a very high elasticity would almost double the reduction of emissions. If domestic holidays were allowed to substitute for international travel (which is not the case in the base model) the cut in emissions could rise to -7.59% (still for a 1000\$ tax). The results are also sensitive to the distance threshold above which the use of aviation is deemed indispensable: if this distance is doubled the baseline emissions are 14% lower, which means that the total share of aviation is smaller and thus the impact of a carbon tax will also be smaller.

The author concludes that "as travel behaviour is not very responsive to the limited price signals that carbon taxation would bring about, behavioural and technical changes may contribute more to emission reduction." (Tol; 2007 : 137). However, non-market measures are not part of this paper.

In some cases the paper shows that carbon dioxide emissions may *increase* caused by an increase of the cost of CO_2. This is for example the case if all international tourists are assumed to travel by air. There may be two causes for this. First the author assumes the relative impact on price of the tickets to be larger for short haul flights then for long haul ones, because the author (rightly) assumes higher emission factors for short then for long haul flights. But this is only true if the ticket cost is more or less proportional to distance flown (as is assumed by the authors with only a moderate \$30 fixed cost per flight). However, the difference in emission factor between short and long haul is rather small for flights above 1500 km and the difference in share of fuel cost in total operating cost on the other hand much larger then assumed by this paper (e.g. 13% for a 1000 km flight with a Boeing 737-400 and 19% for a 7000 km flight with a Boeing 747-400, Dings et al. 2000). A second cause for the *increase* of the emissions at increased carbon costs is the assumption in the Hamburg model that total number of trips remains equal and that people do not substitute between distance classes. Apparently the Hamburg model first calculates all reductions in trips per distance class and then corrects the total number of trip upward with the same factor, to get the original number of flights. Therefore long haul destinations will receive more tourists when the cost of carbon is raised and short haul destination less. Reality will be much different as people will not just of a sudden spent much more on tourism, but will try to compensate by for example choosing nearer destination. This is confirmed by the Hamburg model when domestic tourism is considered to be an alterative for international tourism, causing a much larger reduction of CO_2 emission for a given CO_2 cost. Summarising: the impacts given on CO_2 emissions are most likely too low by lack of substitution to low carbon travel in the model and probably erroneous assumptions regarding the cost of air tickets.

2.2. The Carribean

Pentelowe et al. (2009) examine the impact on tourist flows to the Caribbean of a price of carbon combined with different scenarios for oil prices. The study is limited to the main originating markets (Europe and US) and the time horizon extends to 2020. They have built

18 scenarios combining three carbon prices, two oil prices and three elasticity estimates. The model includes:

- a BAU projection of tourist arrivals and travel emissions;
- a calculation of the change in the cost of air travel owing to the introduction of European Trading Scheme (ETS) in originating markets, and to the change in oil prices, and based on this;
- a calculation of the change in arrivals to the Caribbean using elasticities.

Over the range of scenarios, total arrivals decrease between -1.28% and -4.29% relative to a business as usual (BAU) scenario in 2020. This does not inflect significantly the growth in volume over the same time period which remains around 50%.

The authors also consider the effects on the market of holiday packages through a specific case study on Jamaica. Since flight costs represent approximately 1/3 of the total vacation cost and since 15% of the hotel costs are considered as sensitive to oil price increases, not surprisingly the effect is lower than for flights alone (e.g. -2.6% compared to -3.2% for one scenario). Following this, one could suggest that in a highly competitive market where tour operators are in a dominating position, they should increase their pressure on the local tourism industry so as to pass part of the cost increase onto them, which would further dampen the impact.

This paper also indirectly draws attention on the differences in results that can stem from the choice between a "realistic" option which abides by foreseeable actions in the mid-term (e.g. a gentle cap on the emissions from aviation with only 15% of emissions above cap) and a more normative view (e.g. applying an uplift factor of 2 to CO_2 emissions to take account of the specificity of aviation as in Gössling et al. 2008). Quite obviously as no stringent actions are projected by the institutions and stakeholders, the effects on demand will be low.

This study also takes air arrivals as the base for the model used. Though in this case, evaluating impacts on small islands, this assumption is less problematic as international arrivals will represent a relatively large sector of the tourism industry. But even in this case some countries may compensate part of the disadvantage of loosing international air arrivals by reducing international outbound tourism. Also including domestic tourism will dilute the impact on tourists in a country like Surinam by a factor 5-6 and the economic impacts may be by some factor two (based on UNWTO tourists statistics and domestic calculated with the method presented in Peeters 2010).

