Designing green policy scenarios for the tourism industries of India and the EU

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Supervised by: dr. SB Amelung

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Preface

Through my Bachelor degree in Tourism and my follow up Masters in Environmental Sciences I have found myself right where the two topics meet. Whilst searching for a thesis subject and supervisor I found Bas Amelung, who I have already known from the BSc Tourism. After expressing my concerns that I did not want to take on something too challenging, something I have found myself doing throughout my whole academic career, I unintentionally decided to do just that.. Bas introduced me to Paul Peeters, the creator of the tourism climate simulation model $GTTM^{dyn}$. Paul inspired me to take on the big challenge of converting his global model into regional models. Which was the start of this very thesis.

Thank you Bas, for being my academic advisor and process supervisor for the past (almost) 1,5 years.
Thank you Paul for your enthusiasm, you have been the inspiration for my thesis. A hardcopy of your PhD report has been my bible for the length of my thesis. It has been the first thing I packed everywhere I have traveled.
Thank you Anouk, Floor, Josien, Niels, Davide, and Valentina for all the nice coffee breaks, dinners, and overall good times any time I traveled to Wageningen for my thesis. You were welcome distractions from the daily thesis struggle!
Thanks family and friends who I could talk to whenever my thesis got to me or whenever I had small (or big) milestones to celebrate.
Thanks mom and dad for the continuous support throughout my thesis and when I started struggling with myself. You have been there for me when I needed it.
And lastly, thanks Lieke for believing in me every day. I know it has not always been easy for you living with me whilst working on my thesis. This chapter has come to an end!

Content

Terminology and key concepts

Domestic trips:
Tourism trips within country of residence.

Tourism:

"Tourism comprises the activities of persons traveling to and staying in places outside their usual environment for not more than one consecutive year for leisure, business and other purposes." (UNWTO, 2016)

Paris agreed goals:

An internationally agreed global warming of 2°C compared to pre-industrial levels during the Paris climate convention in 2015. (Paris Agreement, 2015)

Policy scenario:

In this thesis a policy scenario is defined as the policies required to keep CO_2 emissions by the tourism industry within the Paris agreed goals including the according trajectories of the number of trips and CO_2 emissions.

Regional tourism industry:

In terms of 'the tourism industry of India' or 'the tourism industry of the EU28'. This thesis regards the tourism industry from the perspective of the tourists' regions of origin. Therefore, the policy scenarios describe a forecast for the inhabitants and governments of a region of origin.

Trajectory:

The way either the target indicators or the policy measures evolve in the research period 2015-2100. This could be the exact development as calculated through an equity principle. It can also be a trajectory enclosed by the range of possible trajectories, which are bound by the upper- and lowermost extreme equity trajectory.

EU28:

The members of the European Union as of July 1st 2013: Austria, Belgium, Bulgaria, Croatia, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovenia, Slovakia, Spain, Czechia, the United Kingdom, Sweden (Eurostat, 2014).

Summary

All 196 countries that signed the Paris agreement (2015) will have to ensure that their combined CO_2 emissions will result in a maximum temperature rise of 2°C in 2100 compared to pre-industrial times. All industries of those countries will have to undergo a transition in order to reach the Paris agreed goals. The global tourism industry is currently emitting 5% of total CO_2 emissions. In a business as usual scenario, tourism emissions are likely to exceed the Paris agreed emissions trajectory by itself by 2070 (Peeters, 2017). The purpose of this thesis is to identify the regional policy scenarios for India and the European Union (EU28) in which their CO_2 emissions are likely to stay within the Paris agreed goals.

Global policy scenarios concerning tourism and climate change have been developed by Peeters (2017) through his Global Tourism and Transport Model ($GTTM^{dyn}$). A global policy scenario, consisting of policy trajectories and the corresponding CO_2 emission and number of trips pathways, was translated into regional policy scenarios for India and the EU28. The Economic Mitigation Scenario by Peeters (2017) was chosen to be transposed into two regional policy scenarios. Four equity principles were used to assess the most 'fair' distribution of burden and responsibility sharing between India and the EU28. Those principles being egalitarian (equal rights), sovereignty (status quo right: every region same % reduction), responsibility (polluter pays), and capability (mitigate according to wealth) (Den Elzen et al., 2005). It is assumed that climate policies (regional responsibility sharing) are created based upon equity arguments. Therefore, sub regional scenarios were created based upon the equity principles, which describe the range of possible regional trajectories within the economic mitigation scenario. The data required to transpose the global values into regional values were retrieved from secondary quantitative data sources from multiple governmental and non-governmental statistical bureaus.

Only the egalitarian and sovereignty principles delivered useful trajectories to describe the regional policy scenarios for India and the EU28. The capability and responsibility principles delivered negative number of trips for the EU28 which meant that they could not be used to describe the regional policy scenarios' bounds.

The global economic mitigation scenario requires radical change. On a global scale a modal shift is required, away from aviation and towards more sustainable alternatives such as high speed lines. 90% of fuel in aviation should come from renewable sources. This also shows in the regional policy models in which also radical model shifts are required.

The current trends in the development of India's and the EU28's tourism industries do not show the commitment required to transition towards regional trajectories that would fit within the developed regional scenarios. Therefore, this study clearly indicates that more drastic policy measures are required on a regional and global scale to ensure global temperature rise will stay within the Paris agreed operating space. Ultimately this thesis is an provoking explorative piece that clearly illustrates that radical measure are required to make both India's and the EU28's respective tourism industries conform to the Paris agreement.

1. Introduction

Mitigating and adapting to human induced climate change is one of the biggest challenges mankind faces in the Anthropocene. Without any climate mitigation strategies the average global temperature is expected to rise between 3.7°C and 4.8°C by the end of the 21st century compared to pre-industrial levels (IPCC, 2014b). This global temperature rise poses risks to human and natural systems (IPCC, 2014a). Under the United Nations Framework Convention on Climate Change (UNFCCC), which entered into force in 1994, global leaders have decided to fight human induced climate change. Subsequently, the Kyoto Protocol (1997) and the Paris Agreement (2015) have been the main milestones for global policies to fight against climate change. Under the Paris Agreement, 196 governments have agreed to voluntarily install national as well as international policies to reduce CO_2 emissions to try to stay within a safe global warming window of 2°C compared to pre-industrial levels (Paris Agreement, 2015). The aspired goal is even to stay within an upper limit of 1.5 °C temperature rise compared to pre-industrial levels (Paris Agreement, 2015).

In order to tackle the challenge of climate change, all (supra)-national governments are required to voluntarily conform to the Paris agreement. Policies should be installed to create the ideal environment to let all sectors and industries transition to low emission practices. This also goes for the tourism industry, the industry under study in this thesis.

The tourism industry of today emits up to 5% of total global CO_2 emissions (Peeters, 2017). However, the global tourism industry is projected to grow exponentially in the upcoming decades due to, amongst others, many new markets opening up in the developing regions of the globe, the development of mobility infrastructure all around the world, and a reduction in travel barriers (e-tickets, cheaper air tickets, and changes in visa requirements) (World Economic Forum, 2017). Therefore, current projections for global CO_2 emissions by the tourism industry alone are expected to result in a temperature rise exceeding the 2°C global temperature rise limit by 2070 (Peeters, 2017). This means that the tourism industry has to undertake some drastic measures to stay within the Paris agreed safe operating space.

Some scholars have addressed the issue of climate change impact on the tourism industry (Hamilton et al., 2005; Amelung et al., 2007). However, the number of scholars who have assessed the impact of the tourism industry on climate change is significantly lower. Scholars such as Daniel Scott, Stefan Gössling, and Paul Peeters are leading the academic field in which tourism’s contribution to climate change is discussed. Gössling (2002) was the first scholar who tried to assess and quantify the current global tourism industry’s impact on the global environment and climate. Scott, Gössling, and Hall (2012) discuss the complex interdisciplinary interrelations and mechanism between climate change and the various components in international tourism. Peeters (2017) is one of the pioneers in identifying the long term impacts of tourism on the worlds’ changing climate.

There is some insight into what the global (and regional) tourism contribution is to the climate change problem. There has also been some research on the kinds of policies that are required to ensure that tourism will stay within the Paris agreed safe operating space. Albeit on the global scale (Peeters, 2017). No scholar has yet looked into how responsibilities should be shared between regions to keep tourism’s emissions within the Paris agreed goals. That is the gap in literature that is being addressed in this research. It is important to assess what regional policy could actually lead to a desirable outcome. Policy makers could use this information when creating policies. Also, lobbyist could use this information to pressure policy makers to design climate policies concerning tourism.

This thesis will focus on two geographical regions; India and the European Union (EU28), which both have a significant amount of travelers originating from those regions. However, the regions are different as the EU's tourism industry is well-developed but growing slowly if at all, whereas India's is small but currently rapidly developing.

India and the EU are two very divergent tourist origin markets. Therefore, they make two interesting case studies to determine the specific consequences for these regions in the context of global CO_2 emission reduction of the tourism industry. The global average of international trips lies between 0,14-0,19 international trips per person per year (UNWTO, 2016; UNWTO, 2017a; World Bank, 2017). The average Indian has made 0,02 international trip[1] in 2015 (Bhatnagar et al., 2015), compared to 0,58 international trip per person for Europeans in 2015 (Eurostat, 2017b). That puts India on the very low end of the spectrum, and the EU at the very top end of the spectrum. Europeans still travel more even after correcting for the fact that the data is skewed because the EU consists out of many small countries where borders are easily crossed by car, whereas India is a large country, mostly enclosed by oceans and the Himalayas. When regarding the EU28 as a single country, Europeans undertake an average of 0,12 trip per person to a destination outside of the EU (Eurostat, 2017b), which is still 6 times more than on average by the Indians.

Europeans have undertaken on average 1,72 domestic trips per person in 2015 (Eurostat, 2017b), whereas Indians have undertaken 1,09 domestic trips per person per year on average. This is both above the global average of 0,69-0,78 domestic trips per person in 2016 (UNWTO, 2016; UNWTO, 2017a; World Bank, 2017). Considering the EU28 as a single nation, Europeans even undertake 2,19 domestic trips per year (trips within EU28) (Eurostat, 2017b).

Finally, there is also a large difference between India and the EU and the annual growth of undertaken trips. The Indian domestic and international tourist segment is currently very rapidly developing at an average increase of trips of 13,34% each year (2008-2015) (Bhatnagar et al., 2015). In the EU, the amount of trips of residents has somewhat stagnated with a slightly experienced yearly decrease of -1,2% in the period 2012-2015 (Eurostat, 2017a).

1.1 Purpose and research questions

The purpose of this study is to identify possible policy pathways in which the Indian and European travel segments will reduce its current projected impact on the changing climate in line with the Paris agreed goals. This information can be used as a starting point in the global debate on how responsibilities should be shared between regions to minimize tourism's climatic impact. This resulted in the following research question:

What regional policy scenarios for the travel industries in the EU and India ensure that the CO_2-emissions from tourism stay within the Paris agreed safe global temperature rise of 2 °C compared to pre-industrial times?

The regional policy scenarios consists of two different parts. The first part are the targets, which describe the allowed emissions and the development of the tourism industry. The second part are the policies required to reach the targets. This results into the two secondary research questions:

1. What are the targets (CO_2 emissions and number of trips) for the travel industries in the EU and India which ensure that the CO_2 emissions from tourism stay within the Paris agreed safe global temperature rise of 2 °C compared to pre-industrial times?
2. What are the policy trajectories for the travel industries in the EU and India that would result in the identified targets?

The research questions were tackled by transposing the quantitative description of a global tourism scenario (the economic mitigation scenario by Peeters (2017)) into regional values. How this scenario was selected is explained it Chapter 2. The economic mitigation scenario by Peeters (2017) illustrates how challenging it is to convert the current global tourism industry into a sustainable industry which conforms to the Paris agreement. This is illustrated in Figure 2 which shows the BAU yearly CO_2 emissions of the tourism industry and the required CO_2 emissions trajectory under the economic mitigation scenario. Considering the expected growth of the global tourism industry with new markets rapidly developing, such as India, it is safe to say the tourism industry has a big challenge ahead to conform to the Paris agreement.

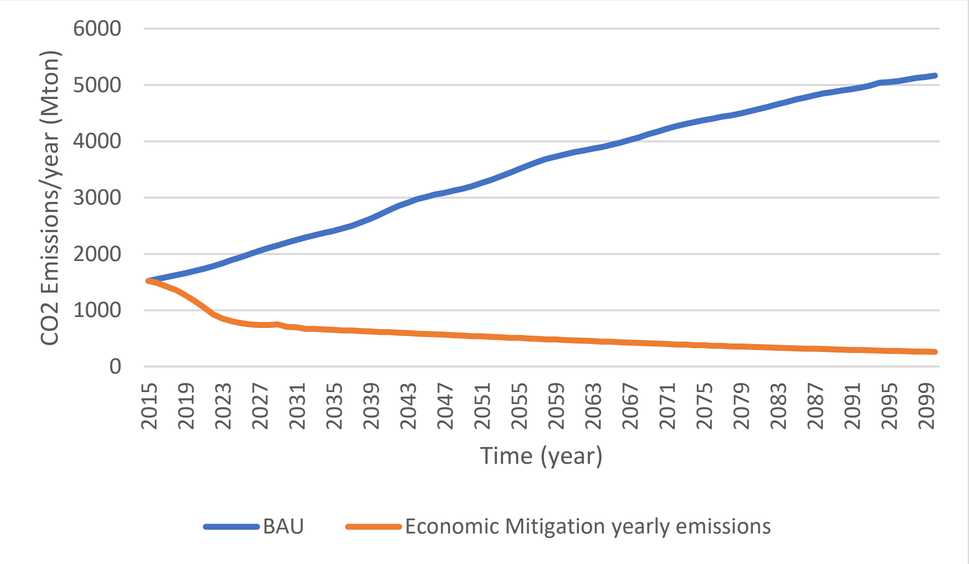

Figure 2 The global CO_2 emissions by the tourism industry under the BAU and the Economic Mitigation Scenario by Peeters (2017)

In chapter 2 it is explained how the Global Tourism and Transport Model ($GTTM^{dyn}$) and the Economic Mitigation Scenario were selected. After which it is explained how the Economic Mitigation Scenario is translated into a regional scenario. This is done through a novel approach through which a range of possible future tourism development trajectories for the tourism industries of India and the EU28 are identified. Chapter 3 includes the results of this thesis in which the ranges of possible trajectories are presented. Firstly, the results for India are presented, than the results for the EU are presented. Results to research question 1 are presented before results to research question 2. In chapter 4 the results are discussed. Chapter 5 concludes with the conclusion of this thesis.

2. Methods:

In this chapter the methods for this thesis will be elaborated upon. The design of this study is a model simulation exercise to which explorative desk research provided the required input data. The data required for answering the research questions come from secondary sources, retrieved from statistical bureaus, governmental and intergovernmental organizations as well as academic literature.

The designed policy scenarios for both India and the EU28 consists of two aspects. Firstly, there is the target aspect which corresponds with sub question 1. This is the aspect were both the range of CO_2 emissions and the range of the number of trips for both India and the EU28 were calculated. In order to define the range of possible trajectories an upper an a lower trajectory was calculated for both the emissions and the number of trips. How this was done is explained in Chapter 2.3 and Chapter 2.4. Secondly, there is the policy aspect which corresponds with sub question 2. Based upon the CO_2 emissions range, the tourism climate policies to achieve the required environmental impact were downscaled from a global to a regional policy measure. How this was done is explained in Chapter 2.5.