2.3. Developing countries

The need to prioritise poverty alleviation in developing countries is often mentioned as a potentially conflicting objective with climate change mitigation that could even limit the possibility to implement a global scheme for air transport emissions. Therefore, even if still minor in global tourism, developing countries are a key of the climate change and sustainability debate, that must be informed with robust and rigorous data, instead of opinions and value judgment. Gössling et al. (2008) deal with ten small developing island destinations. They analyse the consequences for tourism arrivals and the economy of two sets of hypotheses. The first set corresponds to a rather hard version of a "realistic" approach. It is based on the inclusion of aviation in the carbon trading schemes (cost of carbon 65$ in 2020). It takes into account the objectives the EU currently puts forward without having translated them into policy measures: the authors draw themselves from the objectives the implications which seem consistent but that in the current state of things are not accepted by aviation stakeholders. Their EU ETS scenario thus represents "the least favourable scenario for the aviation industry as currently discussed by the EU". The second scenario called "Worldwide serious climate policy" (WSCP) "assesses the consequences of global climate policy for aviation where costs of 230$/t CO2 are introduced by 2020". Both scenarios present a high and a low variant depending in particular on the hypotheses made on elasticity.

For the EUETS scenario the decline in demand compared to the baseline is comparable to (Pentelowe et al. 2009). This means that with an elasticity of -0.5 demand will decline by less than 1% (relative to no EU ETS); with an elasticity of -1 it could decline by up to 6% in Seychelles compared to a BAU. Growth in volume would globally continue but be slowed. In terms of emissions this scenario in fact is far from complying with the objectives of reduction as seen by the EU. Under the WSCP scenario, growth (average of low and high variants) continues for 6 destinations out of ten, decline is clear for Seychelles and Bonaire. On average the conclusion is that growth in volume would continue to 2020 but would be delayed differently according to hypotheses and to countries; what happens after 2020 is another question.

The paper ends with an analysis of the vulnerability of the different destinations taking into account:

- the vulnerability of tourism to emissions (depending on the different carbon intensities of earnings);
- the dependency of the country's economy to its tourism (from around 5% for Sri Lanka or Madagascar to 80% of GDP for Anguilla).

Methodologically this paper suffers from ignoring non-air arrivals, all outbound tourism and domestic tourism. It proves that for most of the countries assessed, the overall impact of mitigation policies is not unmanageable. However, the paper does not investigate alternative policy options, such as the possibility to introduce a favour treatment for vulnerable destinations: differentiated carbon prices, delay in the introduction of taxes and carbon trading, funding some adaptation of the tourism supply or the substitution of tourism by less carbon intensive activities, etc. It also ignores the impacts on outbound and domestic tourism, which might alleviate to some extend the impacts on international inbound tourism.

2.4. Asia Pacific

Veryard (2009b) analyses the potential effects for the coming years of the introduction of a carbon price and of the variation of oil prices on tourism, in Asia Pacific Economic Cooperation (APEC) countries (arrivals, tourism income, GDP). The survey was commissioned by APEC.

The study assumed a carbon price of 50$ per ton of CO2 and three hypotheses for oil prices corresponding to typical situations of the past decade to evaluate the impacts on international arrivals by air transport within the region. "… although there is significant variation across the price scenarios, the overall magnitude of the operating cost change is typically less than 10% for most feasible short-term values for both the carbon price and fuel price. This variation can be compared with the 500% increase in fuel prices observed between 2000 and 2008 or the subsequent 50% reduction since the peak in 2008" (Veryard 2009a: 19). The effect on air arrivals is estimated from this study to be around -3 to -5% compared to BAU, the effects are the lower for the most distant origins which reflects the lack of alternative transport means and the relative high income of the tourists, that are less responsive to price changes. The effect on tourism income should only be slightly lower than on arrivals because the great majority of international tourists in this area come by air. An "indirect tourism income multiplier" is used to assess the effects on GDP (a twofold multiplication of the direct effect); this results in a reduction of 0.1% to 0.6% in GDP.