A big challenge of this study was figuring out where to start to develop regional scenarios for India and the EU28. Neither region had been subject of study for this particular purpose. Therefore, a global tourism climate policy simulation model had to be found which could be translated into regional models. Various global tourism climate simulation models were considered, which is explained in chapter 2.1.

The next step of this study was to find a global tourism climate scenario (generated by the simulation model) that would fit within the Paris agreed goals. This is described in chapter 2.2.

The last challenging step was to create regional tourism climate scenarios from the global tourism climate scenario. This was done based on equity grounds, as is common practice in international policy making regarding climate issues. The regional tourism climate scenarios for India and the EU28 describe both the policies and the impact of the policies. How the scenarios were created is described in chapter 2.3, 2.4 (Sub question 1) and 2.5 (Sub question 2).

2.1. Selection of the model

In the last two decades, multiple tourism greenhouse gas emissions simulation models have been developed (Vedantham & Oppenheimer, 1998; Schafer & Victor, 1999; Dubois & Ceron, 2006; Peeters, 2017). Four indicators were used to select the most appropriate model for this study. The first indicator is the time span of the model, which should at least include the period between 2016 and 2100, since this is the timeframe of the Paris Agreement (2016). Also, the model should indicate the emissions from the tourism industry specifically, hence emissions resulting from commutes and daytrips should be separated from the emissions from tourism trips in the model. Third, the model should provide data on both India and the EU28 to fit the purpose of this study. With the help of the model it should be possible to create a global tourism policy scenario which would conform to the Paris agreed goals. Non-simulation models are therefore not suitable for the purpose of this study. Table 1 shows the models that were considered for this study, the indicators that were used to select the most suitable model, and whether these indicators apply for the selected models.

Vedantham and Oppenheimer (1998) created a model to estimate greenhouse gas emissions by the global aviation sector until the year 2100. However, this model only includes aviation and does not acknowledge any other emission by the tourism industry (Vedatham & Oppenheimer, 1998).

The model that was created by Schafer and Victor (1999) predicts CO_2 emissions from mobility until 2050. This includes tourism, but it also incorporates non-tourism movements such as daily commutes (Schafer & Victor, 1999). Also the time scale runs until 2050, which is not the full temporal extent of the Paris agreement.

Dubois and Ceron (2006) designed a model to calculate greenhouse emissions for French tourists until 2050. In order to make this model fit for application in this study large adaptations are required to make it fit geographical (France to India and EU28) and time scale fit (2000-2050 to 2016-2100). The model includes leisure related trips only (excluding business trips) and including (non-tourism) daytrips (Dubois & Ceron, 2006).

Peeters (2017) has designed a model to predict future CO_2 emissions by the travel industry under different policy scenarios. $GTTM^{dyn}$ is the first model in which the complex underlying mechanisms influencing travel behavior are taken into consideration to make projections for global CO_2-emissions by tourism. The model simulates the global tourism industry as a dynamic system, rather than taking geographical facets into consideration, which is a challenge to account for the purpose of this thesis. As an input, $GTTM^{dyn}$ requires demographic change scenarios (developed by the Intergovernmental panel for Climate Change (IPCC), Special Report on Emissions Scenarios (SRES)) and 24 policy options to regulate the emissions by the tourism industry (found and explained in Appendix I). $GTTM^{dyn}$ then forecasts future characteristics of the tourism industry such as CO_2 emissions, abatement costs, length of stays, segments of mode of transportation, and tourism revenues (Peeters, 2017).

Table 1 Assessing usability of emissions for this particular study based on relevancy indicators

Model	Time span 2015-2100	Tourism emitted CO_2 emissions	Includes India and the EU	Calculate sustainable scenario
Vedantham & Oppenheimer (1998)	x		x	
Schafer & Victor (1999)			x	x
Dubois & Ceron (2006)				
Peeters (2017)	x	x	x	x

As can be seen in Table 1, Peeters' (2017) $GTTM^{dyn}$ meets all the indicators that are required in this study. The $GTTM^{dyn}$ model has the right temporal extent to analyze the tourism industry under the Paris agreement. $GTTM^{dyn}$ also incorporates all sources of the tourism industry which contribute to greenhouse gas emissions (accommodation, movement, activities). For this reason, the $GTTM^{dyn}$ model was chosen to be used in this study to estimate future CO_2 emissions following several policy scenarios.

$GTTM^{dyn}$ is created after $GTTM^{bas}$ and $GTTM^{adv}$ (precursors of $GTTM^{dyn}$) revealed a likely significant growth in CO_2 emissions from the tourism industry (Peeters, 2017). Both precursors did not include an option to simulate policy measures and its effect on the tourism industry and its emissions (Peeters, 2017). This is the gap that $GTTM^{dyn}$ filled. A user of $GTTM^{dyn}$ can tweak policy measures and run the simulation to find the corresponding behavior of the tourism system. $GTTM^{dyn}$ shows the CO_2 emissions, number of trips, length of stay, tourism revenues, total travel distance, total travel time, and travel speed under the selected policy measures (Peeters,2017). $GTTM^{dyn}$ has been designed based on mechanisms rather than tourism growth assumptions (Peeters, 2017).

2.2. Selection of the sustainable global tourism policy scenario

Peeters (2017) used $GTTM^{dyn}$ to optimize global policy scenarios for the tourism industry to fit within the Paris agreed (2°C) goal. The scenario to fit within the Paris aspired goals which is also economically feasible is the *economic mitigation* scenario (Peeters, 2017). This economic mitigation scenario diverges radically from the business as usual trajectory the tourism industry is currently following. Peeters (2017) has designed this scenario as such that all policy settings in GTTM^{dyn} are set to 'mitigate CO_2 emissions most'. Therefore, one should keep in mind that the economic mitigation scenario requires radical change and cannot be easily implemented.

The economic mitigation scenario requires a big global modal shift which is achieved by heavy policy interventions (Peeters, 2017). One of those global interventions is the restriction in the amount of flights that are allowed to take off in a year. In the economic mitigation scenario, at the global scale a maximum of 10 million airplanes are allowed to take off in a year. This is already a reduction from the 2015 value of approximately 12 million take offs (Peeters, 2017). With the expected growth of the aviation sector, this is a difficult challenge. Another policy measure is the very rapid introduction of electric cars. By approximately the year 2030, every car on the road should be electric according to the economic mitigation scenario. An overview of the applied global policy measures in the economic mitigation scenario in comparison to the business as usual (BAU) scenario can be found in Appendix I.

Peeters (2017) had to make a number of important assumptions in order to make GTTM^{dyn}'s sustainable scenarios compatible with the Paris agreed goals. Compared to other industries, a disproportionate large share of CO_2 emissions should be assigned to the tourism industry due to its technical constraints to become more efficient (Peeters, 2017). This is mostly due to aviation within the tourism industry. Airplanes are already approaching maximum efficiency, while still having relatively high CO_2 emissions per passenger kilometer compared to other modes of transportation. Also, regeneration cycles of the aircraft fleet (how quickly a fleet gets replaced by new models) take decades (Peeters, 2017). Even if new, highly clean, technologies would be developed in aviation, the slow regeneration cycle would obstruct the quick adaptation of those technologies. Therefore, one should see the results of this thesis in the light of a broader context which would allow a higher amount of CO_2 emissions for the tourism industry.

2.3. Translating the global scenario into regional scenarios

The next steps in this thesis was to figure out what scenario indicators should be translated from a global value to regional values and how this could be achieved. A schematic overview of how the global scenario was translated into regional scenarios is presented in Figure 3.

Peeters' (2017) GTTM^{dyn} requires policy inputs, which are used to forecast the behavior of the tourism system. The tourism system, as described by Peeters (2017), consists of the following output indicators; CO_2 emissions, number of trips, length of stay, tourism revenues, total travel distance, total travel time, and travel speed. The GTTM^{dyn} calculated indicators are the targets for the tourism industry until the year 2100.

Only the target indicators *CO_2 emissions* and *number of trips* were translated into regional values. The CO_2 emission indicator was selected because the CO_2 emissions describe the climatic impact of the tourism industry. This is essential when describing a pathway to fit within the Paris agreement. The number of trips were chosen as a representation and visualization of the respective tourism industries. The calculated CO_2 emissions pathways and the calculated number of trips provided the answer to sub question 1. Since, this is an explorative research with a novel method, merely those two target indicators were transformed.

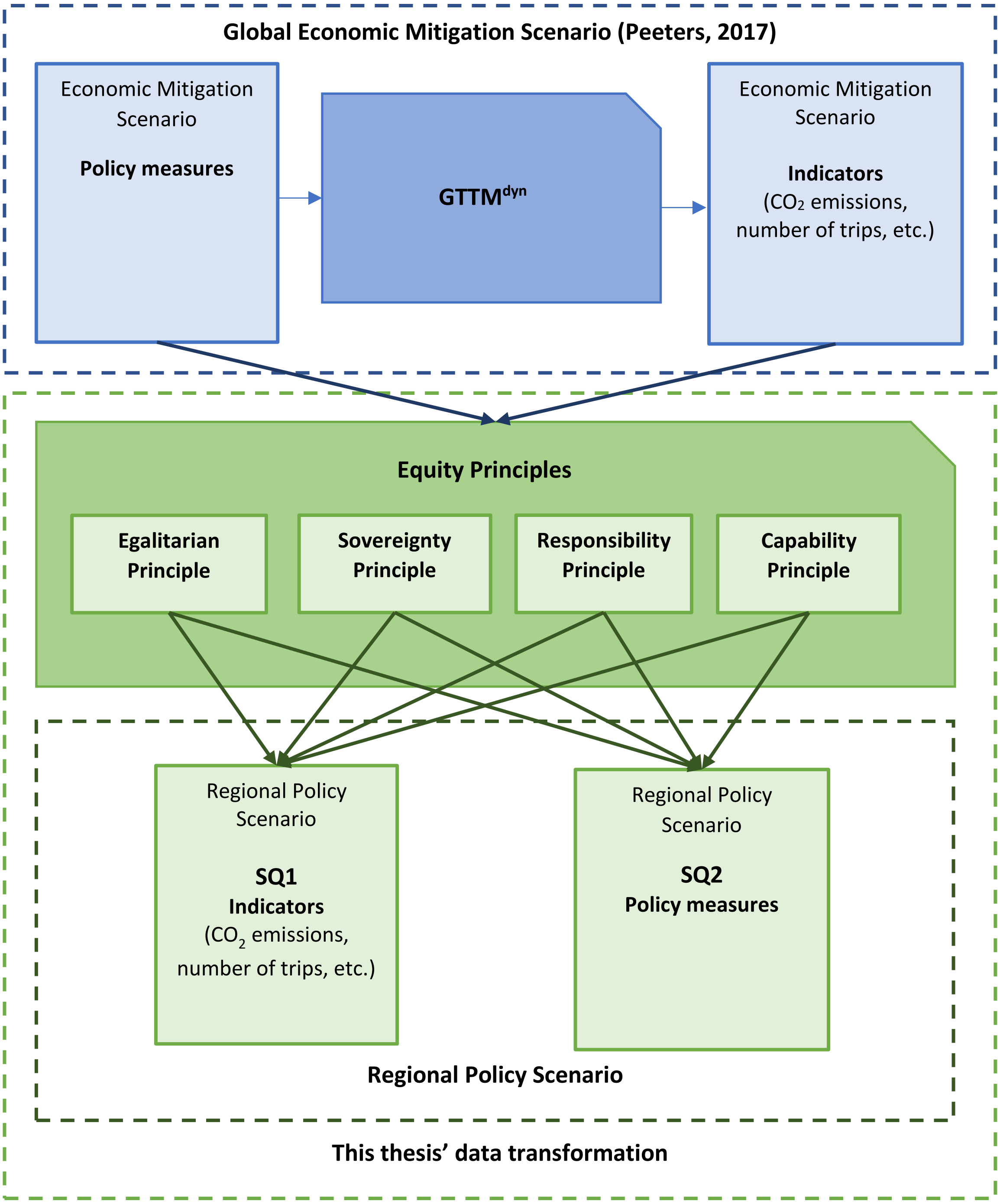

Figure 3 Schematic representation of how the global data was transformed into regional data. In blue the global input data from GTTM^{dyn}. In green the transformation through the equity principles and the output regional scenarios.

The two target indicators consist of a total value and the breakdown values. The breakdown values are made up of the different modes of transportation (car, air, other) and accommodation (CO_2 emissions only). These target indicators should give a rough indication of how the tourism industries of India and the EU28 will look like under the economic mitigation scenario. CO_2 emissions indicate the amount of CO_2 emissions a region is allowed to emit under the economic mitigation scenario. The number of trips indicate the number of trips inhabitants of the respective region are allowed to undertake under the economic mitigation scenario.

A part of identifying the policy scenarios are the identification of the policies itself. The global policy measures to be transposed are described by Peeters (2017) and are used in $GTTM^{dyn}$ as inputs (Appendix I). These global policy measures are translated into regional policy measures, describing the answer to sub question 2.

Peeters' (2017) economic mitigation scenario is a means of describing a common global responsibility for mitigating the climatic effect of tourism. To be able to make a fair distribution of responsibilities (climate policies) and rights (to travel/emit) between regions a framework needed to be created. In international climate debates many different arguments are used which are grounded in different viewpoints on what is perceived *fair*. These different categories of viewpoints can be categorized in four *equity principles* (den Elzen et al., 2005; and Lange et al, 2007). These equity principles are the egalitarian principle, the sovereignty principle, the responsibility principle and the capability principle (den Elzen et al., 2005; and Lange et al, 2007). In practice, all principles are simultaneously used in the design of international climate policies. Amongst scholars and practitioners there is no consensus on which principle weights heaviest (Ringius et al., 2002; Lange et al., 2007). Therefore, the assumption in this thesis is that the most fair climate solution lies somewhere in between those four equity principles.

The egalitarian principle is based upon the principle that every individual has the right to emit as much as every other individual on the globe (Cazorla & Toman, 2000; Ringius et al., 2002; Den Elzen et al., 2004; Lange et al., 2007). Which is fair in the sense that every individual has the same responsibilities and rights as every other individual (Ringius et al., 2002; Den Elzen et al., 2004; Lange et al., 2007).

The sovereignty principle comes from the idea that the status quo conditions, or current emissions, define the right to emit in the future (Ringius et al., 2002; den Elzen et al., 2005; Lange et al., 2007). This is fair in the sense that if a global reduction in CO2 emissions is required, that everyone should reduce their emissions by the *same* percentage (Ringius et al., 2002; Den Elzen et al., 2004; Lange et al., 2007).

The responsibility principle, also known as the polluter-pays rule, stems from the idea that there is an equal rate between (historical) emissions and the efforts of mitigating those emissions (Ringius et al., 2002; den Elzen et al., 2005; Lange et al., 2007). Therefore, the ones responsible for an issue, the polluters, are the ones responsible for solving the problem (Ringius et al., 2002; Den Elzen et al., 2004; Lange et al., 2007).

The capability principle is based on the idea that the regions who have the means to mitigate CO_2 emissions should be the regions to held responsible to mitigate those emissions (Ringius et al., 2002; Den Elzen et al., 2004; Lange et al., 2007). In this way the emissions will be mitigated the fastest, which benefits everyone.

In order to identify the regional policy scenarios for India and the EU28 within the economic mitigation scenario, four separate equity policy scenarios and their according emissions and number of trips, were created per region. Therefore, the regional policy scenarios of India and the EU28 consist of four sub scenarios based upon the four equity principles. Every equity scenario was calculated separately for each region (Chapter 2.4 and 2.5). In decision making over responsibility sharing to counter climate challenges, the four equity principles are never practiced in its purest form. Regional responsibilities and policies are always based on a mix of equity arguments used in the global policy arena (Den Elzen et al., 2004; Lange et al., 2007). Therefore, the four equity scenarios describe the range of possible policy scenario outcomes which could keep global tourism emissions within the Paris agreed goals.

There are two ways to approach the creation of the regional scenarios which were both tried in this thesis. The first method was to alter GTTM^{dyn}'s boundary parameters in a way that the economic mitigation scenario could be ran for either regions. Ultimately altering GTTM^{dyn} from a global model into a regional simulation model. This turned out to be non-feasible for this thesis as the altered GTTM^{dyn} simulation either provided errors or historically incorrect outputs (which are also calculated by GTTM^{dyn} to be able to assess the scenario's validity). Therefore, a second method was developed for the design of the regional scenarios.

Both the GTTM^{dyn} economic mitigation policies and targets had to be separately transposed into regional values. Together they describe the possible regional policy scenarios for both India and the EU28. In the following sections is described how both the targets (2.4) and policies (2.5) were transposed according to the equity principles.

2.4. Translation of the target indicators through equity principles

2.4.1. Egalitarian principle

The egalitarian principle is based upon the principle that every individual has the right to emit as much as every other individual on the globe (Cazorla & Toman, 2000; Ringius et al., 2002; Den Elzen et al., 2004; Lange et al., 2007). This means that a country or region with x% of the global population has the right to emit x% of the greenhouse gases (Lange et al., 2007). In order to work this principle, each GTTM^{dyn} output indicator has been divided based upon the share of the global population that is living in either India and EU28 in that particular year.

The calculation is based on the global and regional population scenarios with a yearly interval from 2015-2100. These population values have been retrieved from the UN (2017) world population prospect database (medium fertility forecast), which provided the required forecasts (2015-2100). The population data has been acquired by adding up the required countries' populations (for EU28 all individual member countries, for India merely India). The global yearly emissions and number of trips are taken from the Economic Mitigation Scenario (Peeters, 2017).

For each yearly interval the x% share of the global population per region (EU28 and India) is then calculated. These proportions can then be used to calculate the according output indicator. Therefore the formula is the following (Eq. 1):

(Eq. 1) $$X_{y,reg} = \frac{X_{y,glob} \cdot P_{y,reg}}{P_{y,glob}}$$

The X represents either the CO_2emissions or the number of trips in a certain year (y) and for a certain region (reg: India or EU28; and glob: global). The P represents the population in a certain year (y) and for a certain region (reg: India or EU28; glob: global).

2.4.2. Sovereignty principle

The sovereignty principle comes from the idea that the status quo, or the current conditions determine the responsibilities different regions have towards the Paris Agreement (Ringius et al., 2002; den Elzen et al., 2005; Lange et al., 2007). This means that the 2015 ratios of emissions and number of trips between regions remain the same in the global economic mitigation scenario. Hence, a CO_2 emissions reduction of x% means that all regions are putting in the same effort to reduce that x%.

In order to calculate regional output one requires the ratios of the required output indicator in the base year 2015 as well as the yearly projected global change for each output indicator. The projected global change for each output indicator is retrieved from the Economic Mitigation Scenario by

Peeters (2017) as well as the global 2015 values. The 2015 regional values are obtained from different sources.

Eurostat provides an estimation of the total trips made by Europeans (approximately 1,2 billion in 2015) (Eurostat, 2017) and the trips made by Europeans by mode of transportation (Eurostat, 2018a). The Eurostat data does not provide specific data on the amount of car trips. The number of car trips by Europeans were calculated subtracting the air and other modes of transportation from the total amount of trips.

Bhatnagar et al. (2015) provides both the number of air departures from India by Indian inhabitants as well as the number of domestic and international trips. Dhar and Shukla (2015) provide insight on the share of road movements (car) and the share of train movements (other).

The regional CO_2 emissions were then calculated by using the number of trips as an approximate because no regional tourism CO_2 data was available. The accommodation emissions were assumed to take up approximately 22% of the total CO_2 emissions by the tourism Industry (Peeters, 2017). The total regional emissions were calculated by dividing the regional trips by the global trips and multiplying by the global CO_2 emissions from the economic mitigation scenario by Peeters (2017). The CO_2 emissions per mode of transportation were calculated through the same method as the total regional emissions. The sum of the separate emissions appeared less than the total CO_2 emissions. This is due to the fact that the distance per mode of transportation and efficiency change were not taken into account.

2.4.3. Responsibility principle

The responsibility principle, also known as the polluter-pays rule, stems from the idea that there is an equal rate between abatement costs and (historical) emissions (Ringius et al., 2002; den Elzen et al., 2005; Lange et al., 2007). Therefore, the polluting region is the region responsible for the effort of mitigating those emissions.

To incorporate this principle created the challenge of overcoming the lack of data or estimates on the historic CO_2 emissions by the tourism industry. Therefore, an estimation had to be made of the historical size of the travel segment in both regions. This estimation is used to roughly indicate the contribution of the travel industry to the global tourism CO_2 emissions. With the historic travel segment size estimation the responsibility principle pathway was calculated for both regions.

The formula that was used to calculate the emissions and the number of trips is based upon the amount a region should reduce compared to the regional business as usual scenario (Eq. 2). Therefore the formula is:

(Eq. 2) $$X_{y,regECOM} = X_{y,regBAU} - X_{y,req.reg.red.}$$

In which *X* represents either trips or emissions. The regional emissions/trips ($X_{y,regECOM}$) according to the responsibility principle are the regional trips/emissions in the BAU scenario ($X_{y,regBAU}$) minus the required reduction per region ($X_{y,req.reg.red}$). The required reduction was calculated by taking the difference between the BAU ($X_{y,glob\ BAU}$) and the Economic Mitigation scenario ($X_{y,globECOM}$) and finding the regional share of the difference (times the regional population and divided by the global population) (Eq. 3). That value was than multiplied by the rate of responsibility (R_{res}).

(Eq. 3) $$X_{y,regECOM} = \frac{X_{y,globBAU} \cdot P_{y,reg}}{P_{y,glob}} - \frac{(X_{y,globBAU} - X_{y,globECOM}) \cdot P_{y,reg}}{P_{y,glob}} \cdot R_{res}$$

The rate of responsibility was estimated by calculating both the global and regional sum of international trips (T) over the period 1991-2015 divided by the population (P) in 2015 (Eq. 4). Dividing this global value by the regional value provides the rate of responsibility of a region.

(Eq. 4) $$R_{res} = \frac{(\sum_{y=1991}^{2015} T(y)_{reg})/P_{2015\,reg}}{(\sum_{y=1991}^{2015} T(y)_{glob})/P_{2015\,glob}}$$

In order to calculate the responsibility principle scenario the forecasted population of India, the EU28 and the world were required (2015-2100). The population data was based on medium fertility population scenario by UN (2017). Bhatnagar et al.(2015) provided the historic Indian international trips, while UNWTO (n.d.) provided the historic EU28 and global trips. The global trips and emissions from the BAU and economic mitigation scenario were taken from $GTTM_{dyn}$ (Peeters, 2017).

2.4.4. Capability principle

The capability principle is based on the idea that the regions who have the means to mitigate CO_2 emissions should be the regions to held responsible to mitigate those emissions (Ringius et al., 2002; Den Elzen et al., 2004; Lange et al., 2007). In order to be able to extrapolate the environmental effects of the model when the capability principle was taken into account, the GDP/capita was calculated. Based on that number the ratio to which each region should be capable to change their tourism behavior was calculated. No India and EU28 specific forecasting data concerning GDP per capita were found. Therefore, respectively Asia's and the OECD's GDP forecasts were used as an approximate for India and the EU28 respectively (IMAGE, 2000). The global GDP forecast was also taken from IMAGE (2000).

The formula used to calculate the capability principle's #trips and emissions is the same formula which was used for calculating the responsibility principle's values (Eq. 5):

(Eq. 5) $$X_{y,regECOM} = \frac{X_{y,globBAU} \cdot P_{y,reg}}{P_{y,glob}} - \frac{(X_{y,globBAU} - X_{y,globECOM}) \cdot P_{y,reg}}{P_{y,glob}} \cdot R_{y,cap}$$

In which *X* represents either trips or emissions. The required reduction was calculated by taking the difference between the BAU ($X_{y,glob\,BAU}$) and the Economic Mitigation scenario ($X_{y,globECOM}$) and finding the regional share of the difference (times the regional population and divided by the global population) (Eq. 3). That value was than multiplied by the capability rate (R_{cap}).

The capability rate ($R_{y,cap}$) (Eq. 6) has been calculated differently than the responsibility rate (R_{cap}). The capability rate has been calculated on a yearly basis based upon the yearly estimated GDP/capita.

(Eq. 6) $$R_{y,cap} = \frac{GDP/cap_{y,reg}}{GDP/cap_{y,glob}}$$

2.5. Defining the policy trajectories within the regional scenarios

In chapter 2.4 the creation of both the regional CO_2 emissions trajectories and the number of trips trajectories based on different principles have been discussed. The following step is to discuss how these regional trajectories translate into regional policies that are required to keep the global tourism emissions within the Paris agreed goals. Peeters' (2017) global economic mitigation policy measures (Table 2) were taken as a starting point for defining the required regional policy measures. For the range defining equity principles, the equity principles whose sub scenarios provided the upper- and lowermost trajectories concerning the target indicators, the corresponding policy measures were identified.

GTTM^{dyn} includes specific policy measures to reduce CO_2 emissions by the tourism industry. These policy measures are presented in Table 2 with the values originating from the Global Economic Mitigation scenario as indicated by Peeters (2017). The use of different principles to determine policy measures require different approaches of distributing those measures between different geographical regions. These approaches are determined by three parameters, namely different timeslots, minimum and maximum capacity and splitting global budgets into regional ones.

Some input policies in GTTM^{dyn} can be set to different levels for different timeslots (2015, 2036, 2057, 2078, and 2100).

Some of the policies are set at their maximum or minimum value in the global economic mitigation scenario and can therefore not be different for both India and the EU28. The regional policies for these measures will therefore have to be equally strict for both regions. This is essential for the design of the regional policies. Policies at their maximum and minimum capacity will therefore not be transposed for different regions based on the equity principles. All policy measures in the economic mitigation are tested for this principle as indicated in Table 2.

Two policy measures: the high speed rail (HSR) investments and the airport maximum capacity policy measures require different calculations. These values are global values that need to be split accordingly for each region.

For the calculation of the trajectories the following rule concerning these parameters was taken into account: If a policy measure fits within either one of the categories “not at max. capacity” or “global budget that needs to be split regionally”, then the policy measure was translated into a regional value. Table 2 indicates the different policy measures that require additional attention in the design of the regional policy scenarios.

Table 2 global economic mitigation policy measures (full explanation of policy measures in Appendix I)

Policy Measures	Economic mitigation (global)	Different timeslots	Not at max. capacity	Global budget that needs to be split regionally
Land-use capacity	Sustainable			
Biofuels that may be used	Yes			
Biofuel subsidies per biofuel feedstock (%)	90	x	x	
Car efficiency change (%/yr)	-3,5			
Share of electric cars policy goal (fraction of fleet)	1			
Factor determining the rate of introduction of electric cars	1			
Air additional efficiency improvement (%/yr)	-0,27			
Other transport efficiency per year change (%/yr)	-2,5			
Accommodation efficiency per year change (%/yr)	-2,5			
Turboprop desired share of fleet (%)	40		x	
Maximum aircraft age operational (yr)	30		x	
High-speed rail investments time curve (billion 1990 USD/yr)	200	x		x
Global airport maximum capacity in million flights/yr	10	x	x	x

Global aircraft cruise speed reduction factor (%)	0	x	
Global operational car speed change policy factor (%)	0	x	
Global operational other transport speed change (%)	30	x	
Global (tourism) carbon tax (1990 USD/ton CO2)	90-450	x	x
Tourism carbon tax applied to all modes and accommodation	yes		
Global ticket tax air transport (%)	200	x	
Global ticket tax car transport (%)	0	x	
Global ticket tax other transport (%)	0	x	
Rate of change of the length of stay (night/trip/yr)	-0,0006		
Marketing policy that factors the desire to travel	0,95	x	x
Marketing policy that factors the attraction-of-distance curve	0,5	x	x

2.5.1. Egalitarian principle

Based upon the rule described above, the eight green highlighted policy measures in Table 2 are translated into specific regional values. Since the egalitarian principle states that all individuals will be granted the same responsibilities, most values (depicted in white) remain the same on a regional scale as they are on the global scale. Only the policies with a global budget had to be split. This is done on population basis. Population values were retrieved from the UN (2017), the medium fertility scenario.

2.5.2. Sovereignty principle

The eight green highlighted policy measures in Table 2 are translated into a specific regional value within the sovereignty scenario. The status quo situation is leading for future situations as well. Therefore, current ratios become future ratios. With this in mind, data on the 2015 situation was required. As currently there are no large scale biofuel subsidies to fuel the tourism industry, no limits on aircraft age, no tourism carbon taxes, and no differentiation marketing policies, those five policy measures remain homogeneous globally. Hence, these policy measures are the same for India and the EU28. The sources for the current ratios between the regions for the remaining three policy measures are as follows: Turboprop share of fleet (Cooper, Smiley, Porter, & Precourt, 2017), high speed rail investments (UIC, 2018) and global airport maximum capacity (Eurostat 2018a; Bhatnagar et al., 2015; IATA, 2018b).

Taking all information mentioned above into account extrapolations towards the year 2100 were made concerning CO_2-emissions by tourist travels for each of the four principles. The results of these calculations can be found in the next chapter.

3. Results

In this chapter both the results for sub question 1 and 2 will be discussed. Firstly, India's results will be presented. Thereafter, the results for the EU28 will be presented.

3.1 India

In this chapter the regional emission scenario for India will be discussed. The India specific scenario is broken down in the scenario's total allowed emissions and trips ranges, and the specific equity scenarios' breakdowns; answering sub question 1. In sub chapter 3.1.6, the answer to sub question 2 will be provided; the required policies.

3.1.1. Economic Mitigation emission scenario range India

The range of the number of trips from India's economic mitigation regional scenario is presented in Figure 4. As is clearly visible in the graph, the total number of trips in the sovereignty scenario follows a much higher trajectory than the remaining equity scenarios. This is due to the fact that Indians already make more trips than the average earth inhabitant. According to the sovereignty principle this will also grant you more trips in the future. As shown, the sovereignty principle provides the upper limit of the number of trips, whereas the egalitarian principle provides the bottom limit. Somewhere in between those two lines the actual future number of trips should fall if India would decide to regulate their tourism industry according to the economic mitigation scenario.