A sensitivity analysis is presented in this study which allows departing from a mid-term "realistic" point of view. Firstly, whereas up to a value of US$100/tonne CO_2 the effects of carbon prices appear to be relatively low, "for much larger carbon prices impacts on aviation arrivals and GDP are proportionally larger, with a carbon price of US$500/ton CO_2 suggesting a near halving of aviation arrivals and GDP impacts of over -2% for many of the sample economies". Secondly the effects are proportional to the value of the multiplier which appears to be badly known: "if the indirect impacts are 2 to 5 times the original impact of the carbon price, the overall impact can be pronounced, particularly for Malaysia, Singapore and Thailand" (Veryard 2009a: 34).

The results of this study are most likely not correct when interpreted as the impacts on the whole tourism industry and GDP of the countries studied. This is caused by the fact that the study just refer to international arrivals by air, ignoring several effects that might improve the contribution of tourism to the GDP of the countries. The study just considers, per country, international arrivals by air, thus ignoring impacts on the local tourism industry from domestic tourism, international arrivals by other modes and international departures both by air and other modes. Therefore the impacts of arrivals and the tourism economy are most likely wrong both in magnitude (percentage damage) and even direction (some countries may benefit from a reduction of long haul travel, because they will both gain from less departures from their own country and increased sort haul arrivals coming from neighbouring countries. A very tentative result from our on-going research using the global tourism database of the GTTM[adv] model (Global Tourism and Transport Model, Peeters et al. 2010) and assuming certain levels of mitigation policies which cause a shift from long and medium haul to medium and short haul world-wide and start a complex chain of reactions with respect to market development for each country individually is given in Figure 1.

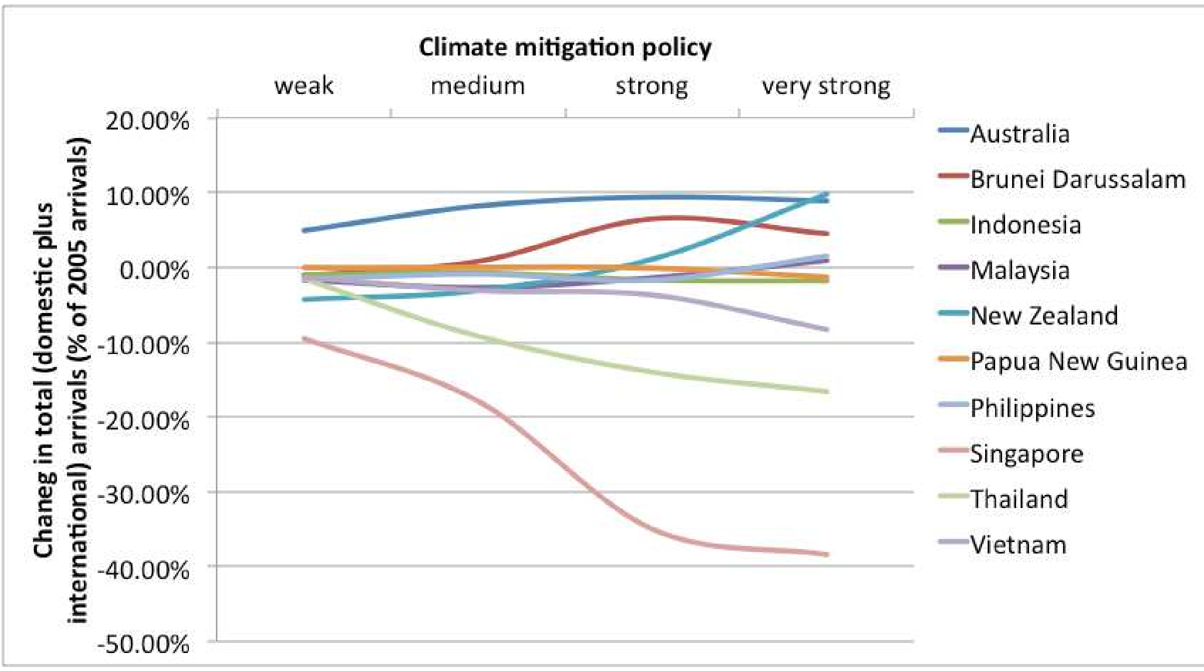

Figure 1: *climate mitigation policies cause very long haul trips to shift to the whole range of short to long haul ('weak' climate policy) up to a shift from medium to very long haul towards short haul only ('very strong' policy).*
Source : Paul Peeters, on-going research

Figure 1 clearly shows that larger countries like Australia and New Zealand may benefit from strong policies, because their strong outbound tourism will reduce as well, compensating for the loss of international arrivals through an increase of domestic arrivals. Very small countries (Singapore) and countries depending very much on inbound tourism (Thailand) might suffer from mitigation measures. This contrasts the results of the Asia Pacific study (Veryard 2009b), that show only reductions of the tourism industry and its contributions to the economy.