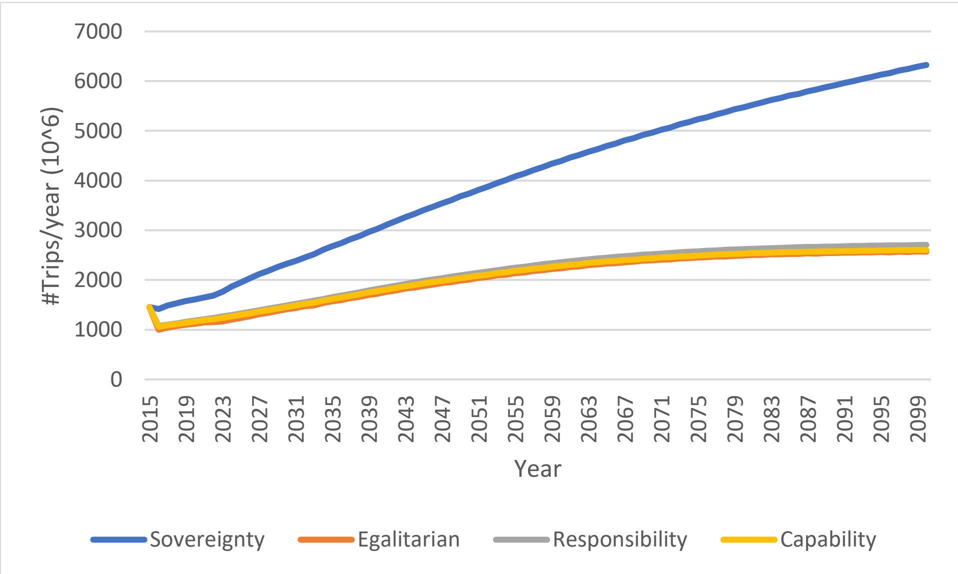

Figure 4 India's regional economic mitigation # of trips range shown represented by the egalitarian principle scenarios

The CO_2 emissions from India's economic mitigation regional scenario is presented in Figure 5.

As shown, the egalitarian, responsibility, and capability scenario emission trajectories require a lower starting point than the sovereignty scenario for India. The sovereignty scenario starts out on the actual base year value of 2015. Showing a quick drop in emissions until 2023, after that a gradual decline in emissions is required until 2100. The egalitarian scenario shows a similar pattern as the sovereignty scenario. However, the egalitarian scenario starts of lower and remains lower in emissions than the sovereignty scenario. The responsibility scenario shows an increase in emissions with a stagnation in around 2085. The responsibility emissions in 2100 are almost 20 times higher than the egalitarian emissions in 2100. The capability emission trajectory shows a gradual increase in emissions until around 2043 after which a gradual but steady decrease sets in until 2100.

The upper limit of the CO_2 emission range is bound by the sovereignty scenario until 2020, and the responsibility principle from 2020-2100. The bottom limit of the range is bound by the egalitarian principle scenario. The responsibility principle and the capability principle scenarios both show higher values than the egalitarian principle scenario. Respectively, this means that India did not contribute to the problem (historical CO_2 emissions) as much as the rest of the globe, as well as that India has less means (low predicted GDP) to reduce the tourism industry's CO_2 emissions.

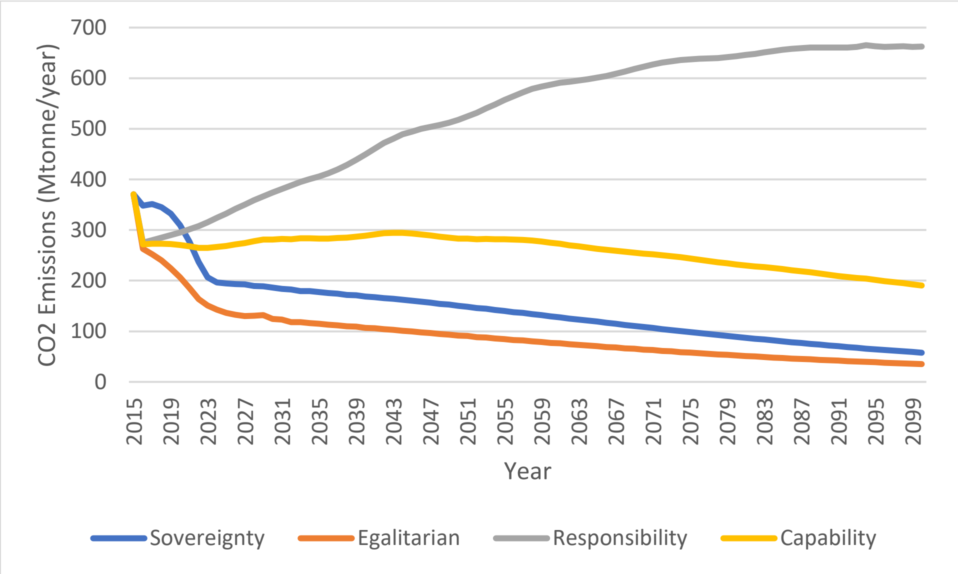

Figure 5 India's regional economic mitigation CO_2 emissions range represented by the egalitarian principle scenarios

3.1.2. Egalitarian principle breakdown

Figure 6 and Figure 7 respectively show the number of trips breakdown per mode of transportation and the CO_2 emissions breakdown per mode of transportation and accommodation in the egalitarian principle scenario.

This principle equally divides all trips and emissions per global citizen. This means that the tourism industry in India would have a large shock concerning the first year of transitioning. India would gain 229 million air trips over 20 million air trips the year prior (base year 2015, also shown in Figure 6), whereas the road movements will reduce from 1272 million to 508 million. In total, the number of trips in the first year will have to reduce from 1452 million to 1056 million. The number of trips per mode of transport will all continue to grow until 2100 except for air movements, which is the general trend in the global economic mitigation scenario.

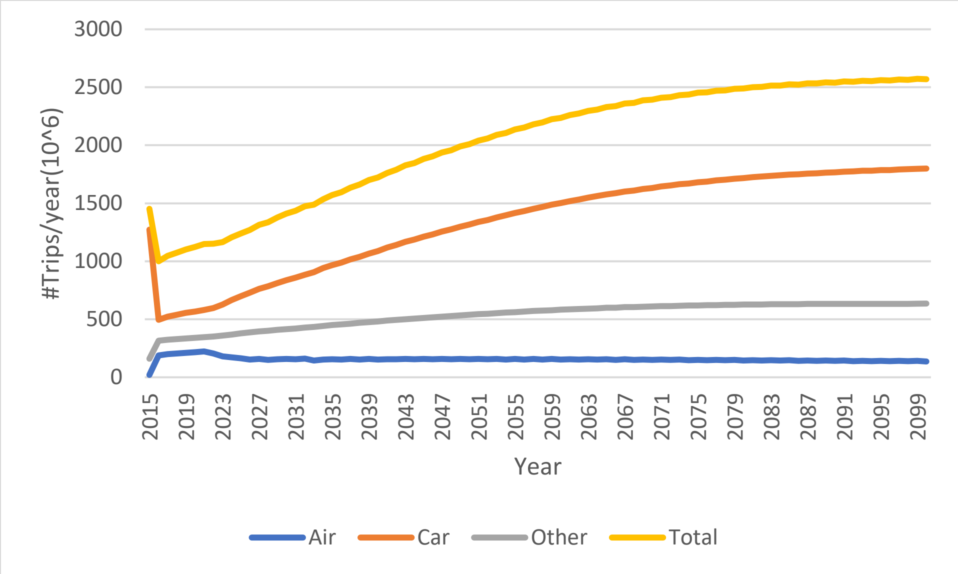

Figure 6 Breakdown of the number of trips per mode of transportation in the Egalitarian principle scenario for India

According to the egalitarian principle scenario, India's tourists will have to cut their total emissions in half in the period 2015-2027. This is achieved by reducing the total number of flights and the implementation of cleaner technologies. After 2027, a gradual decline is required until 2100 over the whole of the tourism sector in India.

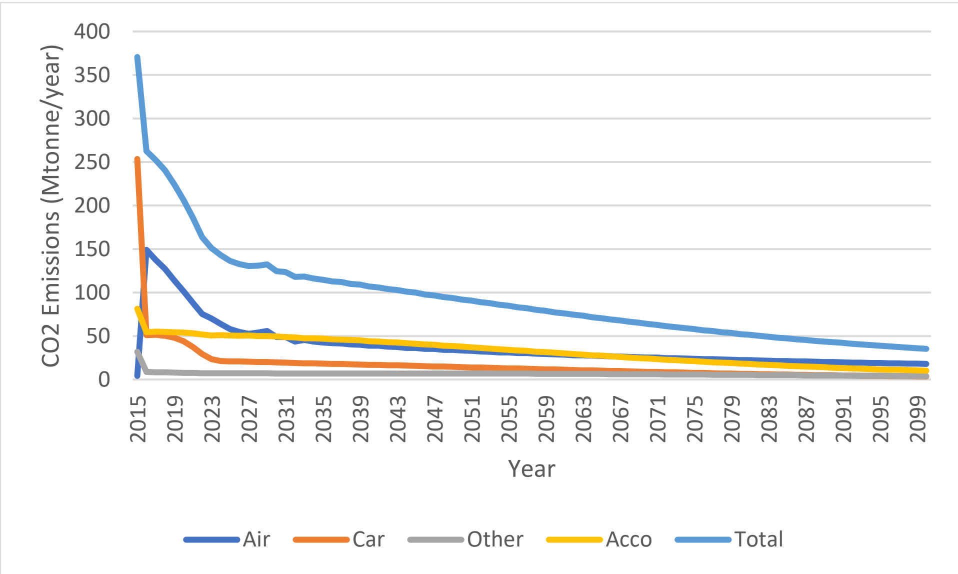

Figure 7 Breakdown of the CO_2 emissions per segment of the tourism industry in the Egalitarian principle scenario for India

3.1.3. Sovereignty principle breakdown

Figure 8 and Figure 9 respectively show the number of trips breakdown and the CO_2 emissions breakdown in the sovereignty principle scenario. In this scenario the 2015 share of the global tourism trips and emissions were used to find the future values for each section of the tourism industry. This would lead to a smooth transition towards a sustainable tourism future (no large initial shocks/transitions). As approximately 88% of India's 2015 tourism movements are done by road (Dhar & Shukla, 2015), road movements remain the largest share of India's movements in the future. Air (≈1%) and other movements (≈11%) are merely a small segment of India's tourism movements.

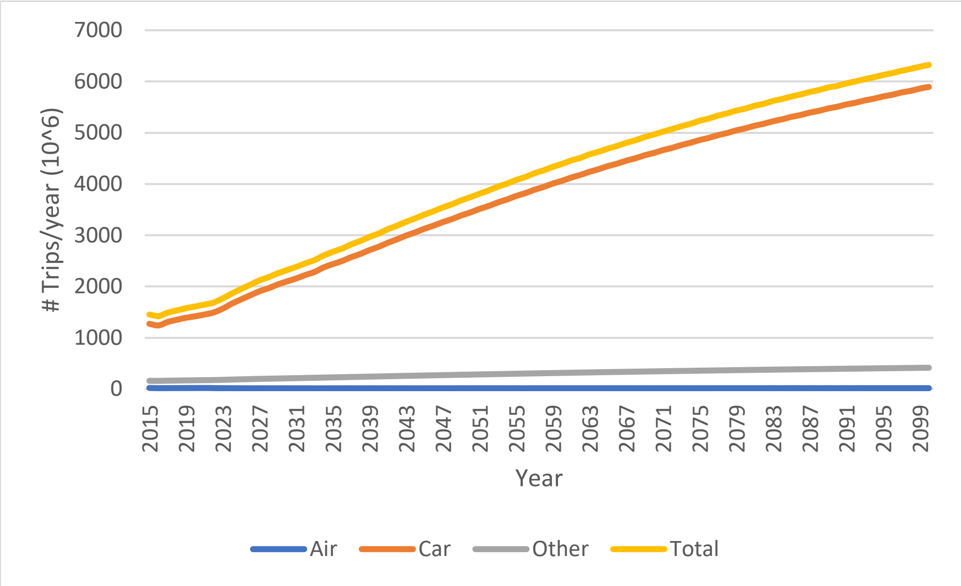

Figure 8 Breakdown of the number of trips per mode of transportation in the sovereignty principle scenario for India

Although the number of road movements in India are expected to grow in the sovereignty scenario, India's car segment is expected to reduce the emissions quite drastically as illustrated by the sheer drop in emissions between 2019-2027 (see Figure 9). After 2027, emissions are required to continue dropping, but at a slower pace.

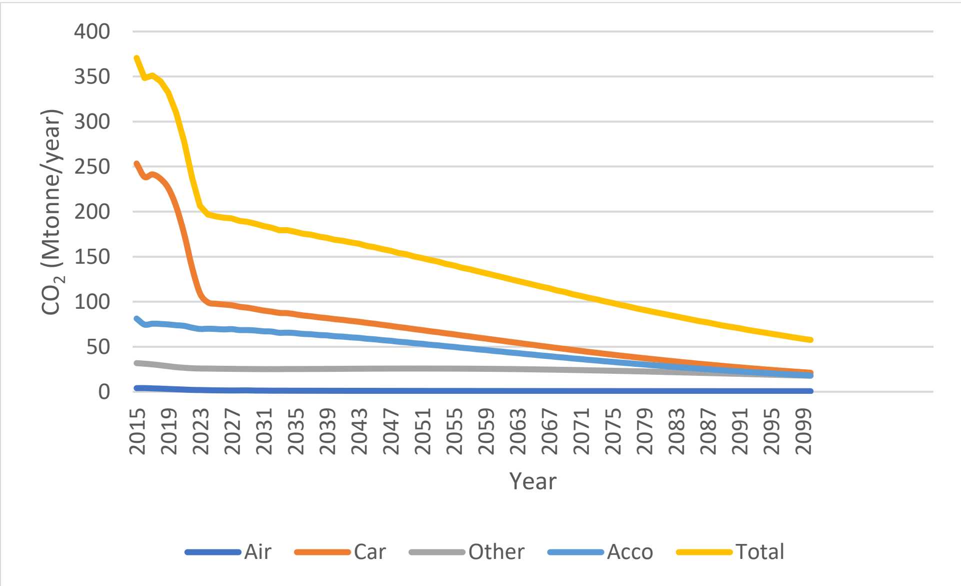

Figure 9 Breakdown of the CO_2 emissions per segment of the tourism industry in the sovereignty principle scenario for India

3.1.4. Responsibility principle breakdown

Figure 10 and Figure 11 respectively show the number of trips breakdown and the CO_2 emissions breakdown in the responsibility principle scenario. Historic data on trips was used to estimate the region's contribution to the CO_2 emissions challenge to calculate the share of CO_2 emissions and trips. Because India's tourism industry is only currently very rapidly developing, past emissions and trips emissions had only a very small impact on the climate change issue. Therefore, all of India's mode of transport number of trips are growing in the future. Most notable is the large rise in air trips, rising almost until 1 billion in 2100 under this scenario.

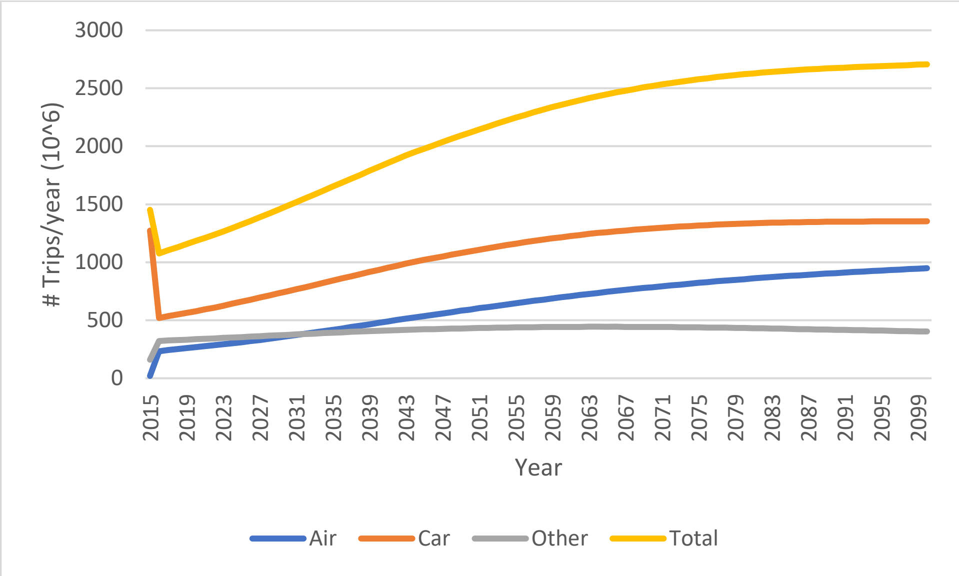

Figure 10 Breakdown of the number of trips per mode of transportation in the responsibility principle scenario for India

The large rise in air trips directly correlates with the big rise in CO_2 emissions in the responsibility scenario. This scenario is the only scenario that has higher CO_2 emissions in 2100 than in 2015 (Figure 5).

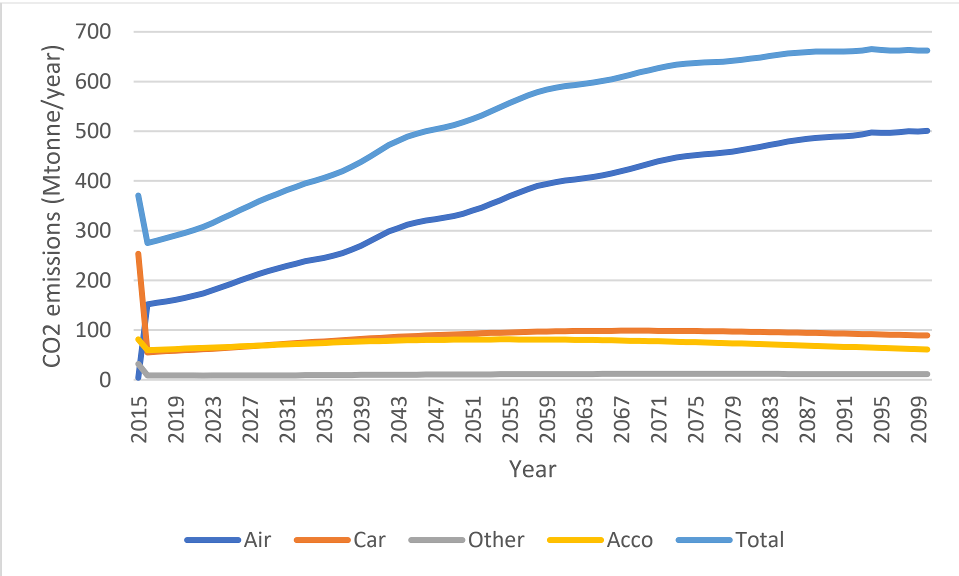

Figure 11 Breakdown of the CO_2 emissions per segment of the tourism industry in the responsibility principle scenario for India

3.1.5. Capability principle breakdown

Figure 12 and Figure 13 respectively show the number of trips breakdown and the CO_2 emissions breakdown in the capability principle scenario. The estimated GDP per capita values for India were used to calculate how much India should reduce their number of trips and emissions. The lower the GDP per person, less emission and trip reduction is required. Compared to the responsibility principle, India does not receive a lot more air trips, whereas overall, the total number of trips in this scenario is similar to the responsibility scenario. On average, India is left with additional room to develop all of their number of trips per mode of transportation.

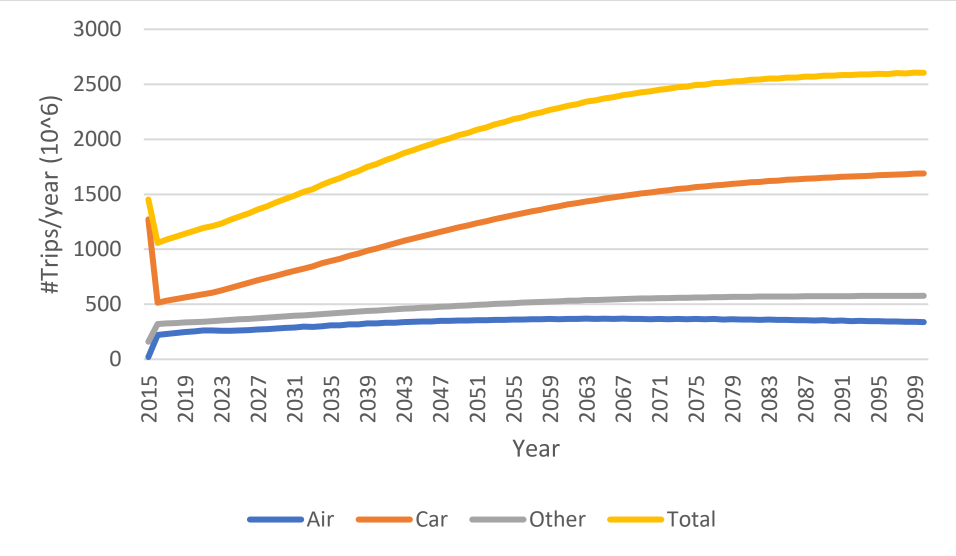

Figure 12 Breakdown of the number of trips per mode of transportation in the capability principle scenario for India

The estimated CO_2 emissions by the capability principle do not show a large overall reduction. In all sectors of the tourism industry, the emissions are expected to grow until around 2039, after which, all of the emissions, except for aviation, will reduce. Ultimately, later in the century, also the Indian aviation sector will have to reduce their CO_2 emissions.

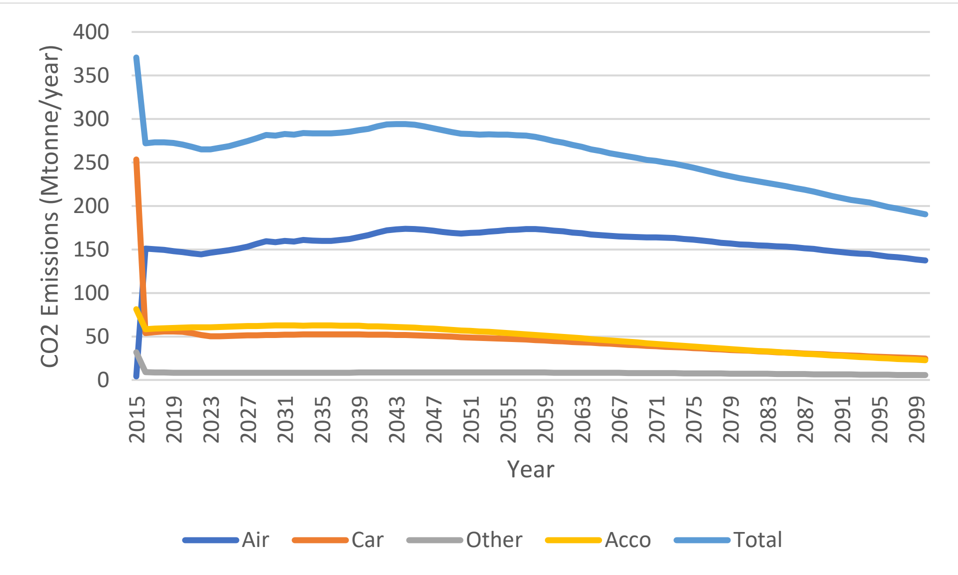

Figure 13 Breakdown of the CO_2 emissions per segment of the tourism industry in the capability principle scenario for India

3.1.6. Policy measures economic mitigation scenario

Table 3 shows the values for all calculated estimated policy measures in the egalitarian and sovereignty scenario for India. The green values diverge regionally from the global policy measures as set by Peeters (2017). All other values are the same worldwide.

In the egalitarian scenario the High Speed Rail (HSR) investment curve starts at $35,5 billion 1990 USD/year and gradually reduces to $27,1 billion 1990 USD/year. This is due to the fact that Africa's population is expected to grow much faster than India's population, therefore India should pay a smaller share of the global investments in HSR. The same principle goes for the airport slots India gets granted in the egalitarian scenario. India starts out with 1,7 million airport slots, which will have to reduce to 1,36 million slots in 2100.

According to the sovereignty scenario, India's amount of turboprops should be 38,9% of all their aircraft carriers. This is 1,1% less than the egalitarian 40%. India's HSR investments should be $0 billion 1990 USD/year. India's airport capacity should be restrained to 0,16 million flights/year.

Table 3 Regional policy measures India

	Egalitarian	Sovereignty
Biofuels that may be used	Yes	Yes
Biofuel subsidies per biofuel feedstock (%)	90	90
Car efficiency change (%/year)	-3.50	-3.50
Share of electric cars policy goal (fraction of fleet)	1	1
Factor determining the rate of introduction of electric cars	1	1
Air additional efficiency improvement (%/year)	-0.27	-0.27
Other transport efficiency per year change (%/year)	-2.50	-2.50
Accommodation efficiency per year change (%/year)	-2.50	-2.50
Turboprop desired share of fleet (%)	40	38,9%
Maximum aircraft age operational (year)	30	30
High-speed rail investments time curve (billion 1990 USD/year)	$35,5 -> $27,1	$0
Global airport maximum capacity in million flights/year	1,7 -> 1,36	0,16
Global aircraft cruise speed reduction factor (%)	0	0
Global operational car speed change policy factor (%)	0	0
Global operational other transport speed change (%)	30	30
Global (tourism) carbon tax (1990 $/ton CO2)	$90-$450	$90-$450
Tourism carbon tax applied to all modes and accommodation	Yes	Yes
Global ticket tax Air transport (+ is tax and – is a subsidy; %)	200	200
Global ticket tax Car transport (+ is tax and – is a subsidy; %)	0	0
Global ticket tax Other transport (+ is tax and – is a subsidy; %)	0	0
Rate of change of the length of stay (night/trip/year)	-0.0006	-0.0006
Marketing policy that factors the desire to travel	0.95	0.95
Marketing policy that factors the attraction-of-distance curve	0.5	0.5

3.2. EU28

In this chapter the regional emission scenario for the EU28 will be discussed. The EU28 specific scenario is broken down in the scenario's total allowed emissions and trips ranges, and the specific equity scenarios' breakdowns; answering sub question 1. In sub chapter 3.1.6, the results to sub question 2 are presented; the required policies.

3.2.1. Economic Mitigation emission scenario range EU28

The range of the number of trips from the EU28's economic mitigation regional scenario is presented in Figure 14. As shown, the sovereignty principle provides the upper limit of the number of trips, whereas the responsibility principle provides the bottom limit. Somewhere in between those two lines the actual future number of trips should fall if the EU28 would decide to regulate their tourism industry according to the economic mitigation scenario. As is clearly visible in the graph, the total number of trips in the sovereignty scenario remains much higher than in the remaining equity scenarios. This is due to the fact that EU28 already make more trips than the average earth inhabitant. According to the sovereignty principle this will also grant more trips in the future. Both the responsibility and the capability trajectory provide lower values than the egalitarian scenario, reflecting that the EU28 is both more responsible for historic tourism CO_2 emissions than average, as well as it is richer than most regions.

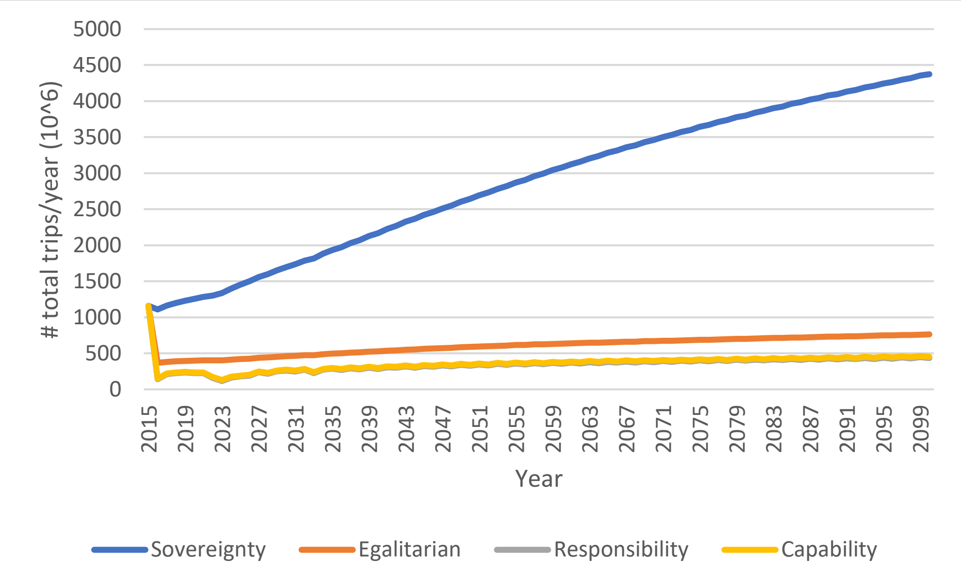

Figure 14 EU28's regional economic mitigation # trips range shown through equity principle scenarios

The CO_2 emissions from the EU28's economic mitigation regional scenario is presented in Figure 15. There is something quite peculiar about the lower limits of this range; namely, the responsibility and the capability trajectories. Both trajectories go well into the negative values: the carbon budget becomes lower than 0. Therefore, the EU28 should be capturing CO_2 from the atmosphere rather than emitting more CO_2. This is, as of yet, impossible in the current tourism industry. Therefore, it is much likely that scenario range is described by the egalitarian trajectory (lower limit) and the sovereignty trajectory (upper limit). In both cases, the EU28 has to drastically reduce the CO_2 emissions of the tourism industry. The sovereignty scenario provides the EU28 with more time to gradually start reducing the CO_2 emissions. The egalitarian scenario demands radical change in 2015, after which a gradual decline is still expected.

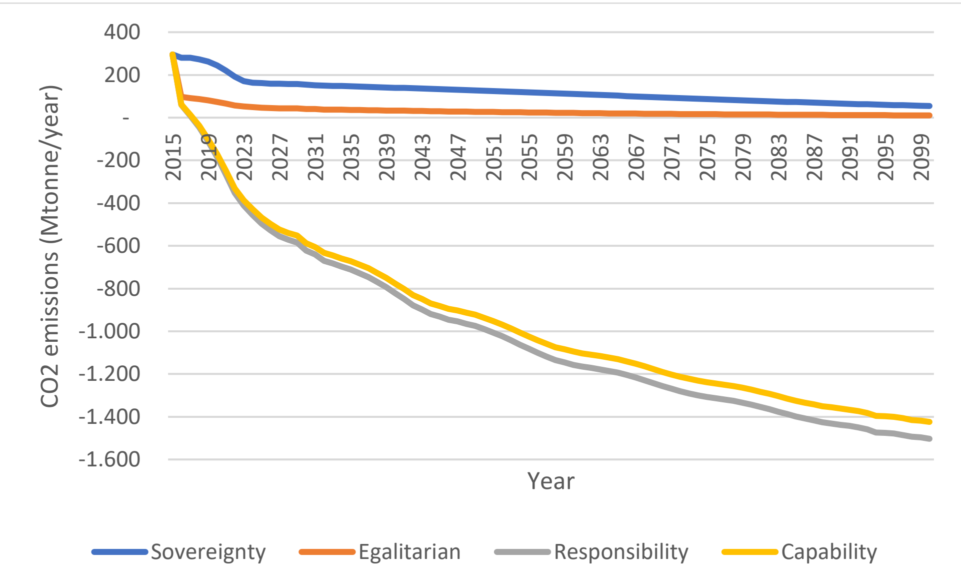

Figure 15 EU28's regional economic mitigation CO_2 emissions range shown through equity principle scenarios

3.2.2. Egalitarian principle breakdown

Figure 16 and Figure 17 show the number of trips breakdown and the CO_2 emissions breakdown respectively in the EU28 specific egalitarian principle scenario. This egalitarian principle equally divides all trips and emissions per global citizen. A total reduction in trips from 1159 million to 393 trips is required. Especially the number of trips by car are heavily reduced in the egalitarian principle scenario (808 million to 189 million in 2015). After the initial shock, all number of trips per mode of transportation are projected to grow except for aviation, which is projected to decline.