3.5. French overseas territories

The study by Ceron et al. (2010) was commissioned by the French Development Agency (AFD) it aims to:

- estimate current GHG emissions caused by tourism to French overseas departments and territories;
- measure emissions against tourism activity (calculating the sector's "eco-efficiency" (Gössling et al. 2005b) and compare different originating markets as well as tourism with other economic activities;
- draft strategies to deal with the carbon constraint by identifying variables that affect emissions and using them to develop scenarios up to the year 2025.

To examine how the carbon constraint will affect tourism in the regions concerned by this study, scenarios were developed. Variables were modified to analyse their effect on tourism using:

- hypotheses on emissions regulation. These hypotheses were developed with regard to recent studies by IPCC researchers, international commitments and the post-Kyoto negotiation process (especially in the aviation field);
- hypotheses on mechanisms specific to the tourism sector in each of the regions concerned.

Results for each territory were compared against those for other territories and metropolitan France (Figure 4).

Tourism eco-efficiency by destination	
	CO2-e/Euro spent (kg)
Towards metropolitan France – All international markets	**2,10**
Towards New Caledonia	**3,61**
Towards French Polynesia	**4,24**
Towards Reunion Island	**6,52**
Towards Guadeloupe	**6,87**
Towards Martinique	**7,33**

Figure 2: *Tourism eco-efficiency by destination*
Source: Ceron and al. 2010

Strategies were identified for tourism development in French overseas territories and considered in the light of international developments in the field of climate change and GHG restrictions. They include:

- reducing air travel (developing closer markets, reducing flight distances, developing the local tourism market);
- improving passenger load factors;
- increasing the length of stay;
- increasing tourist expenditure per night.

Eco-efficiency results are used to build strategies: first to optimize the use of a limited carbon budget within the tourism sector and further to deal with the issue of the share of tourism within the global carbon budget of each territory. The scenarios conclude that for all the destinations studied, a drop in emissions means a drop in arrivals (average -14%). The extent of this decrease and the consequences on revenues depends on the viability of substitute markets and to adopt revenues more than volume strategies. The scenarios endeavour to combine economic development with decreased environmental damage. However, they necessarily involve important societal shifts. Populations are currently unprepared for such radical changes. Examples include:

- a decrease in tourism mobility. This is in direct contrast to the current trend, established over the last ten years, which involves frequent short stays. While this may be acceptable for pleasure tourists, the same cannot be said for visiting friends and relatives (VFR) traffic. In the scenarios developed, VFR traffic has been maintained, although it generates lower revenues. This seems to be an important priority for the populations of French overseas departments and territories. Theoretically, other choices are possible;
- a decrease in tourist arrivals. While the scenarios indicate an increase in revenues, the changing carbon constraint will undoubtedly affect the structure of the tourism sector and will lower the expected growth (Figure 3, for the Reunion island case). Increased competition, shifts in demand, changes in seasonality, and fewer facilities (closed because of fewer arrivals) are likely to be some consequences.

	2003	**2020 (regional strategy)**	**2020 (alternative vision)**
Tourist arrivals	430 000	1 000 000	272 000
Average length of stay (days)	16,2	10 to 12	14,7
Turnover (x 1000 euros)	365 000	950 000	455 000
GHG emissions (tons CO2-e)	1 678 000	4 125 000	1 014 000
Eco-efficiency (kg CO2-e/euro)	5,2	4,3	2,2

Figure 3: *Scenarios for arrivals in La Reunion island : 2003, 2020 official strategy, and alternative vision for 2025*

3.6. The Mediterranean

Blue plan (technical regional center of the UNEP Mediterranean action plan, unpublished yet) study deals with the Mediterranean countries. Its goal is to assess the possibilities of reduction of GHG emissions from tourism in the medium and long term (2020s to 2050s), the effects on arrivals and the capacity of adaptation of tourism to this new context. It encompasses both international and domestic tourism, market and non market measures. It elaborates on several scenarios considering various hypotheses (which feed a sophisticated model of system dynamics) for:

- carbon prices ;
- technological progress;
- infrastructure development;
- regulation measures for tourism transport, including the use of a specific carbon market for the sector.