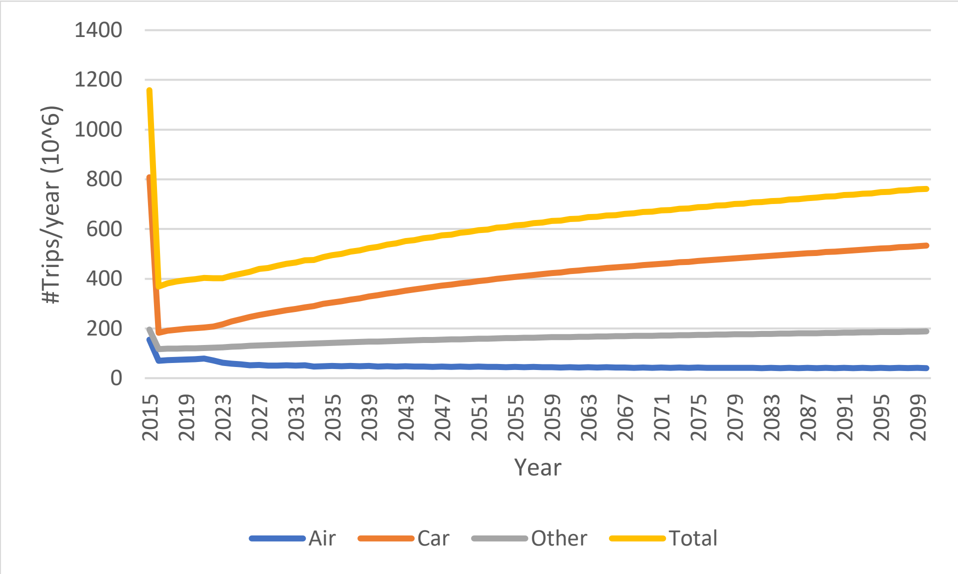

Figure 16 Breakdown of the number of trips per mode of transportation in the Egalitarian principle scenario for the EU28

According to the egalitarian principle scenario, an initial shock in 2015 is required. The initial shock originates from the large difference between the average amount of trips of EU28 residents and the average global citizen. Therefore, initiating the egalitarian scenario in 2015 will require EU28 inhabitants to give up much of their travels within a year.

EU28's tourists will have to drastically cut their total emissions in half in the period 2015-2027 to be able to conform to the Paris agreement within the egalitarian scenario. After 2027, a gradual further decline is required over the whole of the tourism sector in the EU28 until 2100.

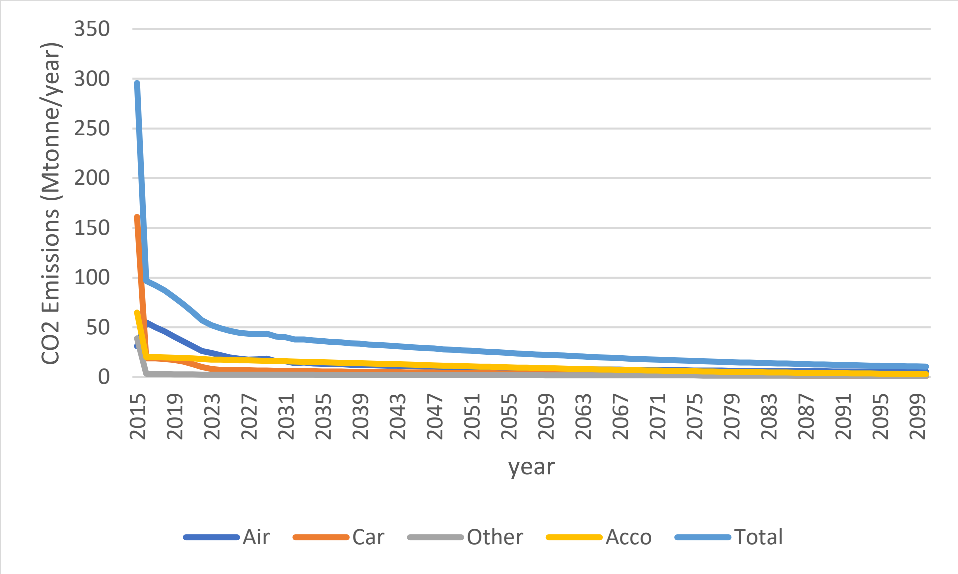

Figure 17 Breakdown of the CO_2 emissions per segment of the tourism industry in the Egalitarian principle scenario for the EU28

3.2.3. Sovereignty principle breakdown

Figure 18 and Figure 19 show the number of trips breakdown and the CO_2 emissions breakdown respectively in the sovereignty principle scenario. In this scenario the 2015 share of the global tourism trips and emissions were used to find the future values for each section of the tourism industry. This would lead to a smooth transition towards a sustainable tourism future (no large initial shocks/transitions). Car trips remain the most popular mode of transportation in the EU28 and will follow a huge growth trajectory up until 2100. Air movements are required to decline in the future. From 85 million air trips in 2015 to 41 million air trips in 2100. Other modes of transportation are expected to grow from 119 million in 2015 to 188 million trips in 2100.

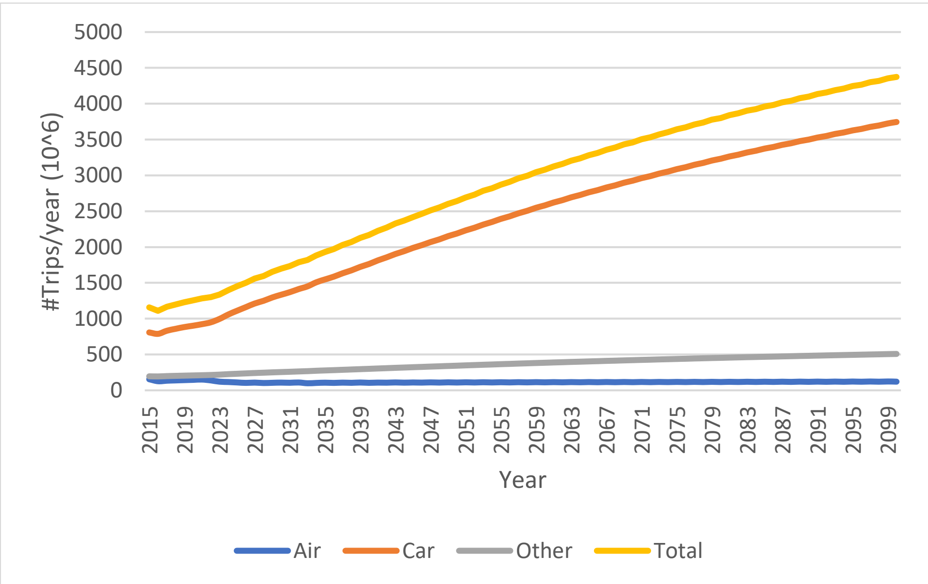

Figure 18 Breakdown of the number of trips per mode of transportation in the sovereignty principle scenario for the EU28

Although the number of road movements in the EU28 are expected to grow in the sovereignty scenario, the EU28's car segment is expected to reduce their emissions quite drastically as illustrated by the sheer drop in emissions between 2019-2027. After 2027, emissions are required to continue dropping, but at a slower pace. All other tourism sectors are also expected to reduce their CO_2 emissions gradually over the century.

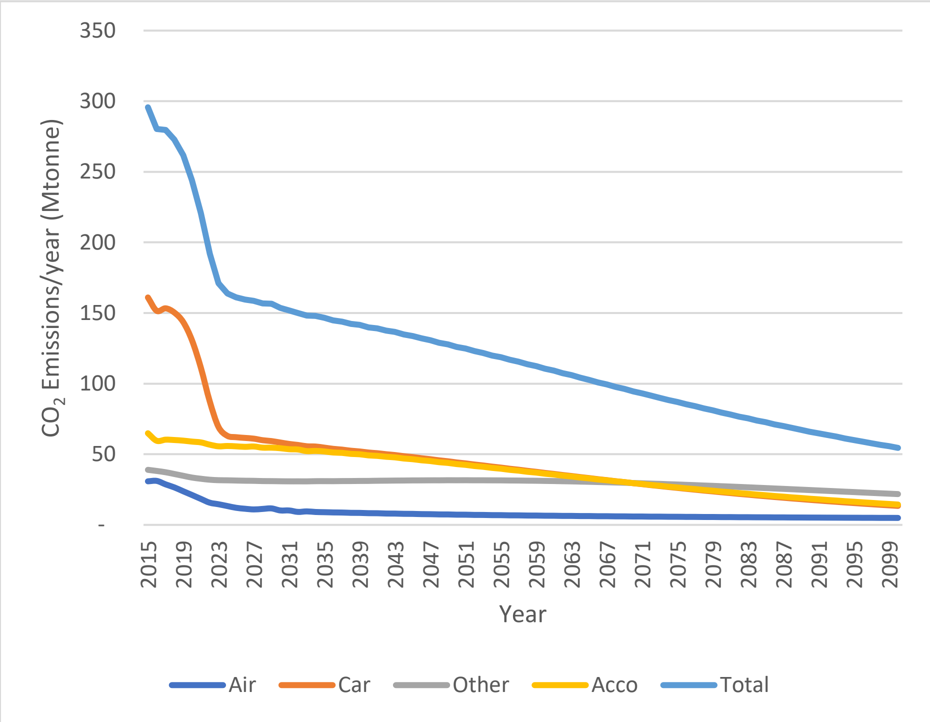

Figure 19 Breakdown of the CO_2 emissions per segment of the tourism industry in the sovereignty principle scenario for the EU28

3.2.4. Responsibility principle breakdown

As mentioned in section 3.2.1. Economic Mitigation emission scenario range EU28, the responsibility principle is not feasible since it requires negative CO_2 emissions. Adding to that, also the number of air trips are required to be negative in the responsibility scenario as illustrated in Figure 20. This is due to the fact that people from the EU28 have made 8,27 times more trips than the average earth inhabitant over the period 1991-2015. Therefore, their reduction (the distance between BAU and EM) is 8,27 as much as the average person on earth.

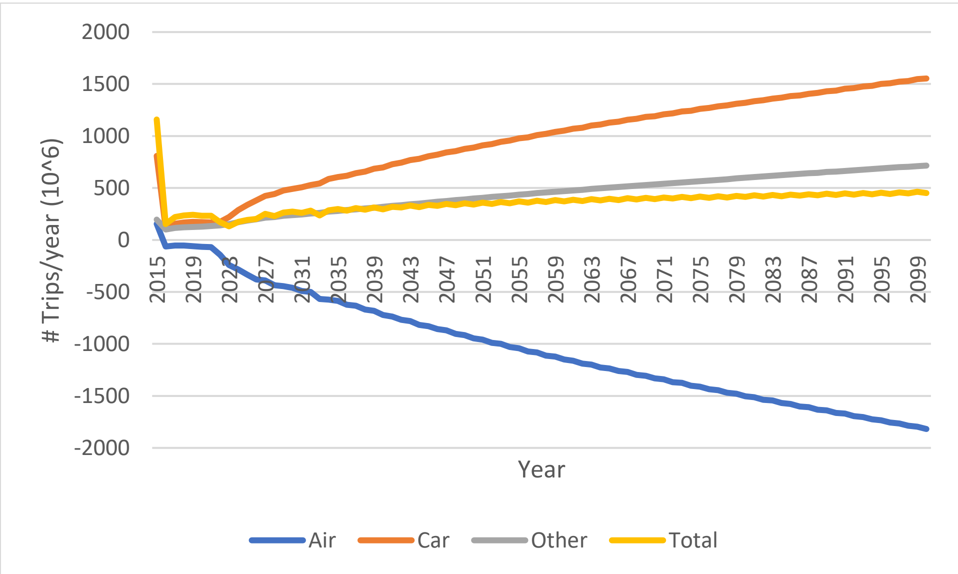

Figure 20 Breakdown of the number of trips per mode of transportation in the responsibility principle scenario for the EU28

Figure 21 illustrates the CO_2 emissions per segment of the tourism industry in the EU28 under the responsibility principle scenario. As illustrated, all segments of the tourism industry are required to emit negative amounts of CO_2.

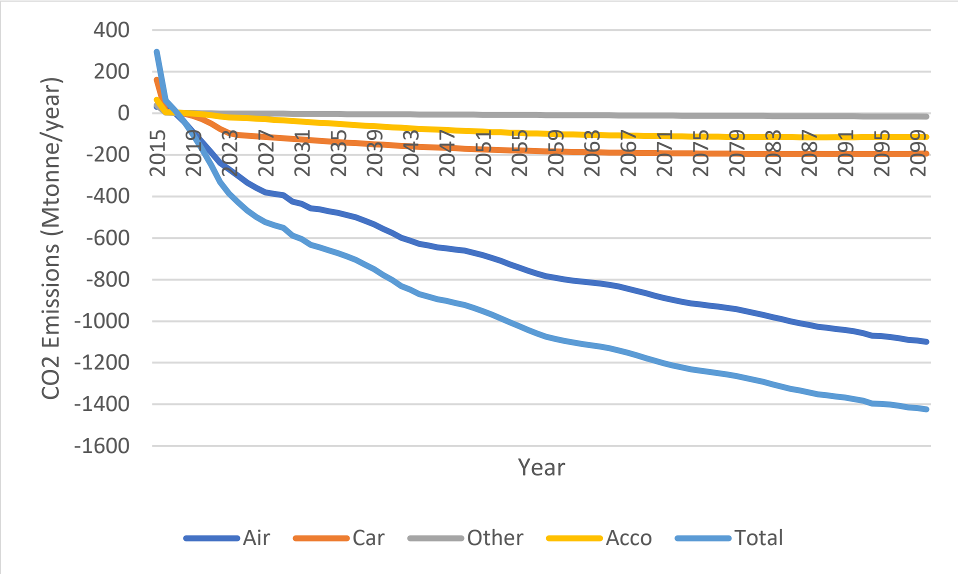

Figure 21 Breakdown of the CO_2 emissions per segment of the tourism industry in the responsibility principle scenario for the EU28

3.2.5. Capability principle breakdown

Just as mentioned in 3.2.1. Economic Mitigation emission scenario range EU28 the capability principle requires negative emissions. Figure 22 and Figure 23 illustrate the number of trips per mode of transportation and the CO_2 emissions per tourism segment respectively under the capability principle scenario.

The capability principle scenario unfolds quite similar to the responsibility principle scenario. With negative aviation number of trips and negative emissions for all sectors of the tourism industry in the EU28.

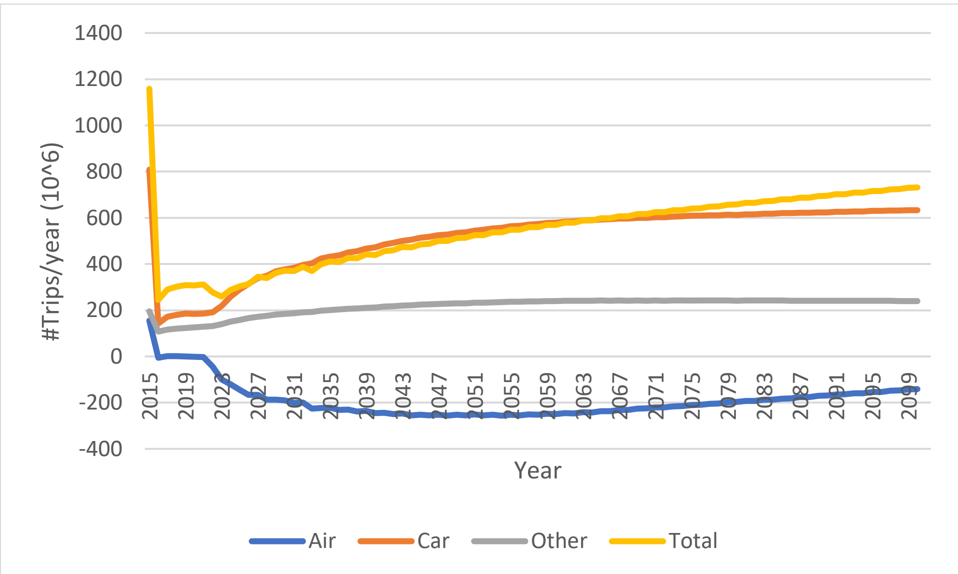

Figure 22 Breakdown of the number of trips per mode of transportation in the capability principle scenario for the EU28

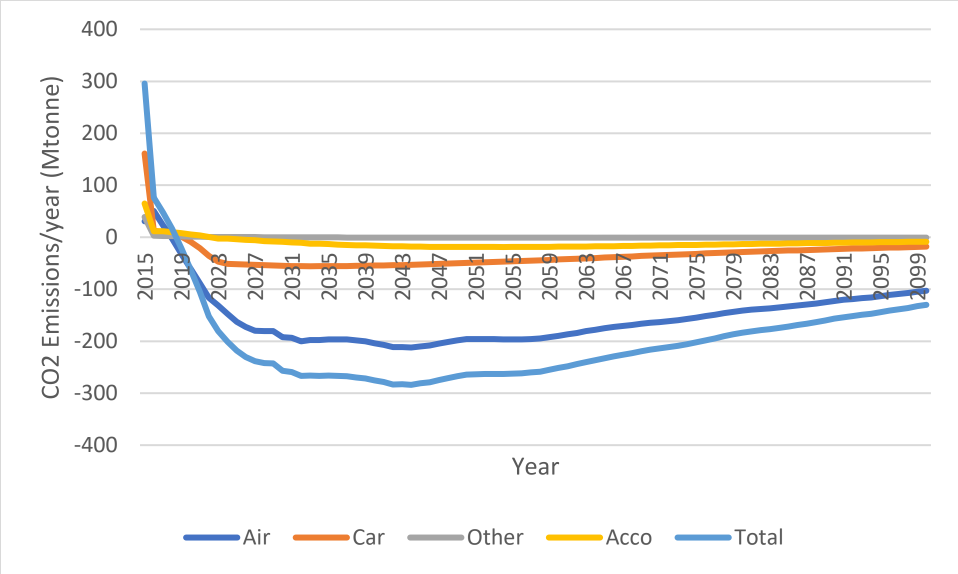

Figure 23 Breakdown of the CO_2 emissions per segment of the tourism industry in the capability principle scenario for the EU28

3.2.6. Policy measures economic mitigation scenario

Table 4 shows the values for all calculated estimated policy measures in the egalitarian and sovereignty scenario for EU28. The green values diverge from the global policy measures as set by Peeters (2017). All other values are the same worldwide.

In the egalitarian scenario the HSR investment curve starts at $13,2 billion 1990 USD/year and gradually reduces to $8 billion 1990 USD/year. This is due to the fact that Africa's population is expected to grow much faster than Europe's population, therefore Europe should pay a smaller share of the global investments in HSR. The same principle goes for the airport slots Europe gets granted in the egalitarian scenario. Europe starts out with 0,6 million airport slots, which will have to be reduced to 0,4 million slots in 2100.

According to the sovereignty scenario, Europe's amount of turboprops should be 41,5% of all their aircraft carriers. This is 1,5% more than the egalitarian 40%. Europe's HSR investments should be $38 billion 1990 USD/year. Europe's airport capacity should be restrained to 1,2 million flights/year.

Table 4 Regional policy measures EU28

	Egalitarian	Sovereignty
Biofuels that may be used	Yes	Yes
Biofuel subsidies per biofuel feedstock (%)	90	90
Car efficiency change (%/year)	-3.50	-3.50
Share of electric cars policy goal (fraction of fleet)	1	1
Factor determining the rate of introduction of electric cars	1	1
Air additional efficiency improvement (%/year)	-0.27	-0.27
Other transport efficiency per year change (%/year)	-2.50	-2.50
Accommodation efficiency per year change (%/year)	-2.50	-2.50
Turboprop desired share of fleet (%)	40	41,5%
Maximum aircraft age operational (year)	30	30
High-speed rail investments time curve (billion 1990 USD/year)	$13,2-> $8	$38
Global airport maximum capacity in million flights/year	0,6 -> 0,4	1,2
Global aircraft cruise speed reduction factor (%)	0	0
Global operational car speed change policy factor (%)	0	0
Global operational other transport speed change (%)	30	30
Global (tourism) carbon tax (1990 $/ton CO2)	$90-$450	$90-$450
Tourism carbon tax applied to all modes and accommodation	Yes	Yes
Global ticket tax Air transport (+ is tax and – is a subsidy; %)	200	200
Global ticket tax Car transport (+ is tax and – is a subsidy; %)	0	0
Global ticket tax Other transport (+ is tax and – is a subsidy; %)	0	0
Rate of change of the length of stay (night/trip/year)	-0.0006	-0.0006
Marketing policy that factors the desire to travel	0.95	0.95
Marketing policy that factors the attraction-of-distance curve	0.5	0.5

4. Discussion

This discussion is made up of four sections. In the first section the answers to the research questions will be discussed. This is where the developed regional scenarios for India and the EU28 are briefly presented. In the second section the plausibility of the regional scenarios will be discussed based on a comparison with real life current developments in policy making. In the third section, this thesis' external validity is discussed. Other studies with similar approaches are discussed and compared here. In the last section the internal validity is discussed. This is where the limitations in data availability and the chosen methods are discussed.

4.1. Answering the research questions

The leading question in this thesis is '*What policy scenarios for the travel industries in the EU and India could ensure that the CO_2-emissions from tourism stay within the Paris agreed safe global temperature rise of 2°C compared to pre-industrial times?*'.

The main research question will be answered by discussing the answers to the two sub questions:

What are the targets for the travel industries in the EU and India which could ensure that the CO_2 emissions from tourism stay within the Paris agreed safe global temperature rise of 2*℃* compared to pre-industrial times?

What are the policy trajectories for the travel industries in the EU and India which could ensure that the CO_2 emissions from tourism stay within the Paris agreed safe global temperature rise of 2*℃* compared to pre-industrial times?

Based on Peeters (2017) economic mitigation scenario, region specific equity scenarios were created. These scenarios defined the range of possible future tourism scenarios to keep tourism's emissions within the Paris agreed goals. One should keep in mind that a regional scenario for one region coexists with the other regional scenario as well as the rest of the globe in the global tourism system. Therefore, regional scenarios can only be sustainable when all regions agree on a global pathway with the corresponding regional pathways. The sum of all the regional pathways must never be greater than the global set pathway. The chance for failing the Paris agreement is high when each individual region decides on their individual pathways within their described ranges without international agreements.

The corresponding regional targets for the number of trips and emissions to the regional policy scenarios as briefly explained below are shown in Figure 4, Figure 5, Figure 14, and Figure 15. As shown, travel is expected to grow in both regions under the regional scenarios, whereas emissions are drastically decreasing. A strong modal shift is required, as well as additional technological advancements that makes all modes of transportation (and accommodation) more efficient.

It was found that the regional responsibility and capability scenarios provided negative number of trips and negative emissions are required in the EU28 (Figure 20, Figure 21, Figure 22, and Figure 23). The method used to calculate these two scenarios translated the European historic contributed tourism CO_2 emissions (± 8 times the worlds average tourism CO_2 emission contribution per person) and European wealth (± 5 times the worlds average GDP per person in 2015 to ± 2 times the worlds average GDP per person in 2100) into ultimately negative emissions and trips. This indicates how extreme the equity scenarios on itself actually are. The regional policies within the regional policy scenarios were not downscaled for the responsibility scenario and the capability scenario for the reason that no policies could lead to a negative number of trips.

In this thesis the responsibility and capability scenarios were not used to discuss the policies required to keep the global tourism emissions within the Paris agreed goals. However, ultimately, the responsibility and capability arguments should not be discarded in the tourism climate discussion. The purpose of this study is not to figure out which extreme equity scenario would be most fitting to battle tourism CO_2 emissions. Ultimately, the global tourism climate discussion should incorporate all equity arguments to find a middle ground between the four equity pillars when defining regional responsibilities. Although the responsibility scenario is too extreme by itself, the EU28 should take more responsibility based on the polluter pays principle. The same goes for the capability principle, although the EU28 is one of the wealthier regions in the globe it is unrealistic to have the EU28 to pay for the whole transition of the tourism industry. However, the EU28 could support the less wealthier regions in the world to transition their tourism industries.

At its core, the global economic mitigation scenario requires a radical transformation of the global tourism and transport sector with a strong modal shift (Peeters, 2017). Strong taxation, subsidies and airport slot restrictions will have to be installed to achieve the required modal shift and keep tourism's CO_2 emissions within the Paris agreed goals. These radical policy measures will likely cause some strong opposition from the tourism and aviation industries (Peeters, 2017). Therefore, making the tourism industry conform to the Paris agreement through the economic mitigation scenario might sound idealistic from an socio-economic standpoint. However, exploring radical policy solutions is highly relevant concerning the severe climatic impacts tourism is predicted to have in a business as usual scenario (Peeters, 2017).

As mentioned, the global economic mitigation requires a radical change of the tourism industry on a global scale. Therefore, both of the developed regional scenarios for India and the EU28 are also radical. For both regions, the identified egalitarian and sovereignty equity scenarios describe the regions' possible futures. However, since most global policy measures require a strong global engagement, many of the identified policy measures are the same worldwide.

The overlapping policies are discussed before going into the region specific regional policies. Concerning alternative fuels (to fossil fuels in aviation) from plants (jatropha, camelina, switchgrass, and palm oil) and algae, all alternatives should be actively stimulated and subsidized (90%) by both India and the EU28.

The policies concerning technological advancements are all maximized globally. Therefore, the goal of the share of electric cars on the road is 100%. With a very rapid transition from fossil fuel cars to electric cars which should happen simultaneously globally. A bigger challenge for India than for the EU28 as this requires large investments in infrastructure and new technologies.

Air transport is demanded to become 0,27% more efficient each year, whereas other transport modes (than road and aviation,) and accommodation should become 2,50% more efficient each year. Other transport modes (mostly rail) should become 30% faster to be able to compete with airlines on shorter distances. On a global level, airlines should agree on a maximum aircraft age of 30 years.

A global carbon tax should be installed. Starting out with \$90/ton CO_2 and gradually increasing to \$450/ton CO_2 by the year of 2100. This measure would gradually start favoring non CO_2 emitting modes of transportation over fossil fuel transport modes. An additional 200% ticket tax should be placed on an airline ticket. A measure that is also meant to discourage tourists to travel by airplane.

Regionally, there are a few policy differences between India and the EU28 based on their regional egalitarian and sovereignty principle scenarios. India should invest in High Speed Rail (HSR) in the range between $0/year and $35,5 billion /year. Whereas their airport slots should be limited to a range between 0,16 and 1,7 million flights/year.

The EU28 should invest between $8 and $200 billion /year in HSR. Whereas their airport slots should be limited to a range of 0,4 and 1,2 million flights per year.

4.2. How realistic are the regional scenarios for India and the EU28

Developing regional scenarios for India and the EU28 are interesting theoretical exercises on how a sustainable tourism would look like. However, are current developments in both India and the EU28 supporting the trends portrayed in the respective regional scenarios? In this section, real world policy developments are compared to the policies in the developed regional scenarios.

Globally, agreements should be made on carbon taxation to conform to both of the regional scenarios. The International Air Transportation Association (IATA), representing 82% of the world's air traffic, released a statement to be not in favor of installing a "green" tax on aviation (IATA, 2018a). IATA (2018) believes that a carbon tax would harm the aviation industry (IATA, 2018a). However, according to Peeters (2017) a reduction of air movements is actually required to be able to conform to the economic mitigation scenario.

India installed the FAME scheme (Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles) to ensure a quick transformation of the car fleet (Ministry of heavy industry and public enterprises, 2015). By 2023 India aims to have 15% of its car fleet to be electric (Ministry of heavy industry and public enterprises, 2015). This goal by itself is already quite challenging. However, to conform to the economic mitigation scenario, at least 27% of the car fleet should be running on electricity by 2023. Therefore, additional measures are required.

India aims to expand their aviation connectivity by increasing their total amounts of airports from around 100 in 2018 to 150-200 airports in 2035 (Kuronuma, 2018). In the economic mitigation scenario there is room for expanding aviation developments for India (the upper limit in the regional egalitarian scenario allows almost a growth of 600%). However, this should go hand in hand with strong reductions in aviation in regions such as the EU28 where current amounts of flight movements are way above the globe's average. Whether this is possible at a short term is very doubtful as most regions across the globe are still building on their aviation infrastructure (e.g the expansion of Schiphol in the Netherlands). Another requirement is that fuel for aviation should switch from kerosene to cleaner or renewable energy sources. The conversion from fossil kerosene to bio kerosene brings its own set of challenges (Hari, Yaakob, and Binitha, 2015). A big challenge is that crops for fuel will have to compete with crops for food, threatening food production (Hari, Yaakob, and Binitha, 2015) and possible resulting in more land conversion, with associated greenhouse gas emissions. More research is required on the feasibility of using biofuels for aviation.

Concerning High Speed Rail (HSR), India has one HSR line currently in the planning phase and is expected to be finished in 2023 (UIC, 2018). Eight other high speed rail lines are in the long term planning phase (UIC, 2018). These lines can in the future compete with short domestic flights. These additional lines will not be enough to accommodate 281 – 538 million trips (from the 160 million '*other*' categorized trips in 2015) as required for the economic mitigation scenario when compared to the Chinese high speed rail system. With a yearly 2,5 billion travelers (Xinhua, 2016) over 27684 km (UIC, 2018), India can expect approximately 45 million over their 508 km planned lines (UIC, 2018).

The European Commission is funding a public-private partnership called European Green Vehicles Initiative (EGVI) (European Commission INEA, 2018). This public private partnership is mainly a research and consultancy agency aiming to develop solutions for installing a competitive and sustainable transport system (European Commission INEA, 2018). However, the EU does not set specific goals for accelerating the transition from fossil fuel cars to electric cars.

The EU28's aviation sector's goals is to achieve 50% of their 2005 emissions in 2050 (European Union, 2017). The EU28 aims to do this through the emissions trading scheme (EU-ETS) (European Union, 2017). However, the EU28 is still expanding their total number of flights. Therefore, the EU28 is focusing on the development of cleaner technologies rather than alternatives to flying. A 50% reduction by 2050 compared to 2005 should be sufficient to make aviation conform to the Paris agreement. However, the 50% reduction should already be achieved much earlier than 2050. Next to that, the EU28 assumes that technical innovation will be able to deal with the overshoot of emissions. This would mean that most of the European fleet would need to be replaced with highly efficient alternatives which do not exist yet. Some of Europe's large airlines such as KLM-Air France (KLM, 2016), Norwegian, and Ryanair (Ryanair, 2018) score high on sustainability indices because of their use of young and more efficient fleets (KLM-Air France and Norwegian), high seat occupation (Norwegian and Ryanair), carbon offsetting (KLM-Air France and Norwegian) and the use of biofuels (KLM-Air France). These airlines manage to achieve a CO2 reduction between 20-30% over 9 years (KLM, 2016; Norwegian, 2018). As on average Europeans fly approximately 5% more each year, even the CO_2 reduction by the most sustainable airlines will not be sufficient to deal with the increase in air traffic.