	S1 Real Politic	S2 Bali	S3 Hansen / S4 Hansen+
Global policy objectives	Fragmented, Copenhague	Strong EU leadership Obj. 2050/1990 : -50 to 60% Northern Med : Energy and Climate Package South and East: 10-15 years delay	Global policy Obj. 2050/1990 : -80% Chocks on way of life
CO2 price 2050	72 €	200 €	595 € / 1000€
Role of tourism and air transport	Trading scheme (EUTS) for Northern countries	Global price of C, no air transport specificity	Specific air transport regime : individual caps + sector caps
Sector evolution	Current trends(open-sky, low-costs...)	Current trends, with a gradual slow down	Abrupt inversion of trends
Infrastructures	Europe planification delayed for transport	Modal integration, Euromed planification implemented	Modal integration, priority to high speed trains, Euromed planification quicklu achieved
Technical change	BAU	Gradual introduction of turboprops aircrafts	Fast introduction of turboprops + slower aircrafts
Pace of change	Slow	Gradual, following international negociations	Immediate

Figure 4: *Climate policy scenarios*

The overall conclusion is that none of the scenarios, even the most extreme ones, result in reductions in line with what scientists show necessary to avoid dangerous climate change (a 65% to 80% reduction in GHG emissions). Only an extreme price of 1000$ per ton CO_2 allows to start curbing significantly in 2050 (S4) the emissions compared to 2005, though not to an extent enabling tourism to take a fair share of the reduction of GHG in the economy. Furthermore the reduction also depends on the background scenario assumed for global population and GDP growth (A1 or A2, see IMAGE-team 2006, IPCC 2000). The growing economy of the Mediterranean, with several emerging and developing economies/tourism destinations, hinders the effect of climate policies.

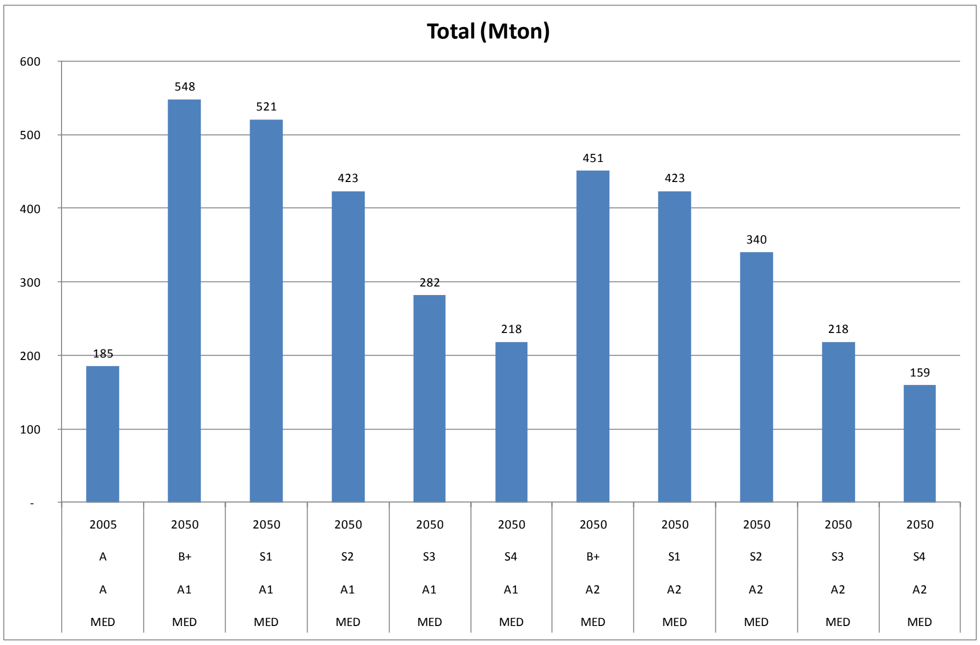

Figure 5: *Evolution of emissions according to scenarios and economic context (overall Mediterranean basin)*
B+: Baseline, A1 and A2: GDP per capita growths of respective IPCC SRES scenarios, MED: all Mediterranean basin.