The European Commission has worked on 2011's *white paper* 'roadmap to a single European transport area' (Scordamaglia, 2015). Instead of leaving HSR development to individual nations, the EU is now actively developing an international HSR network (Scordamaglia, 2015). One of the objectives is tripling the current length of the HSR network by 2050 (Scordamaglia, 2015).

4.3. External validity

The equity principles have mostly been used in a qualitative way to address and categorize arguments used in policy making concerning CO_2 emission responsibility sharing (Cazorla & Toman, 2000; Ringius et al., 2002; Den Elzen et al., 2004; Lange et al., 2007). In research, equity principles are not often used in a quantitative way. Some scholars have tried to create different quantitative CO_2 emission scenarios based upon equity principles (Cantore and Padilla, 2010; Yi et al., 2011)

Cantora and Padilla (2010) created different emission trajectories for large geographical regions under different equity principles. However, they only took the egalitarian and sovereignty principles into consideration.

Yi et al. (2011) have tried to quantify how much the different regions in China would need to reduce their CO_2 emissions based upon equity principles. However, the approach was different as merely three sub scenarios were created: capacity (capability), responsibility and potential (based upon energy consumption) (Yi et al., 2011). Their approach differs from this thesis' approach as slightly different equity principles were used. Yi et al. (2011) only discussed how heavy the CO_2 reduction burden (high, medium, low) per region should be. The approach of this thesis goes a step beyond and identifies the actual reduction target per region. Next to that, this thesis discusses the policies required to reach the goals.

Both Cantora and Padilla (2010) and Yi et al. (2011) approaches were largely similar for the CO_2 - emission calculations. However, this thesis took at a step further by also calculating the number of trips and the policies required to reach the required CO_2 emissions.

4.4. Internal validity

The data used to calculate the egalitarian scenarios are all based on forecasts, which are by default grounded in uncertain assumptions. However, this is a hurdle that cannot be overcome. Future population forecasts were used which were also used in $GTTM^{dyn}$, making this thesis' findings compatible with $GTTM^{dyn}$.

Peeters (2017) has set arbitrary limits to the policy measures settings in $GTTM^{dyn}$. Therefore, the assumption made in this thesis that the limits of $GTTM^{dyn}$ are the actual limits in policy making is not necessarily true. However, a ticket tax of over 200% is possible but highly unlikely. That being said, larger differences between India and the EU28 are possible when looking at the policy trajectories when taking this limitation into account.

It was challenging to find proper data to calculate the sovereignty scenario. Specific data on emissions by sector and mode of transport were required on a regional and global scale to be able to calculate the internal (within region) and external (between regions) ratios in the base year. A lot of assumptions were ultimately required to make the calculations for the sovereignty scenario, which made this scenario highly uncertain.

There are a couple of things that could be done to improve the calculations of the responsibility scenario. There were some constraints to what type of data was available. The data used were the number of trips on both regional scales and on the global scale. However, in order to be able to accurately assess the contribution to the problem, one should actually need the know the historic emissions rather than the number of trips. However, this data was unavailable. A next challenge was finding a dataset that provided historic data as far back into the past as possible. The used dataset provided data from 1991 onwards. Mass tourism started booming in Europe in the 1960's. Therefore, a large part of historic emissions were not incorporated in the responsibility scenario. Since India's tourism segment has just recently received a large boom, the used dataset reveals a more positive image for the EU28. Even with the current responsibility of ±8x the global average. In reality this value is higher. It does not make a big difference in outcome though. The negative number of trips and emissions in the EU28 responsibility scenario would actually be even lower. As this would make the already quite extreme responsibility scenario even more unlikely, it does not make a big difference to even lower the emissions and trips.

To calculate the capability scenarios forecasted GDP's from India, the EU28 and the world were used. The first intention was to use tourism revenues instead of GDP to be able to find a better balance between actual gains from tourism and mitigating the climatic effects of tourism. Therefore, forecasts of the development of both India's and EU28's tourism industries were required. However, these forecasts do not exist. A GDP forecast was therefore used to approximate both regions economic capability. No specific forecasts for India and the EU28 did exist until the year 2100. Therefore, Asian data was taken as an approximate for India and OECD data was taken as an approximate for the EU28. These estimates make the calculated capability scenario highly uncertain.

Although this study is based upon highly speculative assumptions it provides valuable insights in the future of the tourism industry. It has become clear that there is no such thing as traveling without bounds. If India and the EU28, as well as the rest of the world wants to take the climate challenges seriously, as it is posed in the Paris agreement, then drastic policy measures are required to enable a modal shift. In Europe, alternatives to short haul flights should be developed such as an extensive and competitive HSR network. In India, one should not focus on developing new domestic aviation networks, but rather focus on CO_2 low alternatives. When the tourism industries, national and supranational governments take this challenge serious, global citizens will still be able to travel, but they will merely travel differently.

5. Conclusion

Under the economic mitigation scenario, both India and the EU28 have to strictly regulate their respective tourism industries in order to reach the climate targets of the Paris agreement. The targets within the identified regional scenarios for both India and the EU28 require ambitious policy frameworks on a global and regional scale to keep global tourism emissions within the Paris agreed goals. The identified targets of the regional policy scenarios are bound by, and consist of, the ranges of allowed emissions and the range of the expected corresponding number of trips. The ranges are described through four calculated equity scenarios; egalitarian scenario (equal pollution rights), sovereignty scenario (status quo right), responsibility scenario (polluter pays), and capability scenario (mitigate according to wealth). Policy makers should design policy trajectories that aim to get the future tourism emissions and number of trips on a trajectory within the described ranges. The purpose of research sub question 1 was to identify the targets (CO_2 emissions and number of trips) within the regional scenarios. The purpose of research sub question 2 was to find the corresponding policy trajectories to the identified targets.

Only the ranges sovereignty and egalitarian target trajectories are used to describe the target ranges of the regional scenarios. The capability and responsibility trajectories assigned negative CO_2 emissions and number of trips to the EU28 because of its wealth and number of historic travels respectively. Therefore, the ranges became useless to describe possible trajectory ranges. However, when policy makers decide on policy trajectories, capability and responsibility arguments should still be considered. This could be achieved by, not letting Europeans travel less, but perhaps let the EU28 finance tourism projects elsewhere. For example, the EU28 could aid India in their development of a HSR network based upon their responsibility equity principle. The CO_2 and number of trips ranges within the regional scenarios are described by the sovereignty and egalitarian trajectories.

India's population emitted 371 Mton CO_2 emissions while undertaking ~1,5 billion international and domestic trips in 2015. The upper limits in India's ranges are constrained by the sovereignty scenario, whereas the lower limit is constrained by the egalitarian scenario. According to the regional scenario the 2015 CO_2 emissions should have become between 371 Mton and 269 Mton. A fast reduction in emissions is required until 2023 in which the CO_2 emissions should be within 207Mton and 151 Mton. After 2023 a gradual reduction in CO_2 emissions is required with a 2100 range between 58 Mton and 35 Mton. The number of trips are allowed to grow from between the range of 1056 million and 1452 million trips in 2015 until the range of 2570 million to 6325 million trips in 2100.

The EU28's population emitted 296 Mton CO_2 on emissions from tourism related 1159 million tourism related trips in the base year 2015. Under EU28's regional scenario a similar trend in targets is identified when compared to India. The sovereignty scenario provides the upper limit, whereas the egalitarian scenario provides the lower limit of the targets' ranges. The 2015 CO_2 emissions should be between 100 Mton and 296 Mton. A quick reduction in emissions is required up until 2023 with a 2023 range between 52 Mton and 171 Mton emissions. Until 2100 the required reductions are more gradual. The 2100 emission range being between 10 Mton CO_2 and 55 Mton CO_2. EU28's number of trips are expected to grow under the regional scenario with an allowed 2015 range between 393 million and 1159 million trips. The 2100 range is 762 million until 4374 million trips.

Sub question 2 encompassed identifying the policies belonging to the identified targets. Just like the targets, only the according sovereignty and egalitarian policy trajectories are identified and described. The policies are based on a range of policy measures described by Peeters (2017) and can be used to play around with in $GTTM^{dyn}$ to find the effects of the policy measures on the tourism industry and its emissions.

Most policy measures are identified to be the same worldwide due to the extremeness of these measures. Two of those extreme measures are that 100% of the car fleet is expected to become electric and an air ticket tax of 200% should be installed within the regional scenarios. Many of the policy measures lie very close together for India and the EU28. The major difference lies within the measure of allowed air movements (airport slots). Of which India is allowed to have 0,16 million flights/year under the sovereignty scenario and between 1,7 and 1,36 million flights/year in the egalitarian scenario. The EU28 is allowed 1,2 million flights/year in the sovereignty scenario and between 0,4 and 0,6 million flights/year in the egalitarian scenario.

The purpose of this thesis was to identify policy scenarios for the travel industries of the EU and India which would conform to the Paris agreed goals. Ultimately this thesis is an interesting thought provoking explorative piece that clearly illustrates the radical measure required to make both India's and the EU28's respective tourism industries conform to the Paris agreement. The global economic mitigation scenario has served as an example of a set of policy measures required to make the tourism system conform to the Paris agreed goals. However, other sets of policy measures on a global scale could also lead to the aspired outcome; conforming to the Paris agreed goals. Therefore, the same exercise could be practiced for different policy sets in future research. This thesis clearly demonstrates that there is no wiggling room in tourism climate policies. That is why the whole of the tourism industry, at all levels and all sub industries, will have to make climate adjustments. There cannot be any exceptions when tourism transitions into an industry conforming to the Paris agreement.

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Appendix

Appendix I

Table 5 shows the different policy measures in GTTM^{dyn} and its settings in the Business As Usual (BAU) and the Economic Mitigation scenarios. The 24 different policy measures are categorized in 6 main categories: policies for alternative fuels, policies for technology, infrastructure policies, policies governing transport speed, tax and subsidy policies, and behavior (Peeters, 2017). Every policy category is designed to achieve a specific aim.

Table 5 The global policy measures taken in the economic mitigation scenario compared to the reference/BAU scenario

Policy category	Description	Reference scenario (BAU)	Economic mitigation
Policies for alternative fuels	Land-use capacity	Physical	Sustainable
	Biofuels that may be used	No	Yes
	Biofuel subsidies per biofuel feedstock (%)	0	90
Policies for technology	Car efficiency change (%/year)	-0.55	-3.50
	Share of electric cars policy goal (fraction of fleet)	0.1	1
	Factor determining the rate of introduction of electric cars	0.15	1
	Air additional efficiency improvement (%/year)	0	-0.27
	Other transport efficiency per year change (%/year)	-0.50	-2.50
	Accommodation efficiency per year change (%/year)	-0.50	-2.50
Infrastructure policies	Turboprop desired share of fleet (%)	10	40
	Maximum aircraft age operational (year)	50	30
	High-speed rail investments time curve (billion 1990 USD/year)	\$10-29	\$200
	Global airport maximum capacity in million flights/year	500 (≈“unlimited”)	10
Policies governing transport speed	Global aircraft cruise speed reduction factor (%)	0	0
	Global operational car speed change policy factor (%)	0	0
	Global operational other transport speed change (%)	0	30
Tax and subsidy policies	Global (tourism) carbon tax (1990 \$/ton CO2)	\$0	\$90-\$450
	Tourism carbon tax applied to all modes and accommodation	Yes	Yes
	Global ticket tax Air transport (+ is tax and – is a subsidy; %)	0	200
	Global ticket tax Car transport (+ is tax and – is a subsidy; %)	0	0
	Global ticket tax Other transport (+ is tax and – is a subsidy; %)	0	0

Behavior	Rate of change of the length of stay (night/trip/year)	-0.0051	-0.0006
	Marketing policy that factors the desire to travel	1	0.95
	Marketing policy that factors the attraction-of-distance curve	1	0.5

Source: (Peeters, 2017, p. 154-155)

Policies for alternative fuels

The policies for alternative fuels are aimed at switching aviation fuel to cleaner alternatives (Peeters. 2017). The land-use capacity policy measures has two different settings: physical and sustainable. The physical setting allows unlimited cultivation of biofuel crops on the 'technically available' for biofuels (Peeters, 2017). The sustainable land use setting considers sustainability challenges such as biofuel competing with food or land degradation (Peeters, 2017).

The policy measure 'biofuels that may be used' includes five different types of possible biofuel uses. These include micro-algae, jathropa, camellia, palm oil, and switchgrass (Peeters, 2017). The setting 'yes' allows the cultivation and use of these biofuels. Setting 'no' prohibits the use of biofuels.

With the policy measure 'biofuel subsidies per biofuel feedstock (%)' it is possible to regulate the subsidies on biofuels.

Policies for technology

Technology is considered the main 'pillar' for the sustainable development of the tourism industry (including aviation, other transport, and accommodation) (Peeters, 2017). With these policy measures it is possible to regulate the yearly efficiency improvement of cars, aviation, other transport, and accommodation. Also it is possible to set targets for the share of electric cars on the road with 1 being 100%. The rate of introducing electric cars determines how quickly electric cars are being adapted globally. (Peeters, 2017)

Infrastructure policies

These include a number of policy measures concerning infrastructure. The policy measure 'Turboprop desired share of fleet (%)' addresses the use of turboprops (propeller planes), which are generally more efficient then jet airplanes. With this policy setting it is possible to set the share of turboprops used in the overall fleet of aircrafts. (Peeters, 2017)

With the 'maximum aircraft age operational (year)' policy setting it is possible to set a maximum age on aircrafts. Making the rotation faster between older, less efficient, aircrafts and new, more efficient, aircraft. (Peeters, 2017)

With the policy measure 'High-speed rail investments time curve (billion 1990 USD/year)' it is possible to regulate the investments in High Speed Rail (HSR). HSR is considered a more efficient mode of transportation as an alternative to short haul flights. (Peeters, 2017)

With the policy measure 'Global airport maximum capacity in million flights/year' it is possible to set a cap on the amount of flights taking of yearly. (Peeters, 2017)

Policies governing transport speed

With these policy measure it is possible to adjust the travel speed for aircrafts, cars, and other modes of transportation. Every mode of transportation has a most fuel efficient travel speed. However, this is not the fastest way of transporting people. Traveling too slow reverses the fuel efficiency effect when the lower design threshold is reached. (Peeters, 2017)

Tax and subsidy policies

These policy measures all deal with the taxation of - and subsidizing modes of transportation (ticket tax) and CO_2 emissions (carbon tax). (Peeters, 2017)

Behavior

The behavioral policy measures influence the travel behavior. It is possible to stimulate peoples travel behavior through marketing and/or education. (Peeters, 2017)

The policy measure ‘Rate of change of the length of stay (night/trip/year)’ influences the yearly change in how long people stay on a holiday. (Peeters, 2017)

The policy measure ‘Marketing policy that factors the desire to travel’ influences the desire to travel. This policy measure could be seen as demarketing tourism, making it less appealing for people to travel to achieve a CO_2 reduction by the overall tourism industry. (Peeters, 2017)

The policy measure ‘Marketing policy that factors the attraction-of-distance curve’ influences how much people are attracted to travel long distances. Setting this setting lower, people are less likely to travel far away, and are more likely to travel closer to home. This policy measure is also an example of demarketing. However, it demarkets the attraction to distance. (Peeters, 2017)