A conclusion is that whereas a price given to carbon is not by itself an efficient tool to curb emissions, it easily generates an amount of funds quite sufficient to structurally modify transport infrastructure (i.e. specifically extending high speed rail), to foster a large modal shift, to shape a new tourist demand less depending on long haul air transport, which finally may contribute to a change in lifestyles. The scope of this study is much wider than that of the previous ones, through the number of parameters taken into account, the time horizon (2050), the boundaries (international and domestic tourism). It also goes further (alike Ceron et al. 2009), analysing adaptation strategies to a lower emissions context: e.g. promoting domestic tourism and changing lifestyles, reshaping infrastructures and showing that if market measures can contribute to reaching the goals, non market measures are indispensable to fulfil them.

3. Conclusions and discussion

Lessons learnt from the sample of cases presented can be split between methodological recommendations and policy insights, even though both are closely interrelated. Indeed, modelling or elaborating scenarios is seldom neutral, but reflects some orientations (a trust/faith in technology for example) and sometimes some more philosophical options pre-existent to the exercise of modelling (optimism, pessimism) (Dahan-Dalmedico 2007).

In methodological terms, the ways research projects and instruments (models) are conceived are influenced by a dominant view on tourism: excessive perspective on international tourism and international operators on one hand, insufficient consideration of domestic and proximity markets on the other hand. A majority of studies limit their scope geographically, regarding time frame, tourism markets, transport modes and tourism motives. This causes generally a bias towards the disadvantages of existing or envisaged measures within tourism. For example, limiting a study to international tourism ignores the opportunity to preserve a large share of the tourism sector by shifting from international outbound to domestic tourism and thus keeping avoiding part or all of economic impacts to the local tourism industry. A study dedicated to air transport only (like Veryard 2009b) will always conclude there are large damages to the aviation sector, but will not acknowledge the opportunities for the rail and automotive industries. A study just investigating remote least developed islands will not show that some large less-remote-least-developed countries would actually benefit from less air transport as it will develop their (generally large) potential short haul markets. Therefore, more comprehensive modelling is required, as well as more transparency in parameters choice. For instance elasticities are only constants for very small changes and on the short term, therefore elasticity based studies should consider evolving elasticities. Furthermore an economic model based on elasticities will not be able to capture second order impacts caused by structural changes in the tourism system, like a shift in infrastructure investments away from air transport towards rail transport and the impacts of increased patronage on high speed rail connection on their mid-term quality (an increase as the frequency of the services will increase, reducing travel time and increasing opportunities to use it).

Regarding climate policies, a few lessons can be derived from this sample of long term surveys:

- relying on carbon pricing only will probably not be sufficient to curb emissions, given the potential for growth of world tourism and the low substitutability of long-haul air transport;
- open carbon trading schemes point to deadlocks: since air transport can afford paying high prices for a ton of carbon and would have such a large amount of emissions to offset, aviation would likely buy most of emission permits, and therefore prevent some flexibility in other sectors. A close trading scheme could force aviation to reach some more ambitious goals;
- scenarios leave the door open for alternative visions: a combination of technological improvement, but also behavioural changes and adaptation of the tourism and transport supply (infrastructure, products) allow destinations to keep some tourism revenues, even if the growth will be lower than expected;
- therefore, even if market instruments, are useful, notwithstanding their undesired potential effects like inequality, alternative policy options should be more frequently discussed. Given the specificity of air transport, forbidding plane for some short haul trips, capacity restraints in airport development, or introducing individual carbon

budgets (Fawcett 2005, Fleming 1998, Lane et al. 2008, Starkey et al. 2005) are potential policy measures;

- contrary to the situation observed in the past decades, air transport might become under ambitious climate policies, a rare service which allocation would have to be optimised so as to maximise well being and economic revenues. This clearly requires a change in mentality towards an activity more and more deregulated.

Climate change mitigation, if taken seriously, could become a growing constraint / driving force for future tourism policies. Therefore it is more and more important to integrate this issue in discussions on the sustainability of the tourism sector, which often focus on local aspects (cultural impacts, effects on nature conservation and landscapes for instance), neglecting the effect of origin/destination transport on the environment and destination choices.

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